Earth Heritage

The Geological and Landscape Conservation Magazine

A little nose around Trwyn y Parc

The Making of Ynyslas: extolling geodiversity with creative writing

ISSUE 56
Winter 2021

ProGEO—with a global perspective!

Northumberland Rock Festival

Geoconservation highlights of the first year of the Black Country UNESCO Global Geopark

Earth Heritage

Cover: Exposures of the Port Askaig Tillite on Islay with the quartzite peaks of the Paps of Jura in the distance. The Dalradian geology in this area is not only an excellent teaching resource but provides insights into late Precambrian geology, covering a fascinating period of time corresponding to a 'Snowball Earth' glaciation. Find out more on p.57. Photo by David Webster

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INSIDE

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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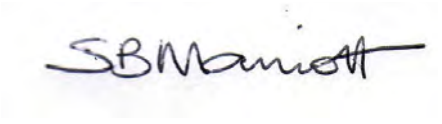
EDITORIAL

As well as updates and new reports on projects, this issue of Earth Heritage brings out our global connections. Lars Erikstad looks at the history of geoconservation in Europe and how the European Association ProGEO has now become the International Association for the Conservation of the Geological Heritage and will give its members the opportunity to work on a much broader scale to influence geoconservation strategies and practice.

Our UNESCO Global Geoparks are also in the news. There are highlights of the Black Country's first year as a UNESCO Global Geopark and a report on revalidation visits to Fforest Fawr and GeoMôn, when UNESCO inspectors were shown many of their geological gems and informed of exciting new developments. Herefordshire and Worcestershire Earth Heritage Trust , one of the founder members of the Abberley and Malvern Hills Geopark, celebrated its 25th anniversary this year by organising a series of walks to visit areas linked to geoconservation and public awareness programmes the Trust has been involved in over that time. Adding to news on our existing Geoparks is the 'Outcrop' from the Charnwood Forest Landscape Partnership Scheme which has been awarded a National Lottery heritage Fund grant to submit an application for UNESCO Global Geopark status. With Ediacaran fossils, unique mineralogical discoveries and evidence of Stone Age habitation, to mention a few of the important geoheritage attributes of the area, the international significance of Charnwood Forest deserves to be recognised.

The issue also highlights how the natural environment is celebrated in the creative arts. For example, Annie Cattrell explains how her sculptures relate directly to geology and observations of geological time and John Mason reflects on the process of writing 'The making of Ynyslas' and attempting to bring to life in a narrative form all the changes that have affected the landscape of the area.

The Earth Heritage Editorial Board has started to plan Issue 57 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

OUTCROPS

Building on our progress

It has been a rather heady time for Saltwells over the last couple of years, and all despite a pandemic! We are very proud to have become a National Nature Reserve for our geology which is based around the Silurian and Carboniferous geology of Brewin's Canal Section SSSI and Doulton's Claypit SSSI and encompasses the Scheduled Ancient Monument which covers the early bell pit coal workings within the ancient woodland. This designation arrived hot on the heels of the Black Country UNESCO Global Geopark designation that we are very proud to support.

We are therefore delighted with not only this external recognition of the importance of the natural assets we have here, but that Dudley Council has invested £0.5 million in a bespoke Wardens' and Education Centre. This rather robust building was built in Middlesbrough by Cleveland Sitesafe in sections before being driven and installed here in Dudley in November 2020. The fit-out was completed a couple of months later. The rather industrial look made some visitors blink at first, but they now are fully supportive.

It contains a workshop/garage, office messroom and a multifunctional classroom. However, we were determined that the improvements would not just stop when we got the keys. We have recently had some Carboniferous inspired artwork installed on the entrance gate. We are also developing an outdoor classroom that will complement the other environmental education activities we offer.

Over the next few months, we will purchase a display cabinet, through a grant bid won by the Friends of Saltwells which also helped us purchase the tables, chairs and a smart screen for the classroom. The display case will show off rock and fossil samples along with some artefacts of our industrial heritage. Over the coming year we plan to apply for additional funding to continue this work to interpret the natural and man-made heritage of Saltwells for a broad range of visitors.

As with every other thing in the world right now the pandemic has meant we have not been able to get people in and we have not been using it quite as we had anticipated. However, we are now proactively engaging with schools and other partners, like the Prince's Trust, to make sure it is a very well used asset that communicates the importance of the geology of the area and helps create the next generation of nature conservationists.

By Alan Preece, Dudley Metropolitan Borough Council

Designs for some of the artwork which will be installed around the entrance to the centre. (c) Dudley Metropolitan Borough Council

The outside of the centre has been painted brown to help it blend in with the fields and woodland. Inside the space can be adapted for different users. Photos by Alan Preece

National Lottery Supported Partnership Launches Charnwood Forest Geopark

In 2020 Leicestershire's Charnwood Forest was awarded a National Lottery Heritage Fund grant of £2,767,300 to put this little-known heritage landscape very firmly on the map. This unique region is of international significance, but very few people are aware of its value—even locally.

The grant, made possible by money raised by National Lottery players, funds the Charnwood Forest Landscape Partnership Scheme. This five-year scheme promotes awareness and understanding of the importance of Charnwood Forest through 18 projects that include geological conservation; habitat restoration; improvements to connections between sites for visitors; the creation of innovative interpretation; outdoor-learning opportunities for young people and adults; and a programme of cultural and heritage activities and events.

The Charnwood Forest Geopark, supported by the Charnwood Forest Landscape Partnership Scheme, will be working with partners, communities, and businesses across the region to celebrate and promote learning about our unique heritage, support sustainable geotourism, and protect local sites. A priority within this will be Charnwood Forest's Ediacaran palaeontological sites, which host some of the oldest animal fossils ever described. Other important stories for the Geopark include its rich quarrying heritage, unusual mineralogical discoveries, and the region's Quaternary geology and Stone Age habitation.

With our intention to submit an application for UNESCO Global Geopark status, we are keen to establish international links, and are pleased to be partners on IGCP Project 726 '*GEOfood for sustainable development in UNESCO Global Geoparks*' and IGCP Project 714 '*3GEO—Geoclimbing & Geotrekking in Geoparks*'. If any other organisations are interested in being involved in these projects, please do not hesitate to contact us.

We very much look forward to updating you again in the future, but in the meantime, as we continue to establish ourselves, please follow our story on social media:

Twitter: @CharnwoodGeo
Instagram: @CharnwoodForestGeopark
Facebook: fb.com/CharnwoodForestGeopark

By Dr Jack J Matthews, Geoheritage Conservation and Interpretation Officer

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

Get ready to celebrate International Geodiversity Day every 6th October.

The 41st General Conference of UNESCO has voted to approve International Geodiversity Day. The first will be 6th October 2022.

International Geodiversity Day will enable coordinated activities to take place worldwide. Bringing together people, communities, organisations, and countries across the world, it is expected that International Geodiversity Day will, among others, include activities to:

- Raise awareness of the critical link between geodiversity and all living creatures
- Promote the understanding of how society benefits from living on a geodiverse planet and the importance of the sustainable use of its resources and the conservation of its geoheritage
- Support the development of all programmes and projects aimed at creating and managing geoparks, world heritage properties, protected areas, and geosites
- Enhance international cooperation in the geosciences, research and development, and education by coordinating activities between learned societies, research institutions, academies, industry, government, and non-governmental organisations
- Better understand Earth systems and its interconnections

Further information http://geodiversityday.org/

By Hannah Townley, Natural England

Visitors examining the Carboniferous geology at Trowbarrow Quarry SSSI, Lancashire. Photo by Hannah Townley

Coastal cave in the coastline around Bari, Italy. Photo from the field trip of the VII International ProGEO Symposium on Conservation of Geoheritage - find out more on p. 17. Photo by Lars Erikstad

PUBLICATIONS

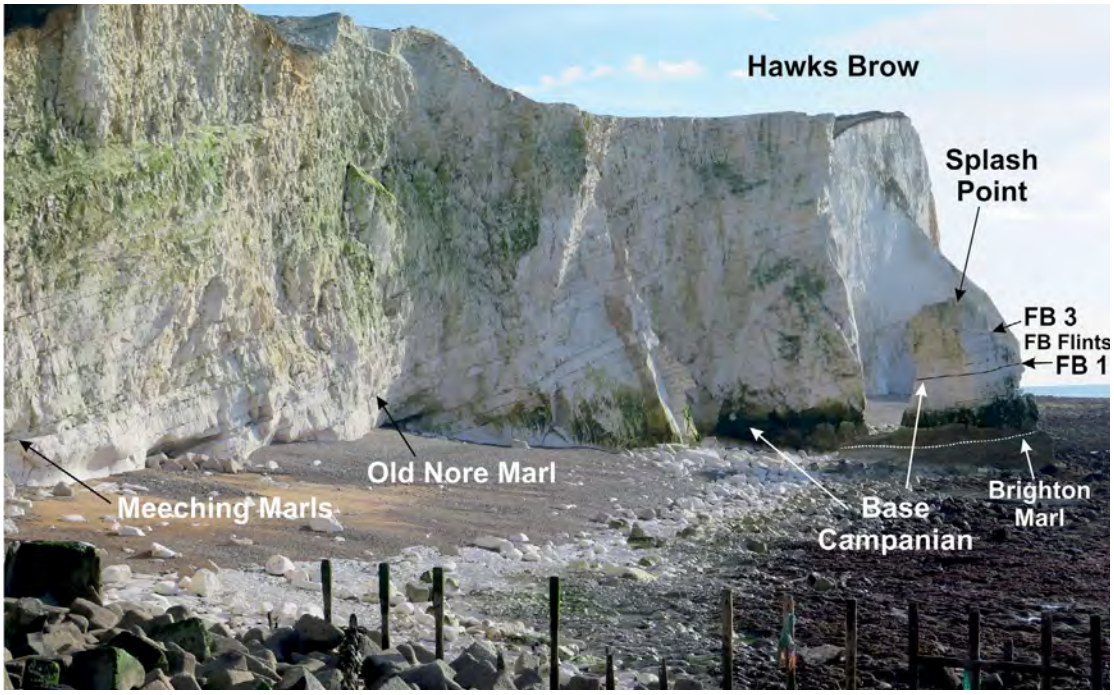
Geologists' Association Guide 74: The Chalk of the South Downs of Sussex and Hampshire and the North Downs of Kent

Mortimore, R.N. 2021. *The Chalk of the South Downs of Sussex and Hampshire and the North Downs of Kent*. Geologists' Association Guide 74, 2 volumes 556 + xii pp. ISBN Vol 1: 978 1 9996757 0 7, Vol 2: 978 9996757 1 4. Price £12/15 per volume or £21/27 for both (GA members/non-members)

Geologists' Association (GA) Guide No. 74 on *The Chalk of the South Downs of Sussex and Hampshire and the North Downs of Kent* is now published in two volumes. Volume 1 contains the introductory scene-setting geology and excursion guides to the East Sussex field sections and the coastal cliffs from Eastbourne to Brighton. Volume 2 takes the geology westwards through the West Sussex South Downs to Hampshire and the western end of the South Downs Way at Winchester and includes all the Kent North Downs itineraries, the index and references.

The content of the guide has been greatly influenced by requests from GA members to include more excursions along the main inland river valleys (e.g. the Adur and Arun valleys, Itineraries 8 and 9), more walks and sites that are accessible by public transport, updates on the geology of the coastal cliffs and to include more measured field sections with illustrations of key fossils. As also requested, the introductory section has been expanded to give more detail on the regional and international geological context and to give an explanation of the applied geology of the Chalk and its relevance to engineering geology and hydrogeology.

Some field sections are of special value in understanding the origin of the Downs, such as the former Shoreham Cement Works Upper Beeding Quarry (Itinerary 8). Some quarries that have been temporarily lost to landfill such as the Asham Pits, are included as they may one day have key parts



View looking east towards Seaford Head showing the sea stack at Splash Point with the Santonian–Campanian boundary section. FB = Friars' Bay. (Reproduced from Mortimore, 2021, by permission of the Geologists' Association)

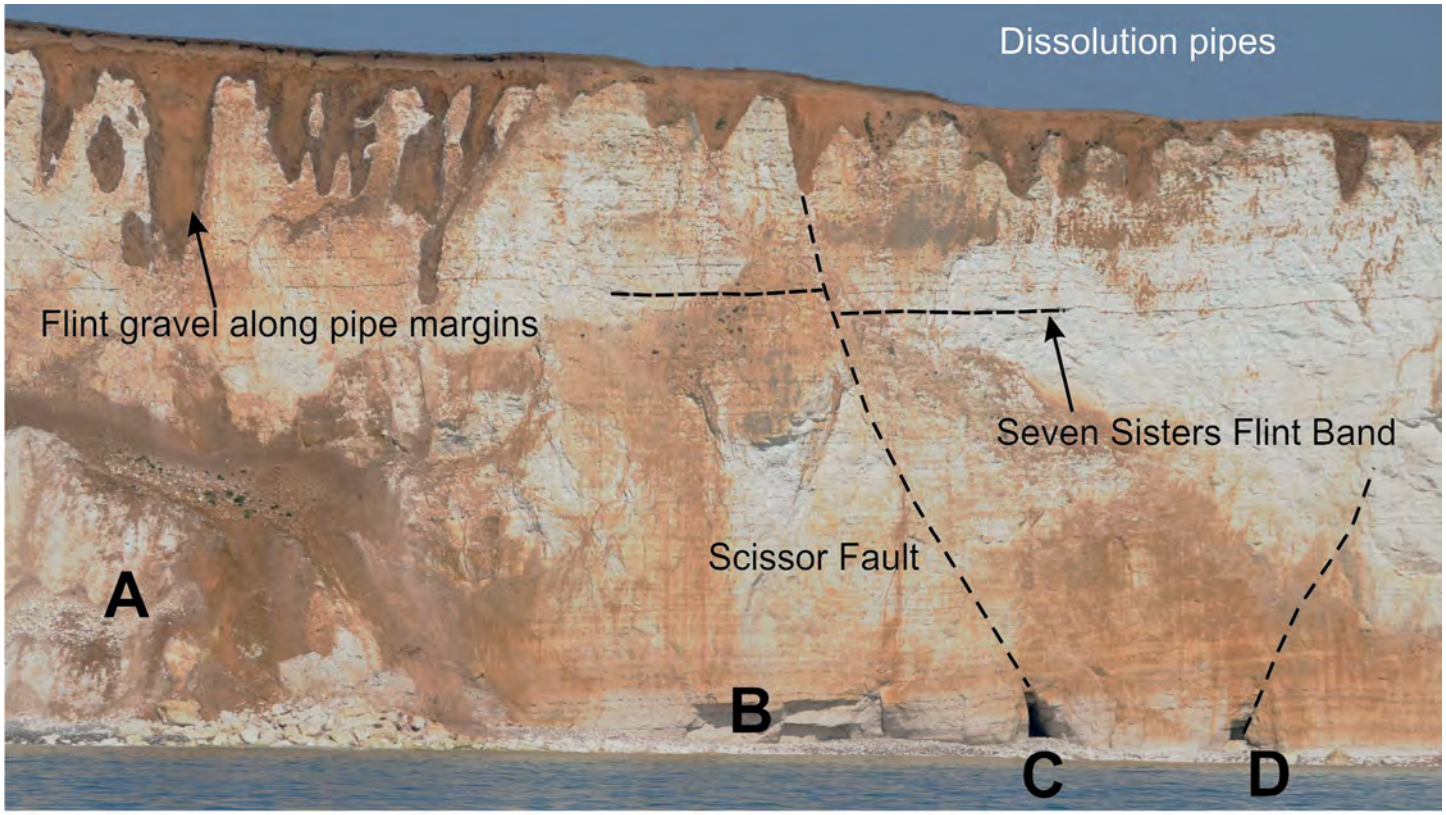
re-exposed as part of developments in geoscience and geoconservation within the South Downs National Park and Area of Outstanding National Beauty. Of particular importance to geoconservation and geodiversity are the international reference sections for key parts of Upper Cretaceous geology including Eastbourne for the Plenus Marls and Cenomanian–Turonian boundary, Southerham Grey Pit, Lewes for the Lower–Middle Cenomanian boundary, Seaford Head for the Coniacian–Santonian and Santonian–Campanian boundaries.

In addition to the Chalk geology the new Guide gives detailed information on the very fine exposures of Quaternary geology in the cross sections of dry valleys between Newhaven and Brighton and the raised beach at Brighton (Itinerary 7). Wonderful examples of periglacial weathering are also present around the Thanet coast of Kent, especially Pegwell Bay (Itinerary 15). Poorly known styles of faulting and stratabound fracturing in the Chalk are illustrated at Beachy Head and Seaford Head (Itineraries 5 and 6) and at Newhaven (Itinerary 7). The extent of karst in the Chalk is shown in many of the itineraries, especially the coastal cliff sections between Beachy Head and Brighton.

There are many more geology walks in the Downs than could be included in the Guide. Those that are included are an introduction to the geology that can then be applied more widely. Opportunities for local groups to make significant contributions in geoconservation and to the understanding of the geology of the Downs are highlighted especially in areas of currently poor exposure. An example is Itinerary 11 Butser Hill and the Hampshire – Sussex border with hints of unusual geology where only local enthusiasts can obtain critical information by logging and monitoring temporary exposures.

This guide book, and others in the GA series, can be purchased via the Geologists' Association website https://geologistsassociation.org.uk/guidesales/

Rory Mortimore, University of Brighton



View from the sea looking north onto part of Seaford Head illustrating the extensive dissolution pipes along the clifftop and the conspicuous Seven Sisters Flint Band. Many of the karst pipes have formed where fractures (mostly faults) reach the surface. These fractures have cavities and small cave systems along them and are the focus for cave formation at the base of the cliff (C and D). A and B = fracture and bedding-plane-controlled cliff collapse and failures at the base of the cliff. (Reproduced from Mortimore, 2021, by permission of the Geologists' Association)

Geoconservation: principles and practice

Evans, D., Brown, E., Larwood, J., Prosser, C., Townley, H. and Wetherell, A. 2021. Geoconservation: principles and practice. Natural England ISBN 978-1-78354-896-5

‘Geoconservation: principles and practice’ builds upon and updates the review of the practice of geoconservation set out in ‘Geological conservation: a guide to good practice’, published by English Nature in 2006. It draws upon seventy years of practical experience accumulated by Natural England and its predecessor bodies, partners and stakeholders over that period. It provides context to geoconservation but focuses on the principles and practice of geoconservation, illustrating the challenges, opportunities, threats and solutions associated with practice through real case studies, demonstrating approaches that have worked well, and other approaches that have not worked so well.

‘Geoconservation: principles and practice’ differs from ‘Geological conservation: a guide to good practice’ in several aspects. The diagrams have been entirely redrafted to (where appropriate) demonstrate positive management activities on geodiversity features. The case studies provide updates on cases illustrated in the 2006 publication, but many are new, and some demonstrate the use of techniques (moulding and casting, fixed point photography, visual management plans) that were in development during or after 2006.

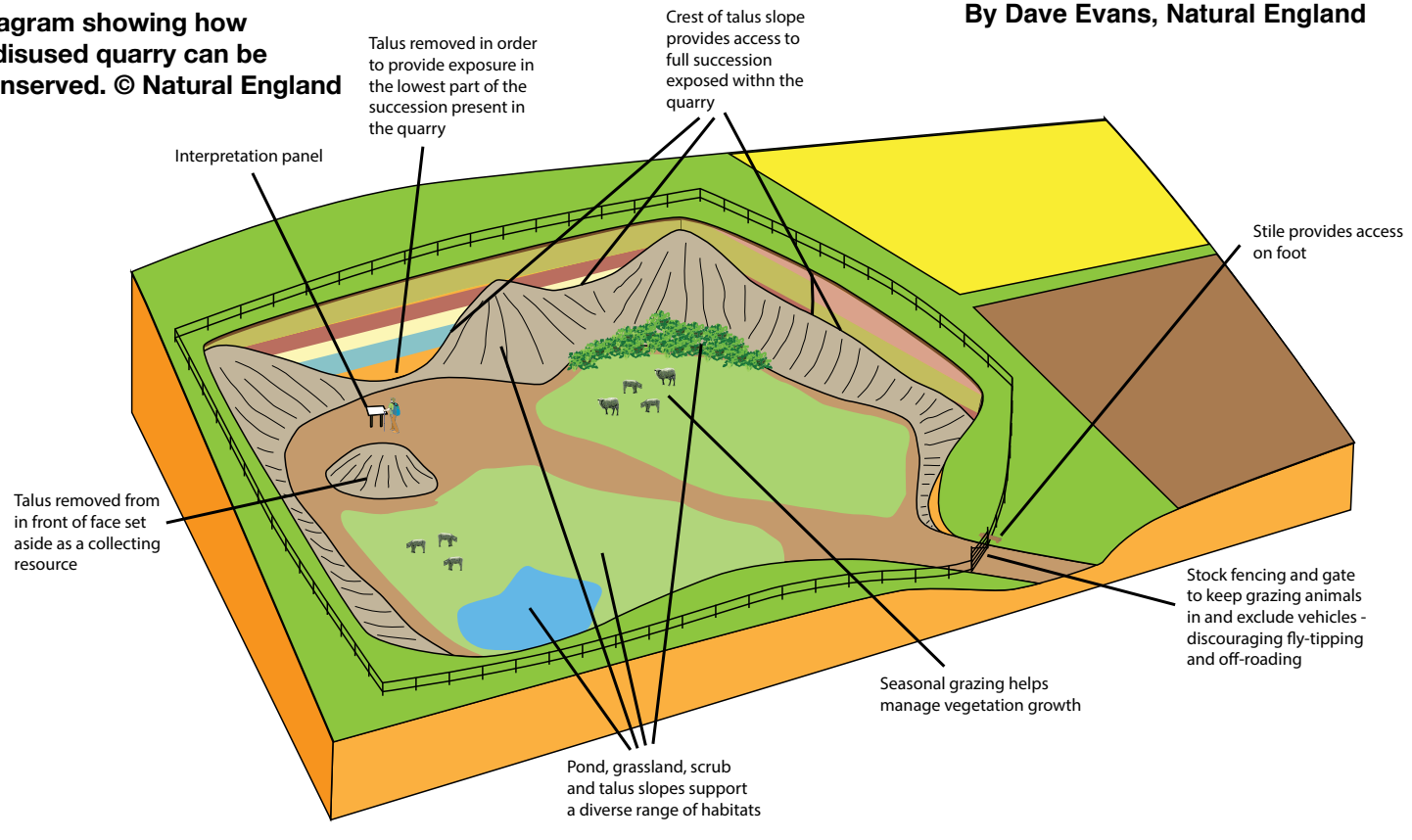
The other major difference from previous reviews is that it has been produced using design and publishing software, giving greater flexibility for future updates, as well as facilitating the development of customised products such as standalone case studies, or adapting the diagrams to illustrate specific requirements to a contractor or developer.

Although focussed on England and primarily intended as a source of advice for Natural England staff, this review is likely to be of interest and relevance to organisations, groups, partners and stakeholders involved in conserving, recovering or enhancing geodiversity anywhere in the World.

Geoconservation: principles and practice will be available soon to download from the Natural England publications catalogue, either as the whole document, or as separate parts.

By Dave Evans, Natural England

Diagram showing how a disused quarry can be conserved. © Natural England



ARTICLES

A little nose around Trwyn y Parc*

Matthew Pound, **Jessica McCoy** and **Martha Gibson**, Department of Geography and Environmental Sciences, Northumbria University; **Raymond Roberts** and **Stewart Campbell**, Natural Resources Wales

*** See Gwynn (2016), further reading**

Current palaeoclimate research at Trwyn y Parc

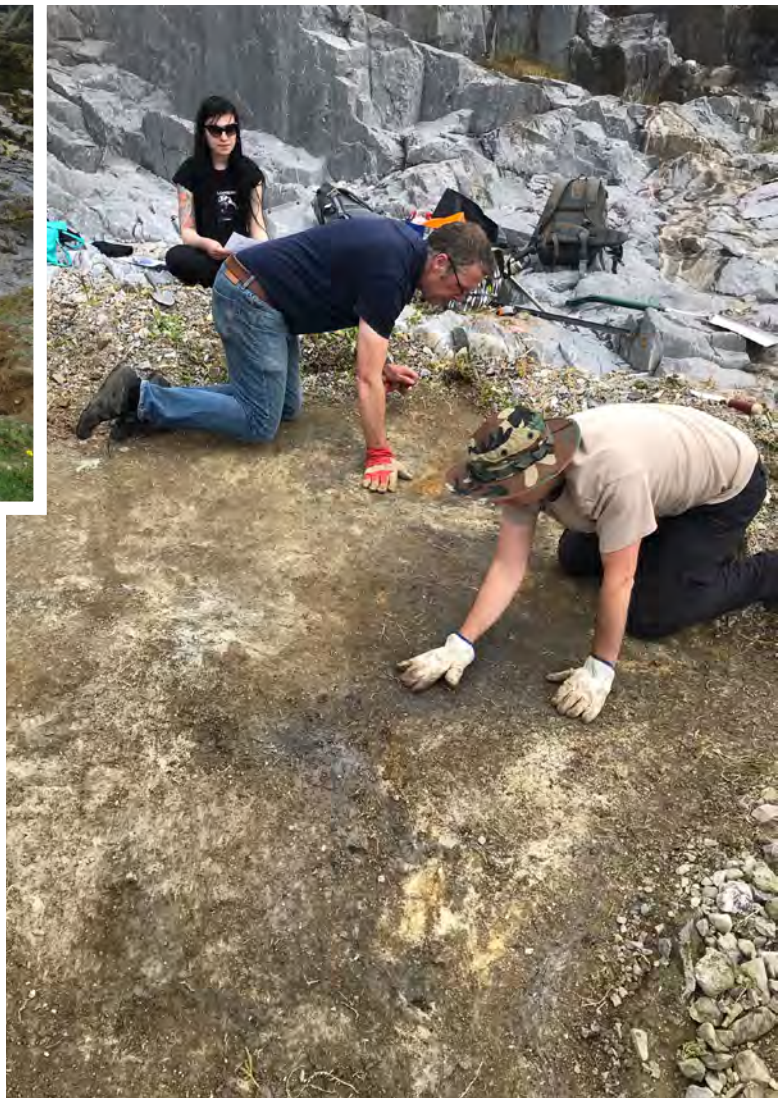
The UK has a remarkably diverse and relatively complete geological record. The entire Phanerozoic timespan is visible in the onshore rock record—until you reach the Miocene… For many this under-represented epoch is just one part of the Cenozoic, but its recent inclusion in the IPCC 6th Assessment Report *Climate Change 2021* as "an interval of interest" (the polite equivalent of a palaeoclimate wanted poster) has elevated its research importance in the eyes of palaeoclimatologists. Unfortunately, Miocene strata are scarce in the British Isles, a small outlier and karstic fills provide the only touchable outcrop. One of these karstic fills is found in a small bay on the north coast of Anglesey and this might provide palaeoclimate data from the warmest (and wettest) interval of the Miocene.

At just over 50 metres wide, you could be forgiven for wandering past Trwyn y Parc—a small headland on a remarkably pretty stretch of coastline to the north of Cemaes. Take the coastal path north and east from Cemaes and the decommissioned Wylfa nuclear power plant looms over the water, whilst ahead lie picturesque Porth Padrig and Llanbadrig. As the National Trust gate closes behind you and you descend the steep slope into the long-disused Gadlys Quarry, the remains of a limekiln, last lit during the Victorian era, stands as the gatehouse to this remarkable piece of geoheritage.

The wave-washed rock platform at Trwyn y Parc, just north of Cemaes on the north coast of Anglesey, provides a rare opportunity in the UK to study on-land Miocene deposits. Photo by Raymond Roberts, NRW

Geologically speaking, the site is a fascinating combination of factors that you would scarcely fathom could come together. The dominant geology is an 860 – 800 million-year-old Precambrian limestone which is faulted, partially dolomitised and in places really showing its age. Despite being the main geology of the old quarry walls and foreshore, the carbonate mass is itself a megaclast in the Gwna Group mélange. At roughly 100 x 100 x 250 metres, it is certainly too big to be classified by a Wentworth card! This carbonate clast has undergone karstification and within these hollows younger unconsolidated breccias and clays have been deposited and then truncated and overlain by Quaternary sediments. The palaeokarst comprises 15 'pipes'—mostly vertical, but with some interlinking horizontal connections. All the pipes have been modified by historic quarrying for agricultural lime and most have surrendered their sediment fill to the Irish Sea. It is the highly weathered unconsolidated pre-Quaternary fill that brings us back to our palaeoclimate "interval of interest".

Some of the clay from conjoined pipe 11/12 has previously yielded a fossil pollen assemblage that was originally broadly dated to the Miocene. We have more recently refined this dating to the Middle Miocene, probably the Langhian. The Langhian (15.97–13.65 Ma) was a period of substantially warmer and wetter climates, when compared to today. Global temperatures were 4–6 °C warmer than the pre-industrial average and we reconstructed the mean annual temperature as 17.2–18.1 °C (the modern mean annual temperature is 10 °C). This warmer climate is associated with atmospheric CO_2 concentrations comparable to 2020–2050 projections. The fossil pollen has also enabled us to



Top: The karstic solution pipes were first studied by Morawiecka *et al*. (1996). Their conjoined pipes, numbers 11/12, are seen here exposed in plan section on the foreshore. These have yielded the palynomorph assemblage reported by Walsh *et al.* (1996) and revisited by Pound and McCoy (2021). Photo by Raymond Roberts

Right: Removal of beach shingle reveals the surface of the Miocene sediments, which are near-vertically bedded. Samples collected will be processed for plant, diatom and siliceous microfossils. Sedimentological investigation will include grain size, XRF/XRD and SEM analysis. An outline of the trench dug by Morawiecka *et al*. (1996) can be identified as the dark patch underneath the right hand of the hatted figure. Photo by Martha Gibson

reconstruct the Middle Miocene rainfall regime, 1217–1356 mm is nearly 150% of the present-day rainfall (836 mm). The data indicate a warmer and wetter landscape than Anglesey today.

If we already know it was warmer and wetter, then why did we decide to revisit the site? Sadly, the original pollen slides were unlocatable and taxonomy of fossil pollen has moved on since the mid-1990s, when the original work was published. This necessitates getting new samples, applying improved processing techniques and both light and scanning electron microscopy to get the best identifications possible on the fossil pollen. Simply, our palaeoclimate reconstructions are only as good as the identification of the fossils we are using. This desire to improve our understanding of UK palaeoclimates, including the record preserved at Trwyn y Parc, will be the focus of Jessica McCoy's NERC ONEPlanet PhD at Northumbria University.

Pipe 13 of Morawiecka *et al*. (1996) is exposed in cross-section on the seaward and southern margin of the old quarry and gives an indication of the considerable scale of some of the karstic hollows. The main target for the current project was sampling the organic seams recognised by Morawiecka *et al*., who only identified fragmentary remains of palynomorphs. It is hoped that modern laboratory techniques will avoid the acid digestion problem that may have affected earlier work, allowing complete specimens to be identified. Photo by Matthew Pound

Our understanding of how terrestrial ecosystems, including the terrestrial carbon cycle, on the Atlantic margin of Europe responded to climate changes during the late Oligocene to Middle Miocene is limited. In this PhD Jess will produce multi-proxy datasets (palynology, diatoms, organic geochemistry) from late Oligocene to Middle Miocene fossiliferous deposits of the British Isles. The late Oligocene appears especially paradoxical: recent work from North Atlantic cores shows increasing ocean temperatures, but corresponding CO_2 reconstructions show decreasing atmospheric concentrations towards the Oligocene–Miocene boundary glaciation. Is this a regional warming in response to a palaeo-Gulf Stream, or perhaps some other mechanism?

The other great benefit of taking new samples and using improved processing techniques, is the possibility of recovering microscopic fungal remains. Understanding how ecosystems will adapt due to climate change involves modelling future scenarios and making inferences from long-term datasets. Palaeoclimate research, specifically from the Cenozoic, provides an invaluable source of long-term data that can be used to understand future climate change. Unfortunately, there is no long-term and large-scale information on how fungi have responded to past climate change, and this prevents us understanding how fungal ecosystems in different regions will change in the future.

Modern ecological data suggest fungal diversity should decrease with increasing temperatures, yet fungal biodiversity is highest in warm biomes. This conflicting information could be

Following the removal of shingle and loose material covering conjoined pipes 11/12, non-intrusive passive seismic data were collected to determine the structure of the infill without unduly disturbing a finite deposit. Photo by Raymond Roberts

due to unforeseen long-term changes that are impossible to investigate on human timescales. The presence of fossil fungi in sedimentary sequences provides a reliable proxy for investigating how fungi respond to warmer global temperatures. No existing works examine fungal ecosystem services or biodiversity in the Neogene. Without an in-depth understanding of past fungal community structure, function, and interactions in warmer-than-present conditions, it is impossible to predict future changes. To fill this knowledge gap FiaWW (Fungi in a Warmer World), a NSF-NERC joint-funded project that brings together a research team from Northumbria University, Morehead State University, Louisiana State University and CONICET in Argentina, will provide the first global view of fungal biodiversity and ecosystem services during an interval of geological time that is in line with future warming scenarios.

Wider geomorphological implications and Earth heritage conservation

The preservation of the fossiliferous Miocene deposits at Trwyn y Parc is something of a miracle. The Miocene pipe deposits appear to represent the remnants of a once much more extensive weathered land surface or saprolite—a deposit of clay and disintegrated rock fragments formed by the weathering and 'rotting' of rock *in situ*. At Trwyn y Parc, saprolites and palaeosols have been selectively preserved because karstic solution over a lengthy timescale allowed them to sag and subside into a series of deep 'pockets' or 'pipes' that were developing in the underlying Precambrian limestone—itself a fortuitous host in the form of a carbonate megaclast, part of the lithologically varied Gwna Group mélange! These tiny pockets or outliers of Miocene deposits have an importance out of all proportion to their size. In geomorphological terms, they show that the shape and form of Anglesey's landmass were well established by the end of the Miocene and this has major implications for understanding the wider geomorphological evolution of the British Isles. The deposits also give a tantalising glimpse of the vegetation that cloaked the landscape and of the prevailing climate; providing rare and important palaeoenvironmental data that will be supplemented and elaborated by the ongoing studies. The fact that these fragile unconsolidated sediments were not obliterated by the erosive effects of various Pleistocene glaciations, including the well-documented Irish Sea ice sheet that moved onshore here during the Last Glacial Maximum, is also remarkable; certainly at this time the vast bulk of the Anglesey land surface was scoured of its pre-existing unconsolidated cover which was reworked and deposited elsewhere.

In recognition of their rarity and importance, the fossiliferous Miocene karstic pipe-fills at Trwyn y Parc were registered as a Regionally Important Geodiversity Site (RIGS 152) in 2005 as part of a sub-network of Anglesey RIGS providing evidence for long-term landscape evolution. Since that time, the site has been regularly used for teaching and field visits by Anglesey's UNESCO Geopark, GeoMôn, and renewed and ongoing interest in the site for globally significant palaeoclimate research suggests that Trwyn y Parc warrants enhanced geoconservation status as a Geological Conservation Review (GCR) site. The site lies within Llanbadrig-Dinas Gynfor SSSI (notified for its Precambrian of Wales GCR site) and overlaps with Gadlys Quarry RIGS (Precambrian stromatolite fossils). It lies within Anglesey's AONB and Heritage Coast. The adjacent limekiln is of historical value.

Acknowledgements

Matthew, Jessica and Martha are grateful to the National Trust for giving permission to access the site and collect samples. Mr L. Farrow is thanked for facilitating vehicular access.

Further reading

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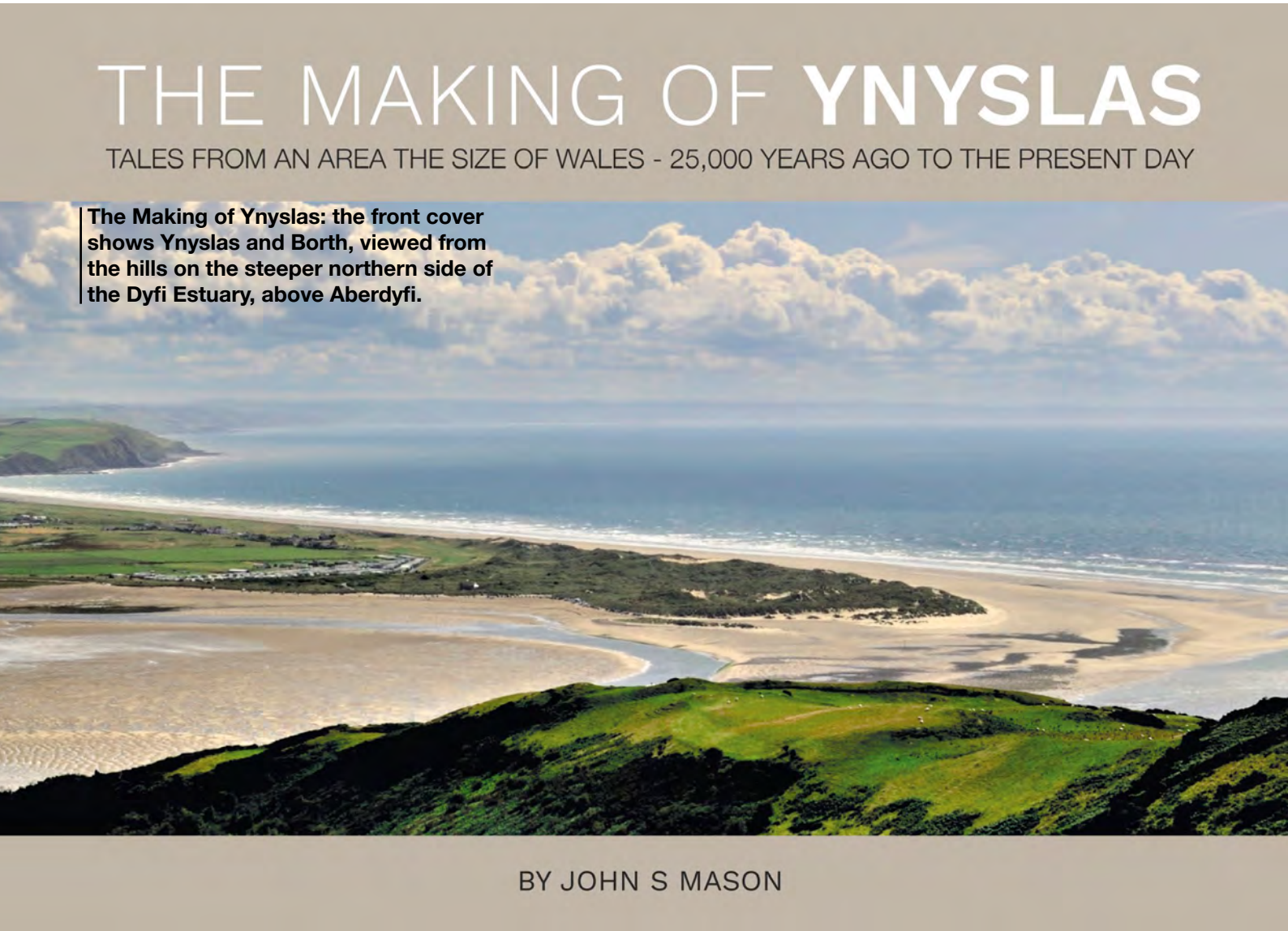
The *Making of Ynyslas*: extolling the virtues of geodiversity with creative writing

John Mason, Geological Consultant

The *Making of Ynyslas* is a new booklet written by experienced geologist and weather watcher, Dr John Mason. Here, John shares his personal experiences of the project which was undertaken during the COVID pandemic. He highlights the value of presenting hard geological facts in a digestible and enjoyable form for a non-specialist audience.

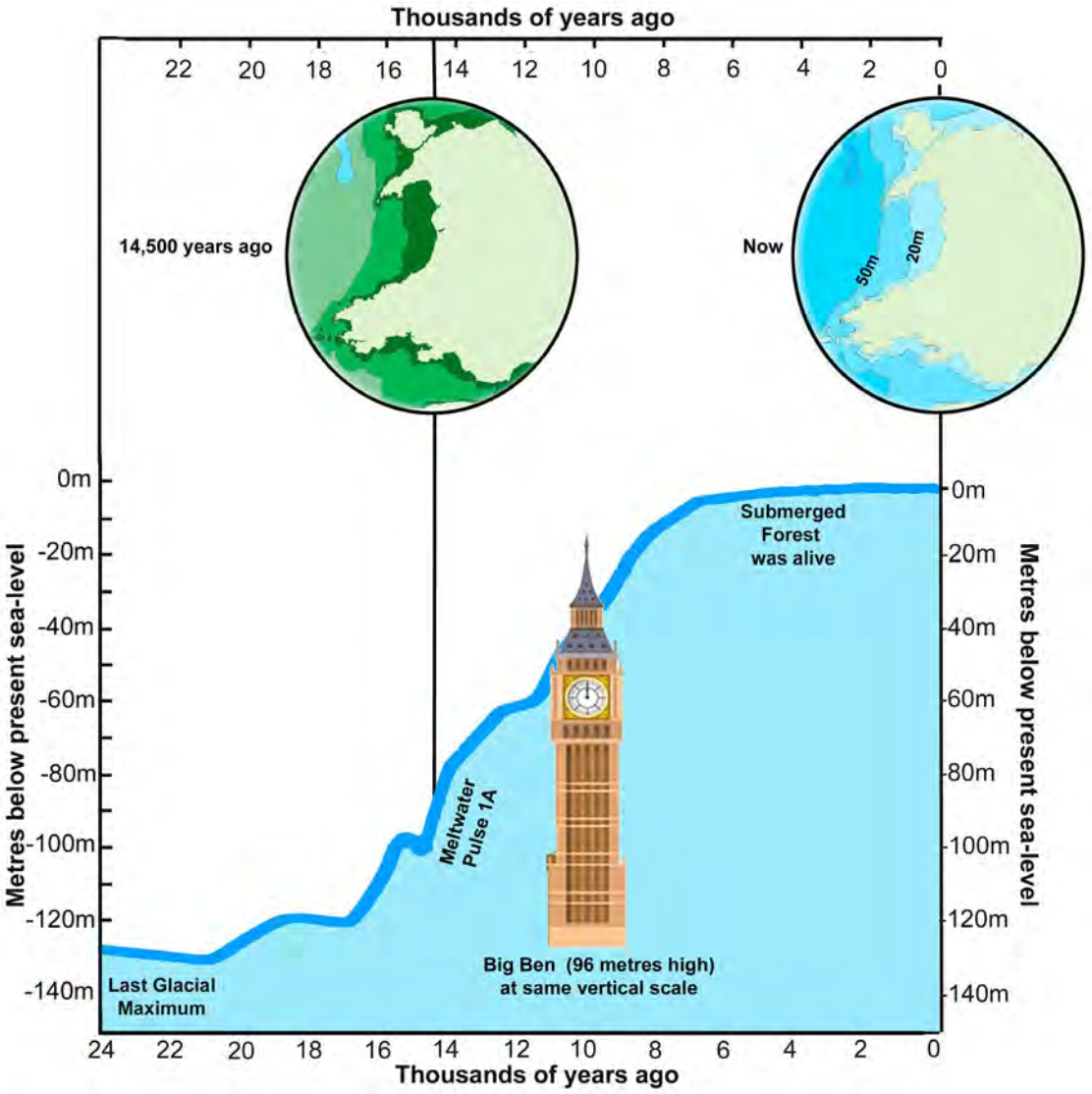
Rocks, whether hard and craggy or soft and squishy, have many tales to tell those who understand their sometimes-cryptic features. There is, of course, a continuum between these extremes, yet many geologists seem to fall into one camp or another: hard rock or soft rock. In this project, I certainly had to jump camps. In late summer 2018 I went to work for Natural Resources Wales, joining the team of seasonal managers who run the Visitor Centre at Ynyslas, a National Nature Reserve on the Cardigan Bay coast. This extensive site consists of a shallow-gradient, sandy surf beach, backed locally by a steep shingle storm ridge. The beach is famous for its ancient tree stumps that are intermittently exposed at low tide. Beyond the shingle, to the north and north-east, is a broad tract of sand dunes, home to specialised flora and fauna, and the Dyfi Estuary, with its vast expanses of intertidal mudflats, creeks and salt marsh. Inland, to the east of Ynyslas beach, lies the impressive



The Making of Ynyslas: the front cover shows Ynyslas and Borth, viewed from the hills on the steeper northern side of the Dyfi Estuary, above Aberdyfi.

Holocene peatland of Borth Bog. Managing this vast complex of geodiversity and biodiversity and accommodating the highly varied demands of the 250,000 people who visit in a typical year, are challenging tasks that can require quick and decisive thinking, for incidents can and do happen.

As I went about my daily duties, a realisation dawned upon me: the place's tale had not been fully told. Here was a wonderful narrative of place and time, with heaps of well-established geological evidence wherever you looked, ripe for the telling. Thus, early the following year, I put aside the recrystallised quartz-sulphide lodes and altered igneous rocks that are my normal geological fodder, to research and write *The Making of Ynyslas*. Without the geological and geomorphological changes of the last 25,000 years, the place would simply not exist. Ynyslas is a direct product of deglaciation (the melting of ice sheets) and the accompanying change in eustatic (global) sea levels. Isostatic rebound is less evident here than in other parts of the UK, for Mid-Wales sits approximately on the fulcrum between uplift to the north and subsidence to the south. It is all about sea-level rise, itself an increasingly important topic in modern times. Here was an opportunity to explain how things panned out in the millennia following the Last Glacial Maximum (LGM) as, around the world, glaciers retreated and, on occasion, vast ice sheets collapsed. Here was a rare chance to turn Meltwater Pulse 1a (an unusually sharp rise in post-glacial sea level) into a household term. This was also a moment in which it would be possible to show precisely how Earth Science works. Evidence for the dramatic changes from the Wales of the LGM to the present day comes from diverse sources; from the nature of the drift (boulder clay and meltwater sediments with their characteristic clast assemblages) deposited by the Welsh and Irish Sea ice sheets exposed at various localities along the coast, to the core logs from the numerous offshore boreholes investigated in Cardigan Bay. Thus, we can surmise that the Irish Sea ice sheet, that at the LGM stretched down from western Scotland to



A timeline of meltdown: the most up-to-date reconstruction of how sea levels rose following the LGM, with Big Ben inserted into the vertical scale to show graphically the magnitude of the process. If all the ice in the world melted in the coming centuries (a real risk), the waters would only come just over halfway up that building.

All photos by John Mason

Scattered remnants of the submerged forest at Borth-Ynyslas are sometimes visible at low tide and especially after the scouring effects of winter storms and spring tides. The remains include numerous stumps, trunks and branches (mostly of pine and oak, but with some remains of alder and birch), as well as associated peat and clay. These submerged forest beds are known to extend inland where they underlie much of Borth Bog.

beyond the Isles of Scilly, beat a hasty retreat, leaving in its place a vast expanse of bouldery rubble, gravel, sand and clay. Over time, vegetation colonised this ecological blank canvas and soils began to form. Trees followed and it seems likely that what is now Cardigan Bay became a fertile lowland plain, across which sluggish rivers flowed out to the coastline, at that time situated around 100 km to the south-west.

Cardigan Bay is shallow: large parts of it are less than thirty metres deep and the fifty-metre submarine contour lies a long way offshore. Most of the 120-metre sea-level rise that accompanied deglaciation took place over some 12,000 years, beginning around 20,000 years ago, so that for around 10,000 years, much of Cardigan Bay remained land: even Meltwater Pulse 1a (between about 14,700 and 13,500 years ago) had no effect here. The peatlands of Borth Bog and the submerged forest now seen on the beach between Borth and Ynyslas record just the last gasp of this whole overall process.

Such fundamental changes are hard to imagine, which is where creative writing comes to the fore, in bringing them to life. How I work on such books is firstly to read and digest the peer-reviewed literature on a topic, talk to researchers if necessary, get the facts established and then translate that mountain of information into non-scientific English. The importance of that first step cannot be underestimated and it is necessarily time-consuming. Following the paper trail, searching with Google Scholar, tracking down citations, contacting corresponding authors, reading publication after publication and responses to them, in due course help to identify the areas of relative certainty and controversy.

The extensive forest at Ynyslas and Borth was eventually overwhelmed by a developing peat bog – the result of a rising water table. Remnants of the lower peat layers can still be seen alongside tree remains on the beach between Ynyslas and Borth. Miraculously, the hardened peat surface has preserved locally the footprints of humans and animals—including these prints of a hoofed animal.

The Dyfi Estuary, seen looking north-east from the dunes at Ynyslas.

Once a factual framework is in place, the writing, which is the fun bit, can begin, after which come the stages of layout and editing. I worked with an excellent graphic designer, Sara Holloway, who turned diverse scientific diagrams into eye-catching illustrations, while my sister, Fiona Mason, whose demanding occupation is writing grant applications for clients in the Arts, tightened up the manuscript during the final editing, when we could see how the thing looked. Never be fooled into thinking you can be a one-man band with such publications: they are invariably best done as a team effort.

Creative writers with a science background perform an essential task because they bridge the gap between the peer-reviewed literature and the general public, something that is so important today in a world full of potential misinformation. We have seen this with the COVID crisis and we likewise see it with climate change; in both cases, hard science is accessible to those who are equipped with the key skills to interpret it, but to those who are not, their lives having taken another path, there is always the risk of falling victim to misinformation. With the widespread use of social media, it can sometimes be difficult to distinguish fake news from fact. This is where we come in, presenting hard evidence for things that indeed happened and providing references for those who want to explore topics in more detail, whilst producing something that is readable and enjoyable. After all, everyone likes a good story, even when it is all rooted in fact. *The Making of Ynyslas* was a thoroughly enjoyable project and learning about marketing from scratch was an interesting challenge. Although the pandemic adversely affected sales, the best outlets are slowly reopening now and orders have picked up. In the meantime, lockdown gave me the opportunity to undertake a much bigger project, dealing with that huge span of geological time beginning with the formation of our Solar System and ending with the oldest rocks exposed here in Wales.

Further Information

www.geologywales.co.uk

The Making of Ynyslas is available to buy online - https://www.anglebooks.com/the-making-of-ynyslas-tales-from-an-area-the-size-of-wales-25-000-years-ago-to-the-present-day-by-john-s-mason-98911.html

Deep Time in Sculpture

Annie Cattrell, multidisciplinary visual artist

I have always engaged in immersive experiences that cannot be 'switched off', which are in essence 360 degrees, such as climbing mountains or watching brain surgery. It is the phenomenological observations I can make while in these situations of the place, space, sounds, textures, smells etc. that influence decision-making later in my studio. Often in the countryside or in specific environments, I find this can amplify my awareness and expand and transform sensation into ideas, thought and artworks.

One example of this approach was when I was on Orkney in 2010, undertaking a Royal Scottish Academy residency hosted by the Pier Art Centre. Daily, I was able to observe, film and draw the tidal and wave energy of the surrounding sea, particularly the Pentland Firth that separates the north of mainland Scotland and Orkney. I observed deep time, as visible in the coastal geology at the precipitous Yesnaby cliffs, and then discussed renewable energy developments and challenges with research scientists at the Heriot Watt University at their campus in Stromness. This process of conjoining a theoretical understanding of the surrounds with site visits to observe time made for thought-provoking combinations, both then and now.

Earlier influences have been many, but one stands out from when I was child watching the Royal Institution of Great Britain's annual Christmas Lectures, then broadcast on BBC1 in the 1970s. The programmes made scientific research, ideas and theories accessible and clear to absorb and helped

View detailing the sculpture ECHO *in situ*, completed in August 2007, as part of the Forest of Dean Sculpture Trail. State-of-the-art digital lidar scanning technologies were employed, and proved critical during the concept stage capturing details of the crumbling rock face, in an old quarry setting, and its interface with the soil and vegetation of the forest floor. ECHO was then made by casting these rock faces, soil and tree roots using silicone rubber and finally cast in aluminium powder and resin . © Annie Cattrell

understanding. The beautiful bespoke sculptural models and apparatus were one of the highlights; often appearing magical, transformative and defying reason. It fuelled and nurtured my imagination, making anything seem possible and bringing science to life.

So in 2002 it was a privilege for me to be the first Artist in Residence at the Royal Institution supported by the Leverhulme Trust. This opportunity meant I could meet with researchers, staff and members, and spend time in the extensive archives seeing original texts and books such as Faraday's hand-written and illustrated laboratory notebooks.

Books of all types have had considerable influence on me, such as *The Living Mountain* by Nan Shepherd, in which her poetic prose shares a thoughtful and highly perceptive understanding of the Cairngorm Mountains as interconnected organisms of rivers, rocks and trees.

I would describe myself as a multidisciplinary visual artist. My focus is informed by acts of paying attention, noticing, contemplating and watching. At times it seems almost forensic. I am drawn to discrepancies and inaccuracies, seeing if and when structures, patterns or meanings can emerge. Part of this process involves observing subtle topographical changes in the landscape, or atmospheric fluctuations and weather conditions or, more intimately, inside the human body and brain.

This 'noticing' is partly aimed at capturing the fleeting and what is not obviously visible; highlighting the almost imperceptible changes, flux and transformations that are ceaselessly occurring inside the human body and in the natural world. This sculptural arresting or pause is designed to allow for in-depth scrutiny and reflection to occur.

Casting Loch Ness! Annie pulling the silicone mould from the rocks at Loch Ness in the summer of 2017. Once in her London studio the moulds, taken from the different rock structures on each side of the Great Glen Fault, were used to cast the final piece in resin and brass/bronze powders. © Annie Cattrell

I constantly draw; take photographs and film as a way of recording and thinking aloud and making visual notes. Sometimes, I cast the landscape directly on-site and gather relevant information and collect sample materials that help to formulate and trigger ideas later in the studio environment in London. There, I cast, assemble, fuse, weld and etch using techniques in bronze, glass, wood and many other appropriate materials. This brings the ideas into form and structure. New digital approaches have led me to explore and use state-of-the-art technologies, for example topographical lidar laser scanning allowing the gathering of virtual data, similar to the 'casting' process, to assist in the production of permanent sculptural commissions.

My focus also involves cross-disciplinary discussions with specialists and is informed by dialogues between the empirical, phenomenological and theoretical. To this end, I have undertaken a number of fellowships, residencies and public art commissions, working with historians, in museum archives, researchers and different communities. These have included working recently at Cambridge

Annie with SEER on the day it was installed on the banks of the River Ness, at Friar's Shott, Inverness in November 2018. The title SEER is derived from the Brahan Seer, known in his native Scottish Gaelic as Coinneach Odhar, a predictor of the future, who made a number of predictions about the River Ness. © Annie Cattrell

University, where I was Lead Artist for their building development at the New Museums Site between 2014 and 2019. There, I have completed a large-scale two-part commission at the Old Cavendish called Remains to be Seen (I & II). It was conceived after viewing C.T.R. Wilson's Cloud Chamber, an apparatus that he was inspired to make after his observations of condensation trails while working at the Ben Nevis Observatory. The Cloud Chamber was the first apparatus to show subatomic particle movement.

Aligned to this aspect of my practise of making public art, I have made further sculptures that relate directly to geology and James Hutton's observations of geological time. For example, I have cast rock surfaces in the Forest of Dean; on either side of Loch Ness and at Siccar Point in the Scottish Borders. These casts have then been used to form Echo (2008), Fault (2018), SEER (2018) and more recently COMPASS in 2021. (FAULT is the first iteration of SEER). The casts are taken directly from specific geological locations. Echo from a quarry of Pennant Sandstone, in the Forest of Dean, which was formed towards the end of the Carboniferous Period about 310,000,000 years ago when the area was part of the Supercontinent of Pangaea situated near the Equator. This deep geological time is physically evident, in the cast, in the layered rigid structures of the rock and impermanence of the trees, pine needles and earth. FAULT and SEER were cast from either side of Loch Ness the ice-eroded trench marking the line of the Great Glen Fault that separates the geologically distinct areas of the Grampian Mountains and Northern Highlands.

James Hutton (1726–1797), the 'father of modern geology', wrote the *Theory of the Earth* (published in 1788) that proposed the idea of a rock cycle in which weathered rocks form new sediments and that granites were of volcanic origin. At Glen Tilt, in the Cairngorm Mountains, he found granite intruded into metamorphic schist; demonstrating that granite was formed from the cooling of molten

rock. As a result of his many geological observations regarding geological timescales Hutton famously remarked:

"that we find no vestige of a beginning, no prospect of an end."

In the spring of 2021, I participated in *Landmark* a Sky Arts competition that was televised this autumn on Channel 11 Freeview. For *Landmark* I made a large-scale sculpture called Compass that draws inspiration from Scottish geology and James Hutton's *Theory of the Earth*, specifically the unconformity at Siccar Point in the Scottish Borders. COMPASS includes some casts I made of significant parts of the rock outcrop there made famous by this pioneering geologist. Sky Arts filmed a discussion on-site between Dr Angus Miller and myself that informed part of the episode of *Landmark* broadcast on 11.10.2021. Please see my Instagram account anniecattrell for further images and information about this project. COMPASS is now installed at the Hutton Institute in Aberdeen from October 2021 until July 2022 and can be viewed by appointment. (please see press release below for more information)

Additionally I am planning for, and working towards, a Royal Scottish Academy residency at An Lanntair, the multi-arts venue, in Stornoway in the Outer Hebrides in spring 2022. There it is my aim to 'map' the interconnected geological and cultural qualities of where land and water meet on Lewis; in particular, finding ways of gathering on-site data (through walking, filming, direct casting etc.) and first-hand information (through archive research and discussions with local people and academic specialists). It is where land and water meet and how these sites have evolved through deep time that interest me most. The currently visible geology and landscape allow for certain readings of time that have not been so overexposed to human intervention i.e. the Anthropocene. Geology can be read as a physical manifestation of how to read time and significant cosmological events. Water through its behaviour and gravitational flow, epitomises and acts as a metaphor for the course of time.

I will be having an associated solo exhibition at An Lanntair in Stornoway called SOURCE, which will include existing work such as FAULT and new work made on Lewis during the RSA residency. The Private View is on Saturday 23rd of April 2022 and will be open for 4–5 weeks.

Further information and contact details

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An Lanntair RSA Residency 2020-21

https://islandgoingresidencies.art.blog/2020/10/28/annie-cattrell-rsa-artist-in-residence-2020/

Transformation Q&A with Richard Bright for Interalia Magazine

https://www.interaliamag.org/interviews/annie-cattrell/

UCLH commission

https://www.ucl.ac.uk/brain-sciences/news/2020/mar/artist-appointed-ucls-new-neuroscience-facility-grays-inn-road

https://www.ucl.ac.uk/drupal/site_ion-dri-programme/public-art-grays-inn-road/annie-cattrell

https://sculptors.org.uk/artists/annie-cattrell

PRESS RELEASE

Extracts from THE JAMES HUTTON INSTITUTE News Release, 12 October 2021

Scottish Landmark artwork on display at James Hutton Institute

Until July 2022, the James Hutton Institute's Aberdeen site will host *COMPASS*, a sculpture by Scottish artist Annie Cattrell that draws inspiration from Scottish geology and James Hutton's Theory of the Earth, specifically Siccar Point's Unconformity.

COMPASS won the Scottish heat of Sky Arts' *Landmark* series, which sees artists from Glasgow to Guildford create a new wave of Great British public art. Six heats have taken place across the UK, each spotlighting three artists competing to create local landmarks for their home region or country.

Annie Cattrell was born in Glasgow and studied Fine Art at Glasgow School of Art, University of Ulster and the Royal College of Art. She is an interdisciplinary artist, and her practice is often informed by working with specialists in science and at geologic locations.

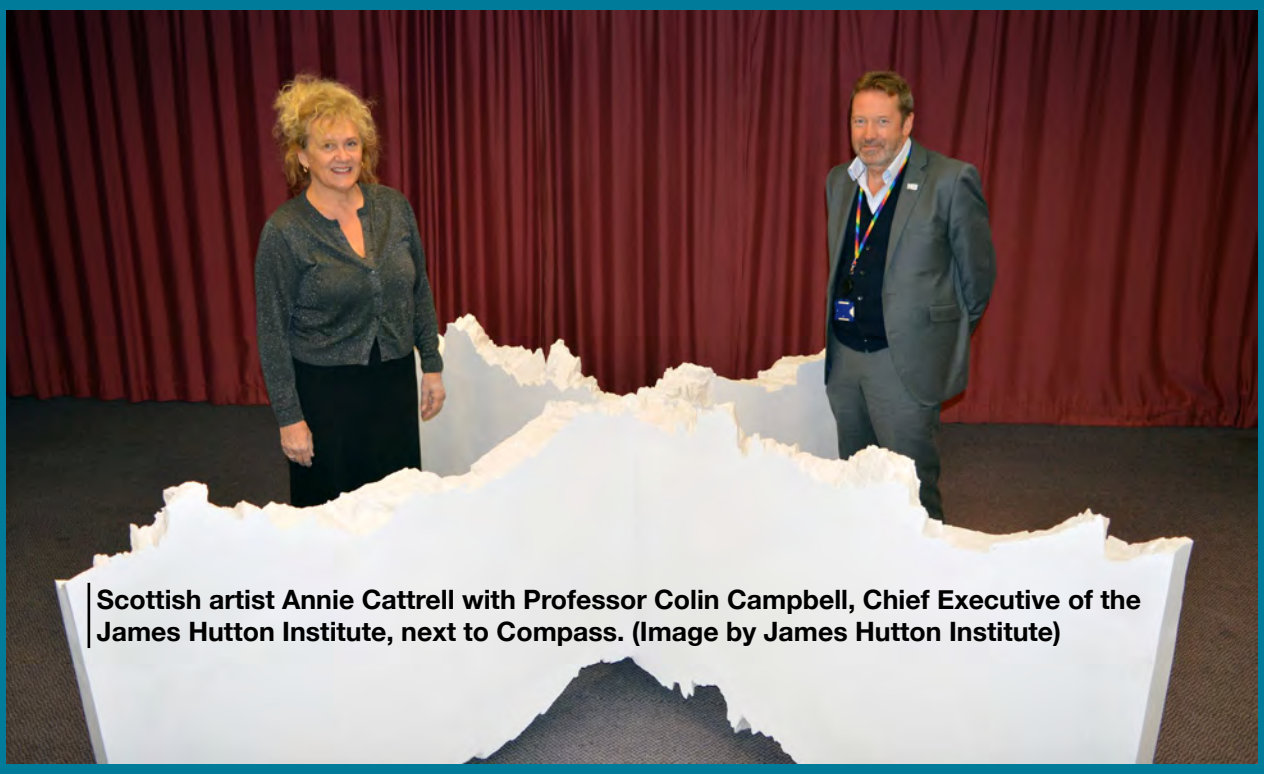
About *COMPASS*, Annie says: "I would like to continue the ideas that I started near Inverness with the sculptures FAULT and SEER, both of which were cast directly from the geology at either side of Loch Ness. Each side of the loch are distinct land regions, called the Northwest Highlands and Grampian Mountains, that were formed from two tectonic plates converging and forming what has become Loch Ness.

"*COMPASS* references the tectonic movement and specific locations using a cross axis/map co-ordinates and profile of the land near Loch Ness or in London. It also addresses the relationship that humans have, in terms of how measurement relates to location. Also, how we understand geological deep time and are affected by the landscape and location of where we live."

Professor Colin Campbell, Chief Executive of the James Hutton Institute, commented: "We are delighted to host *COMPASS.* The work of our scientists also reflects exchanges between places and timescales that go beyond the human lifespan. Our land, soils and associated crops and biodiversity are the product of many different factors but with geology and topography at the base and formed over the course of millennia.

"As in Hutton's time during the 18th century Enlightenment period in Edinburgh, art and science can complement each other to mutually inspire and so we are very happy to host this thoughtful and inspiring art work at the James Hutton Institute."

COMPASS can be visited by the public at the Institute's site in Craigiebuckler, AB15 8QH on Wednesdays during business hours. Due to the Institute's COVID protocol, registration is necessary. Please email info@hutton.ac.uk to register.



Scottish artist Annie Cattrell with Professor Colin Campbell, Chief Executive of the James Hutton Institute, next to Compass. (Image by James Hutton Institute)

Northumberland Rock Festival

Angus Lunn, Vice-president, Northumberland Wildlife Trust

2021 marks 50 years since the origin of the Northumberland Wildlife Trust (NWT). To celebrate the occasion, and to recognise that geodiversity, as well as biodiversity, is a focus of conservation, Ian Jackson, a trustee of NWT and retired Operations Director at British Geological Survey, came up with the idea of featuring 50 geosites within the county. For each site there is a brief downloadable account (the *Gelt Linn* and *Butt Hill* channel example is shown) and each month there is a fossil of the month (an example is *Philiderpeton*) and a rock of the month, as well as a selection of trail guides and short YouTube videos. The Rock Festival is for Trust members and for the wider public, and descriptions have been deliberately written to engage non-geologists. It runs until March 2022.

Northumberland's geology includes sedimentary strata from Silurian to Permian, as well as granites, other igneous intrusive and volcanic rocks. The intrusives include the Whin Sill, the archetypical sill of geological science, and an outcrop was, of course, chosen by the Emperor Hadrian for Rome's imperial frontier. Barons and monarchs later placed castles on other outcrops of the Sill.

Much of the county is underlain by Carboniferous rocks, including part of the famous Northumberland and Durham coalfield in the county's south-east—a reason why Newcastle upon Tyne was one of the most prosperous cities in Britain during the Industrial Revolution and its aftermath. In the North Pennines (Alston Block), which Northumberland shares with Durham and Cumbria, lead and zinc ores added to local wealth. Thirteen of the sites

Above: Gelt Linn and Butt Hill channel leaflet © Northumberland Wildlife Trust

Right: Model of *Philiderpeton*.

All photos by Ian Jackson unless otherwise stated

Top left: **Overfold in Eelwell Limestone at Saltpan Rocks, south of Berwick-on-Tweed.**

Inset: Gigantoproductus **in Fourlaws Limestone at old Green Carts quarry.**

Bottom left: **Permo-Carboniferous whin dyke on foreshore just south of Cullernose Point.**

To access the Rock Festival sites and trails visit www.nwt.org.uk/rock-festival-sites

All eleven virtual rock trail videos are now live and on a playlist at: https://www.youtube.com/playlist?list=PLjwznYV1Sm0iNMnh0702TDoLbQCMn0Y_2

are included because of their mining and heritage connections, including the building stones of the City of Newcastle upon Tyne, and St James' Park, home of Newcastle United, which overlies thick coal seams.

The connections between rocks, landscape and wildlife are signalled. North of the Tyne Gap the sequence of gently dipping limestones, mudstones, siltstones, and sandstones has produced a classic cuesta landscape, especially notable in the west of the county. Horizontal strata south of the Tyne Gap in the North Pennines exhibit rather a plateau–benchland-dale landscape.

The widespread Quaternary deposits and landforms range from a giant erratic raft, Down Hill, which caused Hadrian's engineers to divert the Vallum (the earthwork just south of the Wall), to striae on outcropping sandstones and limestones. Holocene peat is another important sediment, and by coincidence 2021 also marks 50 years since Northumberland Wildlife Trust began restoring damaged peat bogs in the Kielder Forest. This initiative, in partnership with Forest Enterprise and others, has led to the restoration of an entire peatland ecosystem, the Border Mires.

Celebrating the 25th Anniversary of Herefordshire and Worcestershire Earth Heritage Trust

Moira Jenkins, Herefordshire and Worcestershire Earth Heritage Trust

Herefordshire and Worcestershire Earth Heritage Trust (EHT) has been celebrating its 25th anniversary this year by organising a series of walks over the summer and all of these have visited areas covered by geoconservation and public awareness programmes carried out over the years. These guided walks were arranged to take people to areas described in trail guides or on apps developed in more recent EHT projects. They have been well attended and enjoyable. The two counties have a wide variety of interesting geology, structure, glacial features and geomorphology, which we hope that the photos below will encourage you to visit.

The first of the series of walks was in the Ross-on-Wye area immediately following the virtual 2021 AGM of the EHT. Wilton Bluff cliff, designated a geological SSSI, is composed of the Lower Devonian Brownstones Formation showing cross-bedding and former river channels. These fluvial features formed in sediments laid down by seasonal streams crossing an arid landscape and are also seen in the building stones of the town, as described in the EHT Ross-on-Wye trail guide. This is one of a series of 16 geology and landscape trail guides produced by the EHT.

***Above*: The first summer walk celebrating Herefordshire & Worcestershire Earth Heritage Trust's 25th anniversary visited Wilton Bluff SSSI at Ross-on-Wye. Photo by Kay Hughes**

***Right*: A building stones walk visited St Peter's Church, Bromyard, which has a beautiful Norman arched doorway carved in Old Red Sandstone. Photo by Julie Schroder**

There are also 14 building stones trails, four of which were produced as part of our mainly Lottery-funded project *1000 Years of Building with Stone* (2013– 2017). The walks this summer looked at Bromyard, Ledbury, Hereford and Worcester. For example, Kate Andrew, who managed the building stones project, described the building stones of St Peter's Church in Bromyard. The beautiful carving in Old Red Sandstone from the Bringsty area is seen around the Norman arched doorway.

There were walks in the Lickey Hills and on Little and Great Doward. These are two of the areas with volunteers acting as 'Champions', continuing the work of the *Community Earth Heritage Champions* project (also Lottery-funded, 2008– 2011) which encouraged local people to find out more about the geological sites in their area and to look after them, organising events to increase public awareness. Lickey Hills is in an area with complicated geological structure. Julie Schroder showed a recently cleared site on the top of Bilberry Hill, where the Silurian Rubery Formation has an irregular junction with the underlying Ordovician Lickey Quartzite. This area is described in one of the 10 booklets produced for the *Champions* project as well as in the free-to-download app produced for the *Voyages in Deep Time* project (2015– 2018).

Little and Great Doward have outcrops of uppermost Devonian Quartz Conglomerate and Tintern Sandstone, Carboniferous limestones, calcareous tufa and limestone pavements. This area above the Wye Gorge is described in an EHT trail guide and also has a *Champions* booklet and one of the

***Above*: At Bilberry Hill, Lickey, the contact between Silurian and Ordovician rocks can be observed. Photo by John Schroder**

***Left*: King Arthur's Cave, Great Doward. The cave, with its water-smoothed walls, is located high above the deeply incised Wye Gorge and the present-day River Wye. Photo by Moira Jenkins**

Deep Time Voyager apps. The apps are self-guided walks with well-illustrated information about geological history, structure and the deep-time environments in which the rocks were laid down. The walk looked at the rock sequence, King Arthur's Cave and the old lime kilns which have been recently restored as part of the *Overlooking the Wye* heritage Landscape Partnership project in which EHT worked with Wye Valley AONB, English Heritage, the Woodland Trust and other partners. The limestone pavement on Little Doward and other sites in the area had clearance work done as EHT's contribution to the *Wye Valley Partnership,* another multi-party conservation project. Jim Handley led walks this summer for EHT and for Malvern U3A showing walkers King Arthur's Cave, one of a line of caves and water-smoothed cliff line, eroded in the Carboniferous Gully Oolite at a level high above the present River Wye before it was more deeply incised into the landscape and produced today's Wye Gorge.

***Above*: A landscape walk visited the dramatic scenery of Cat's Back and the Olchon Valley (right of picture), at the edge of the Black Mountains. Photo by Moira Jenkins**

***Right*: A walk to observe landscape features formed during the ice age visited Staunton on Wye moraine ridge and Letton Lake area. Photo by Ros Raha**

The walk at the Darens and the Cat's Back, on the edge of the Black Mountains is also described in one of the freely available Voyager apps developed as part of the *Voyages in Deep Time* Project. The Cat's Back ridge is an arête capped by the Devonian Senni Formation overlying a calcrete, the Ffynnon Limestone, with the main Black Mountains ridge further south-east. The Olchen valley between the two was filled with ice in the Pleistocene. There are fine exposures of Devonian rocks with interesting sedimentary features. There is a landslip area at Black Darren and a pronival rampart formed during periglacial conditions in the Pleistocene. Mike Brooks and Dick Bryant described the rocks on the Cat's Back ridge and the glacial history of the Olchon Valley area.

For the current *Ice Age Ponds* project, EHT is working with Herefordshire Amphibians and Reptiles Team and the Herefordshire Wildlife Trust, seeking to record and preserve Pleistocene features such as kettle hole ponds. Some of the walks were linked to this project, including the walks at Staunton on Wye and at Almeley looking at landscape features created during the ice age. At Staunton the visiting group were able to stand on a ridge of glacial moraine and look down at the lowland, where the glacial Lake Letton once existed when the valley of the River Wye was blocked by moraine, causing the river to be diverted to a course further to the south. The former and later courses of the Wye were pointed out to the walkers by Dick Bryant and Moira Jenkins.

There was also a walk in the Swardon area, which is one section described in a journey down the river in our *Frome Valley Discovery Guide*. There were walks in the Malvern Hills area, which also has a *Deep Time* app, looking at the geological succession, landscape and structure, also described in trail guides and the *Geopark Way Guide*. This last EHT book describes the first long-distance footpath devised to look at geological features en route, which is now recognised by the Ordnance Survey. These and many other guides have been printed during the 25 years of projects dealing with geoconservation.

Looking back on the activities since the formation of EHT in 1996, much has been achieved. The first important work was to record geological, glacial and geomorphological sites and compile the information into a database. Regionally Important Geological/ Geomorphological Sites (RIGS), now called Local Geological Sites (LGS), were designated to give them some recognition and protection through the planning system. A geodiversity audit of sites led to the production of Geodiversity Action Plans for both Herefordshire and Worcestershire. Wherever possible site management plans were drawn up to help conserve geodiversity sites and there were projects to monitor their condition. There was also a desire to educate the public about local geology, and amongst other public activities, Rock and Fossil Roadshows for children were held, which were greatly enjoyed. EHT was also a founder member of the Abberley and Malvern Hills Geopark, one of the earliest geoparks in the UK. Funding was obtained for successive projects from the Aggregates Levy Sustainability Fund. This is no longer distributed by the government and is a great loss to geoconservation.

Looking forward to the future, the EHT is working on a new project to find and conserve erratics in the north of Worcestershire and Birmingham areas. The *Ice Age Ponds* project continues with management plans being developed for kettle hole ponds. There is an ongoing annual programme of clearance work at geological sites in the Malvern Hills AONB, which has left them in a wonderfully clear condition suitable for educational visits and field trips. We hope that the next 25 years will be as successful as the first. There is so much exciting geology to explore in Herefordshire and Worcestershire, and a need for more public awareness programmes so that people appreciate their local Earth heritage and support its conservation for future generations.

‘I guess you geoscientists might have a contribution to the climate change debate’*: ‘Net-zero’ for GeoWeek – what was it like?

***Paraphrased comment from a ‘Friend of the Earth’ participant at a GeoWeek ‘Net-zero’ event.**

Chris King, Earth Science Education Forum

Our overarching theme for GeoWeek 2021 was ‘Net-zero by 2050 – what will it mean for our region?’. The plan was to encourage people across the country not only to follow up and expand on the 76 GeoWeek events run in 2019, but also to add some ‘Net-zero’ field trips across the UK. We planned to ask leaders to take members of the public to areas with views and rock exposures, and there to discuss the impact on the local area that the government targets to reduce carbon emissions to ‘net-zero’ by 2050 (2045 in Scotland) might cause. This would provide a useful backdrop to the COP26 climate discussions held in Glasgow in November this year.

To this end, we planned a launch event, where the British Geological Survey’s Director, Karen Hanghøj, would speak, followed by a panel discussion.

We realised that, like many of us, potential field leaders might only have a partial knowledge of what impacts on the local area might be from strategies to mitigate and adapt to climate change. For this reason, we developed a series of information sheets and ‘thinking activities’ to be published on the Earthlearningidea website for teachers, that could also be used by field leaders. The sheets have been prepared and will be published as part of the Earthlearningidea normal two-weekly publication schedule, but meanwhile, they can all be accessed pre-publication at:
https://www.earthlearningidea.com/home/Net_zero.html
They include an introduction; 20 sheets on climate mitigation—from solar farms to ‘blue’ hydrogen and from pumped storage schemes to enhanced weathering; and four sheets on adaptation—from landslide management to agricultural responses: 25 sheets in all. A complete list of these is given at the end of this article.

In the event, the COVID outdoor ‘rule of six’ regulations operating in early May meant that, while we were able to run the launch event virtually through Zoom, we were not able to advertise any national ‘in person’ events through the GeoWeek website at: https://earth-science.org.uk/geoweek/ since such national advertising might encourage more than five people to join a field leader, so breaking the COVID regulations. Instead, we encouraged groups across the country to add to the GeoWeek map examples of their self-guided geological walks (that people could try during COVID). We also planned a few locally advertised ‘in person’ ‘Net-zero’ events that we added to the GeoWeek map retrospectively.

We describe some of these experiences below, in the hope that you will become interested and inspired, and be keen to join us to lead 'Net-zero' and a range of other GeoWeek events in May 2022. GeoWeek 2022 will run for the nine days of 7th – 15th May with the launch event on the evening of Thursday 5th May 2022.

The 'Net-zero' experience of Elizabeth Devon at Berwick-upon-Tweed

Three groups of five people met at the Halidon Hill viewpoint overlooking Berwick-upon Tweed. In front of us were Carboniferous sedimentary rocks, (sandstones, mudstones and limestones) with the andesite lavas and granite of the Cheviot Hills in the distance. We could see as far as Lindisfarne where the Whin Sill crops out on the island, and also inland. The area is good agricultural land so large-scale solar farms were not thought appropriate. Similarly, using land for growing biofuel crops was not considered worth while. Everyone agreed with the latest developments in biofuels, where the waste cellulose from agriculture and forestry is used. Trees have been planted on some of the marginal land in the area and participants were keen to encourage local communities to plant trees on waste land.

Participants were open to the idea of offshore wind farms, possibly with green hydrogen production alongside. Much of the coastal area is designated an Area of Outstanding Natural Beauty (AONB) and the Cheviot Hills are in the Northumberland National Park so it was felt that onshore wind farms were not appropriate.

A possible tidal barrage across the Tweed was discussed but it was felt that the returns would not justify the initial costs, or the initial high carbon emissions from construction. There is not a large tidal range here.

Geothermal power could be considered, making use of the Cheviot granite but it was felt that the restrictions of the National Park and the relatively low population density would make the construction costs uneconomic, but it was agreed that it could be done.

Torness nuclear power station (an old Advanced Gas-cooled Reactor) is on the coast about 20 miles north of here. Some people were interested in the new Small Modular Nuclear Reactors being developed but no-one was keen on a GDF (Geological Disposal Facility) for radioactive waste in the area; the geology is not suitable anyway being too faulted and folded.

The view from Halidon Hill, overlooking Berwick-upon-Tweed.
Photo by Patrick Dixon

The basalt from the Whin Sill complex in the south of the area is already being taken from quarries here to spread on agricultural land further south for fertiliser and enhanced weathering.

There are some small old coal mines in the area but it was felt these were not deep or extensive enough for use for hot water geothermal energy.

Part of the coast has already been protected by sea walls and riprap and it was agreed that these measures would have to be increased to cope with rising sea levels. The Elizabethan ramparts around the town would not be sufficient.

Excellent feedback was received from the two Zoom talks on the topic with many views expressed in the Zoom chat and by email.

The viewpoint at the head of the Porter Valley, Sheffield on a good day. Photo by Peter Kennett

The 'Net-zero' experience of Peter Kennett overlooking Sheffield

I discussed the possibilities for zero carbon in the city region of Sheffield with two geologist colleagues, standing at a stone-built viewpoint above the western suburbs of the city. The middle ground consists of Coal Measures rocks, with the Permian scarp on the horizon. Six coal-fired power stations are named on the pointer dial, installed in 2005, and in the far distance, on a really superb day, the Humber Bridge 52 miles away, can be seen. Some days later, the two one-hour sessions for a total of nine people from local interest groups were held in wet, cold and windy weather and the views had to be imagined in the swirling cloud! Of the six power stations, only Drax is now operational—and coal has largely been replaced by 7.5 million tonnes of wood pellets being imported from North America each year!

Some of the measures outlined in the Earthlearningidea activities are already visible in this area, e.g. the city's incinerator, providing district heating for many city centre buildings; several small wind farms; solar panels on buildings; and the farming of sheep, providing wool for insulating buildings. The British Geological Survey (BGS) section of the rocks beneath our feet showed suitable structures for the sequestration of carbon, and a micro-hydro waterwheel could be installed at the site of a former mill dam below us, although the potential would be much better in the lower River Don. The possibility of extracting geothermal heat from the many flooded coal mines in the region caused excitement, but nobody thought it likely that a tidal power station would be constructed in the Humber Estuary.

Very thoughtful feedback was received by email including from one person who pointed us to a long-term building site where carbon sequestration by enhanced weathering might have been going on as we spoke.

Coincidentally, a report on how Sheffield might achieve 'zero carbon' has just been produced by Arup, on behalf of Sheffield City Council: https://www.arup.com/perspectives/publications/research/section/pathways-to-zero-carbon-in-sheffield

The 'Net-zero' experience of Chris King and Doug Robinson by the Severn Estuary

Our visit was to Sand Point overlooking the Severn Estuary near Weston-super-Mare in Somerset. We ran a pilot visit in April, inviting members of our U3A geology group to join us in groups of four for a 2.5 hour visit, one in the morning and a second in the afternoon. The pilot ran well and generated much interesting discussion, so we repeated the plan during GeoWeek.

We discussed the 5m raised beach the group in the photo is standing on. We considered how this had formed by sea-level rise caused by climate change due to natural processes, and how a 5m higher sea level might impact the estuary coastline. We explored whether a tidal barrage across the estuary in the distance might be built and what its impact might be. The Carboniferous limestone exposed on the beach on the flank of an anticline was investigated as a potential site for carbon capture and storage (CCS) (not possible). The basalt outcrop on the beach was also considered as a source of material for enhanced weathering. Meanwhile the wind turbines on the Welsh coast in the distance and the windy weather prompted debate on wind energy, whilst the Hinkley Point nuclear power station being constructed (not quite visible) promoted discussion on the potential of the area as a geological disposal facility (GDF) for nuclear waste (not possible).

GeoWeek 'Net-zero' at Sand Point where we considered how the Severn Estuary area will be impacted by the 'Net-zero' plans? Photo by Chris King

We used graphs and diagrams to discuss the geological background to climate change, the 'Net zero' targets, and the potential of a wide range of other strategies to contribute. Fortunately the feedback from the two U3A groups and the two GeoWeek groups was excellent—prompting thinking of how this could be repeated for larger groups in the future.

The series of Earthlearningideas on the theme 'How will the 'Net-zero' target affect your local area?' available at https://www.earthlearningidea.com/
You can read more about the background to GeoWeek here: https://earth-science.org.uk/geoweek/

Topic			Earthlearningidea title
Introduction			How will the 'Net-zero' target affect your local area?
Possible mitigation measures	Use alternative energy sources	Solar	Harnessing the power of the Sun
		Wind	Farming the wind: through onshore and offshore wind farms
		Tidal	Tidal energy
		Nuclear	Nuclear waste disposal
		Biofuel	Liquid biofuels: keeping our wheels turning into the future
		'Blue' hydrogen	Blue hydrogen: the fuel of the future?
		Geothermal – hot rocks	Deep geothermal power from 'hot dry rocks': an option in your area?
		Geothermal – flooded mines	A new use for old coal mines
		Hydro – small scale	Small-scale hydroelectric power schemes
		Heat pumps	Heat from the Earth
		Waste – incineration	Energy from burning waste
		Waste – methane	Energy from buried waste
	Stop fuels releasing greenhouse gases	Carbon capture	Capturing carbon?
	Store energy from sources that give irregular energy supplies	Batteries	Nuclear batteries: the future?
		'Green' hydrogen	Green hydrogen used to even out renewable energy supplies?
		Hydro – storage	Matching supply and demand using stored water
		Compressed gas	Storing gas underground: What can we store? How can we do it? How will it help?
	Provide raw materials for new technologies	Electric vehicles	Electric vehicles: the way to go?
		Insulation	How do I choose the best insulation?
	Remove carbon form the atmosphere	Enhanced weathering	Speeding up nature to trap carbon dioxide
		Tree planting	Let's plant some trees
Possible adaptation measures		Coastal flooding	How will rising sea level affect our coastlines?
		Inland flooding	Inland flooding: a Sheffield case study
		Landslides	Landslide danger
		Agriculture	The future for global agriculture

Geoconservation highlights of the first year in the life of the Black Country UNESCO Global Geopark

Graham Worton, Dudley Museum Keeper of Geology and Black Country UNESCO Global Geopark Lead Officer

On 10th July 2020 the Black Country became a UNESCO Global Geopark—a recognition of internationally important geology and its influence on local history and culture (see *Earth Heritage*, 54, 20–22). It also gave confidence to its people who strive to conserve, enhance and wisely use this resource for the long-term benefit of all. Despite the disruption of the COVID-19 pandemic this has been an amazing year for the Black Country UNESCO Global Geopark.

Our effort moved away from events and activities involving large gatherings to targeted action around advocacy, awareness, infrastructure and access, new interpretation, and education. We have grown

***Below*: To celebrate the birthplace of Abraham Darby, local communities, businesses and the council have created a sculptural monument adjacent to Wren's Nest NNR.**

***Inset*: Branding for Wren's Nest NNR. This style of branding has been adopted across the Geopark. © Black Country UNESCO Global Geopark Partnership.**
All images by Graham Worton unless otherwise stated

our international collaboration and are currently working on projects and bids with other Geoparks. There was a pressing need to ensure that communities had local safe spaces to explore and take exercise and the Black Country Geosites were perfect. Routine management to maintain these has continued and a landmark was reached on 6th August 2021: 500 consecutive Geopark Pandemic Posts (https://www.facebook.com/BCGeopark/).

Geodiversity and Geoconservation

Improving Geosites

Among our most significant achievements was Saltwells Local Nature Reserve and Geosite becoming a geological National Nature Reserve (NNR) (see *Earth Heritage*, 54, 23–26) and the opening of its new warden's base which Alan Preece discusses in this issue (see page 4). The nearby Wren's Nest, England's oldest geological National Nature Reserve, has just celebrated its 65th birthday. Here new warden facilities are also anticipated with the purchase of the previously rented warden's base and surrounding land by the local authority. Also, a new Geopark 'Home of the Dudley Bug' sign has been erected and, to celebrate the birthplace of Abraham Darby, local communities, businesses and the council have created a sculptural monument adjacent to the NNR.

Elsewhere Bumble Hole and Warrens Hall Local Nature Reserve Geosite, a classic geo-industrial landscape of intersecting canals, canal tunnels, old mine buildings and spoil heaps, has upgraded its footpaths, particularly for wheelchair users. Alongside this, new Geopark guided walks have been developed to link the geological and landscape story.

The new trail at Bumble Hole and Warrens Hall Local Nature Reserve Geosite.

New sites and sections

Over the last year several opportunities have arisen to re-expose old sections and examine new sections. At Castle Hill in Dudley, a new Very Light Rail (VLR) innovation centre and trackbed for the Midland Metro Tramway are being constructed that has involved cutting back into the hillside of soft fossiliferous shales of the Silurian, Ludlow Series. This yielded a 'once in a lifetime opportunity' to record, sample and report on these strata. There were unexpected geological structures, ten bentonite horizons, and the opportunity to collect fragile and less-well-preserved fossils (previously not well represented in the local collections from these strata).

In Kingswinford, works at Ketley Claypit, an SSSI and Geosite, required harmonious landscaping with its surroundings. Following advice from the Geopark and Natural England the developers assisted in shaping the area to create a shallow basin from which the rock faces can be viewed, vegetation has been cleared and regrading will allow easier future maintenance. Showing the contact between the Carboniferous Etruria and Halesowen Formations, the extended rock faces revealed a small fault and exposed river channels and palaeosols.

In Wolverhampton the Geopark team was approached about an abandoned sandstone quarry in the early Triassic, Wildmoor Sandstone Formation. As part of the development there was interest in enhancing its geology and linking it to the nearby Stafford Road Geosite. Decisions were made, works were funded including clearing and regrading, fencing, and site interpretation. Detailed sedimentary logging and sampling revealed a stacked river channel system. Findings were reported and interest flourished within Wolverhampton City Council who subsequently funded a robust interpretation panel for the site boundary.

Lastly, a significant initiative that has been worked on during the past 12 months, is integrating specific Geopark policy into the Black Country Plan—the strategic planning and development plan up until 2034. Consultation is ongoing on this and should result in bespoke policy that mandates consideration of the Geopark and its Geosites in future development.

Under pressure

As a large urban area with 1.1 million residents, local demand for public outdoor spaces surged during the pandemic. Some of our Geosites saw a rise of more than 400% footfall almost overnight creating an unprecedented pressure. There were challenges (more litter, more cars, increased erosion), however, this introduced completely new local audiences to these places. Many discovered for the first time 'hidden gems' of natural and cultural heritage on their doorstep, raising local awareness and value. To manage expectations and behaviours social media, online publications (and more recently new guided walks) prepared people for their visits. More people were engaged and have told us about their deepened sense of connection to the landscape and its fragility. Another important outcome was the increase in face-to-face communication with site visitors raising awareness of the important role played by our teams across the Geopark and its sites.

The future

Capacity building is now in sharper focus for the future of the Geopark. The local authorities see the Geopark as having a significant role to play in confidence building and as a new visitor attractor important in the post-pandemic recovery. The Geopark Team is in the final stages of approval for

Castle Hill, Dudley. Very Light Rail Innovation Centre site
Cutting for retaining wall
View looking west towards current zoo entrance north end of excavation

White bentonite clay (Volcanic ash) layers

Geological Section
No 1
(northern end of excavation)

Strata Horizontal

Faulted ground
Strata dip to the south

Strata folded and dip to the north

SOUTH

White bentonite clay (Volcanic ash) layers

Preliminary geological observations
Graham Worton, borough geologist site visit, Monday 2nd December 2019

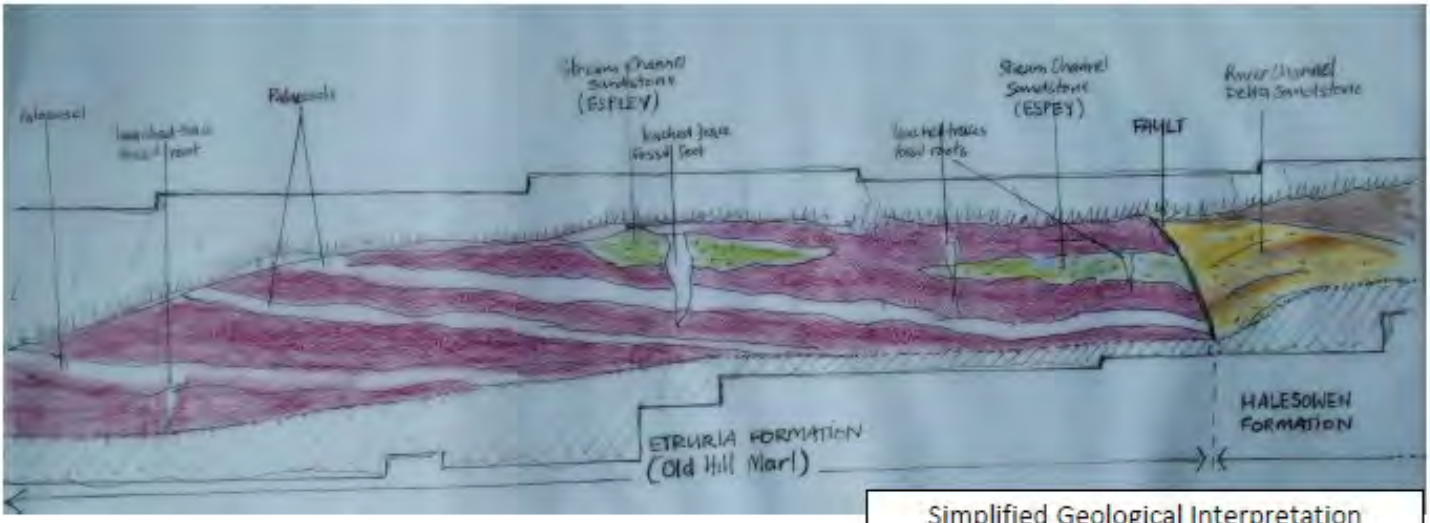
NORTH

***Above*: Images of the temporary section at Castle Hill and some of the fossils found from the exposed Silurian strata.**

***Below*: Images and cross section of the new exposures at Ketley Claypit SSSI.**

Ketley Quarry SSSI, Kingswinford.
Detail of Exposed strata
(Images Taken 10/9/2020 - G J Worton, Keeper of Geology Dudley Museum)

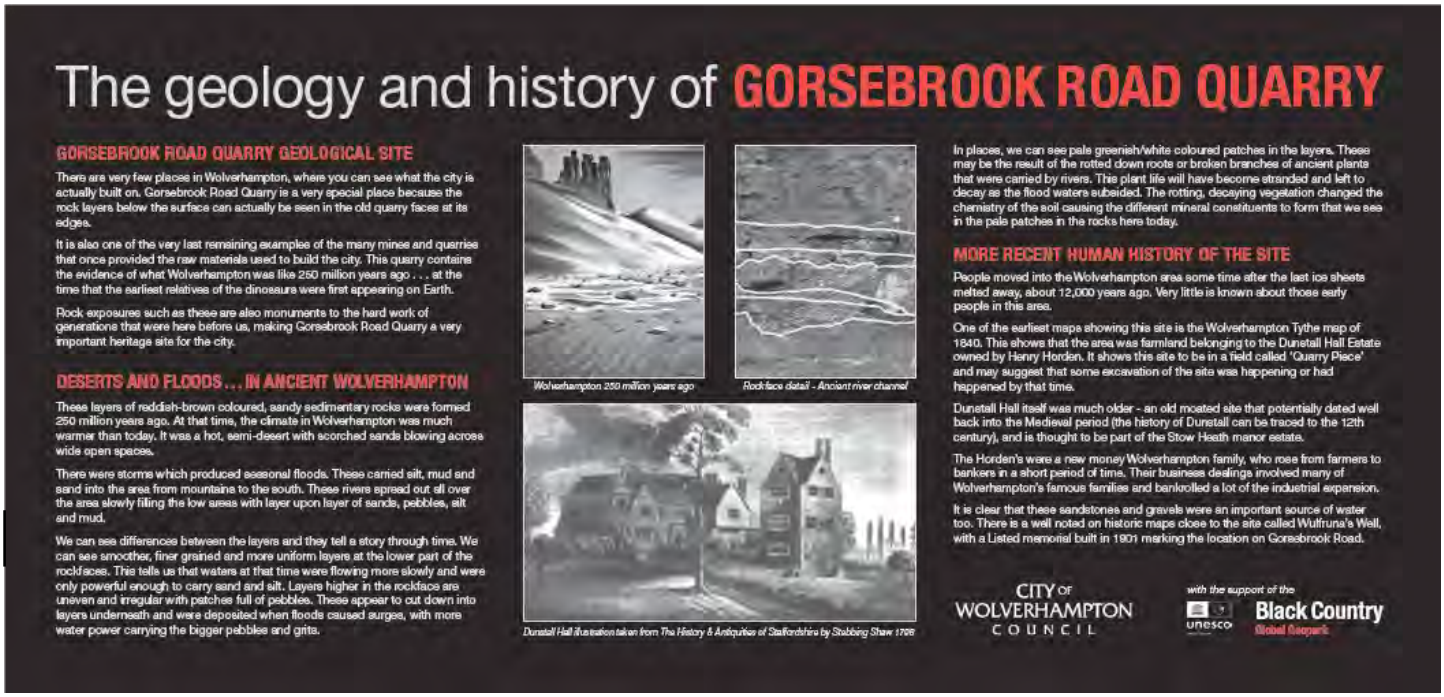
Detail of central Section of Exposure)



Simplified Geological Interpretation

the recruitment of three new dedicated Geopark officers to develop on-the-ground projects, funding, monitoring, and educational offers. They are important as connections with several very large-scale projects are being discussed for the future years of the Geopark that will further embed the Geopark as a heritage destination supporting the visitor economy, accommodation, hospitality and learning sectors.

In our first year the Geopark has been a fun, learning, and discovery mechanism that reconnects people to their local landscapes. In doing that, it garners wider support and creates an impetus for improving access and learning. It also generates new conversations with all sorts of people and opens doors of opportunity, particularly with developers who are so active in the urban setting. Geosites delivered direct benefits to more local people than would have been the case without the pandemic, they are better valued because of a journey of personal discovery of people new to these sites that are now much more visible and connected.



The new interpretation panel at Gorsebrook Road Quarry, Wolverhampton. © Black Country UNESCO Global Geopark Partnership.

Further Reading

UNESCO Global Geoparks: http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/unesco-global-geoparks/

The Black Country UNESCO Global Geopark: https://blackcountrygeopark.dudley.gov.uk/bcg/

The Geological and Palaeontological Highlights of the Black Country UNESCO Global Geopark http://gcr.khuisf.ac.ir/article_682471.html

Dual revalidation visits for the Welsh UNESCO Geoparks

Raymond Roberts and **Chris Byrne**, Natural Resources Wales

Normally the four-yearly UNESCO Global Geopark (UGG) assessments, or revalidation missions, in Wales are out of sync for the two UGGs, but due to last year's postponement of the visit to Fforest Fawr, a rearranged programme has allowed the revalidation of GeoMôn to be undertaken by inspectors on the same trip.

Geopark revalidation missions assess all aspects of the Geopark, including management structure, financial status, infrastructure, educational activities, marketing, conservation and sustainable development. Therefore, it is no surprise that the missions are an intensive mix of site visits, meetings and events involving the extended Geopark family. In addition to Geopark staff, Board members and volunteers, the local authority, politicians, Natural Resources Wales, local businesses and communities are heavily involved in showcasing the continued effort in promoting geodiversity and sustainable economic development within UNESCO Global Geoparks.

Inspectors are drawn from a large global pool of Geopark Co-ordinators and the Welsh UNESCO Global Geoparks welcomed Goran Radonic from Papuk Geopark in Croatia and Oliver Gulas from the Styrian Eisenwurzen Nature and Geopark in Austria. The inspectors began with GeoMôn in North Wales and over 5 days they were shown many of Anglesey's geological gems during field visits to Ynys Llanddwyn, Llanbadrig, South Stack and Mynydd Parys. At the Marquess of Anglesey's Column the visitors heard of exciting new developments following the receipt of major funding totalling more than £800k from National Lottery Heritage Fund. Notified as a SSSI for the Precambrian blueschist, the site is also of historical and cultural significance for the Grade II* listed column which was constructed in 1817 as a memorial to the Marquess of Anglesey who played an important role in the Battle of Waterloo. The project will involve reopening the 27m-high column allowing visitors to access the top and have panoramic views over the Menai Strait, in addition to building an accessible viewing platform for those unable to climb the 115 steps within the column. The involvement of GeoMôn in the project will ensure that the rare blueschist exposed in natural outcrops and old quarries will also be a key part of the story told at the site.

Holyhead Breakwater Country Park is a key geosite in the north of the island and the location of one of a network of GeoMôn interpretation boards. The Country Park is centred on the extensive quarries that exploited the Cambrian Holyhead Quartzite in the mid-19th Century to build the 2.4km-long breakwater protecting Holyhead harbour, the longest breakwater in the UK. Inspectors, Goran Radonic (Papuk Geopark, Croatia), Oliver Gulas (Styrian Eisenwurzen Nature and Geopark, Austria) are pictured with Cynthia Burek and John Conway (both GeoMôn). Photo by Wil Stewart, Warden Isle of Anglesey County Council

After a scenic train ride through Wales, the inspectors arrived in Fforest Fawr for another packed itinerary. Geological highlights included visits to the Waterfall Country, Cwm Cerrig Gleisiad NNR and sites in the west of the Geopark towards Llandovery. A visit to Ogof Ffynnon Ddu NNR at Penwyllt allowed a quick walk along the Beacons Way; this challenging 99-mile route passes through the World-class geology of the geopark—here the karst landscape of the Dinantian limestones pocked by dolines and limestone pavement, is topped by the more impermeable Namurian sandstones, while in the distance (in good weather!) you can admire the spectacular scenery of Fan Hir. (This path was the dramatic scene less than 24 hours later of Cave Rescue teams from across the UK converging to carry out the longest cave rescue ever undertaken in Wales.) During the five-day visit, the inspectors also had the opportunity to see how Fforest Fawr works closely with community charities across the Geopark with visits to the café at Ty Talcen in Myddfai and the Community Centres at Black Mountain, Penderyn and Ystradowen.

The inspectors will now compile their reports and present them to UNESCO for consideration in the coming months. Fingers are crossed that a successful outcome for GeoMôn and Fforest Fawr will allow both geoparks to continue to fly the flag for Wales on the international geodiversity and geoconservation stage; an excellent example of Sustainable Management of Natural Resources (SMNR) in practice.

Signage and visitor management are high up the agenda for Geoparks and is closely scrutinized during revalidation visits. A visit to the Bronze Age standing stone at Maen Llia, allowed the inspectors to admire the dramatic upland landscape of the Old Red Sandstone of the Brecon Beacons. The innovative design of the interpretation panel echoes the shape of the stone but also provides the information to highlight the value of the site, important following historic graffiti. The standing stone comprises an intraformational conglomerate from the ORS sequence, but has not been traced to any local outcrops, leading to many questions as to why this particular rock was chosen and how it was transported to its current location. Photo by Chris Byrne, Natural Resources Wales and inset by Fforest Fawr UNESCO Global Geopark

ProGEO—with a global perspective!

Lars Erikstad, ProGEO

Geoconservation has a long history in Europe, going back to the 1600s when caves in Germany were subject to decrees controlling access. Inspired by the national park movement in the US, several countries got new legislation aimed at protecting nature, some even mentioning geology as one of their aims. During the first half of the 1900s several countries got relevant legislation that made protecting geology possible, but little else was achieved. Some countries, however, launched work that marked a start for a more systematic approach to geoconservation. The most important was in the UK which created new legislation, established the SSSI system and the Geological Conservation Review. However, the activities in most European countries were much more modest, and it was clear that the progress for geoconservation was dependent on not only national efforts, but international efforts.

In the Netherlands Gerard Gonggrijp was working in geoconservation and made efforts to gather interested parties and systematise Dutch geoconservation. He realised the need for international cooperation and took the initiative to a meeting in 1988 to establish a European working group for Earth Science Conservation. One of the issues the working group focused on was the international exchange of ideas and experiences as a vital part to achieve success for geoconservation. This need was, however, larger than the relatively small working group could facilitate. A couple of years later it was decided to form a more formal member-based association that could take on this task. This process was fulfilled in 1993 when the first general assembly in the new association, ProGEO, was held.

Coastal cave in the coastline around Bari, Italy. Photo from the field trip of the VII International ProGEO Symposium on Conservation of Geoheritage.

All photos by Lars Erikstad

The first international symposium on geoconservation was arranged a couple of years earlier. It was very clear that a major issue was the international dissemination and justification of geoconservation within the wider context and as part of the nature conservation efforts that already exist in most countries. The symposium authored a declaration, known as "*The Digne Declaration*" that placed geoconservation into a wider perspective ("*Our history and the history of the Earth cannot be separated. Its origins are our origins, its history is our history, and its future will be our future*"), underlining that geoconservation was about the total environment. Geology's part in nature at all scales was emphasised, and all nations were urged to protect their geological heritage *("request all national and international authorities to take into consideration and to protect this heritage, by all the legal, financial and organisational measures that may be necessary"*).

***Left*: The Island of Leka, Norway, with ultramafic rocks formed in the deep parts of the oceanic crust and upper parts of the mantel exposed. The island has been elected as the "National Geological Monument" by Norwegian geologists. It is a part of the UNESCO Global Geopark Trollfjell. http://trollfjellgeopark.no/**

***Right*: Biggenjarga natural monument (Norway), protected in 1967, shows a 600 million year old tillite resting on a sandstone with glacial striae.**

The Digne symposium was not only a European event, it was truly international; participants came from all over the world. This has also been the case for all 9 symposia arranged later as a series of International ProGEO Symposia on Conservation of Geoheritage. It has always been clear that there was a need for truly international efforts in this field and that in the long run ProGEO should transform from a European into an international association.

This need has been illustrated not only by the international symposia, but also in the membership of ProGEO that has included members from outside Europe. It has also been underlined by the fact that ProGEO has for a long time been an affiliated organisation to the International Union of Geological Sciences (IUGS) and a member organisation of the International Union for the Conservation of Nature (IUCN). ProGEO has worked truly internationally, and the results can be seen in our scientific journal GEOHERITAGE, issued by Springer and now reaching an impact factor (five year) in 2020 of 3.089.

Our activities as an IUCN member have shown results through our work with other organisations in getting resolutions accepted in the World Conservation Congresses since 2008 (*WCC 2008 Res 040: Conservation of geodiversity and geological heritage, WCC 2012 Res 048: Valuing and conserving geoheritage within the IUCN Programme 2013–2016, WCC 2016 Res 083: Conservation of moveable geological heritage, WCC 2020 Res 089 - Geoheritage and protected areas*). IUCN has now adopted the principles of geoconservation and accepted geodiversity as a term on a par with biodiversity. However, much work remains to get this acceptance transformed from principles addressed every fourth year on the World Conservation Congresses into practical work on an international scale in the multitude of strategies and programmes that form IUCN activities.

Very early on, ProGEO collaborated with IUGS in a project called GEOSITE. This aimed to create an international list of Geosites based on systematic inventories inspired by the British GCR experience. Several European countries have done their inventories based on the described methods and established a geological framework for Geosite inventories and selected sites. International comparison of sites and selections on an international level has, however, not been achieved.

At present two international projects have been developed following the idea of an international list of Geosites. IUCN based theirs on the approved resolution of 2020 on Geoheritage work to develop a system of Key Geoheritage Areas and IUGS are developing a project about International Geoheritage Sites. ProGEO and ProGEO members are involved in both projects. The projects illustrate the need for ProGEO to draw on an international member base and have an international perspective on its work. The task now is to develop these two initiatives in synergy, not in competition, so that this idea of international listing can result in a major new step forward for geoconservation on a global scale.

This year the 10th International ProGEO symposium was arranged in Spain as a fully digital event. Not only was the Digne declaration confirmed and renewed, but on the ProGEO General Assembly it was decided to transform ProGEO into an international Association. The name of the Association has changed from "*The European Association for the Conservation of the Geological Heritage*" to "*International Association for the Conservation of Geological Heritage*". Its statutes (articles) were changed accordingly, and international members were elected to supplement the existing staff of ProGEO officers.

The change may seem formal and perhaps not so important, but for ProGEO it is a major and important change. Firstly, we have achieved an important goal that has been present for many years —establishing an organisation for geoconservation on a truly international level. Secondly, being international we will have a new platform from which to work on influencing international nature conservation strategies. Thirdly, we will establish ourselves as a resource for geoconservation in all

countries and regions of the world and, as such, have the opportunity to recruit members and officers on a much broader scale than we have had previously.

Preparations for this transformation have been ongoing since the last General Assembly in Poland in 2018. After its implementation in 2020 we have a couple of years until the next General Assembly to work with the organisation and its members to make the transformation a success. We will also work with IUCN and IUGS to develop the Geoheritage and Geodiversity concepts to serve geoconservation all over the globe. This is not a small task and our victories will be gradual and sometimes small. But we hope with renewed international inputs and status we will have a better platform than we had before. Especially important are the strategies to develop Key Geoheritage Areas within IUCN on a par with their Key Biodiversity areas, and to work with IUGS so that their project of Important Geoheritage Sites can supplement and strengthen the IUCN work.

It will also be an important task to work with UNESCO on their World Heritage and Global Geopark programs, both extremely important for developing geoconservation concepts and goodwill internationally. Everyday life is busy, and cooperation on this level takes a lot of time, so these tasks are demanding for an association like ProGEO. Our hope is that the new international status will result in new members from around the world and increase our capacity to take on the challenge.

Further information

O´Halloran, D., Green, C., Harley, M., Stanley, M. & Knill, J. (eds) 1994. *Geological and Landscape Conservation*. Geological Society, London

www.progeo.ngo

https://www.iucn.org/commissions/world-commission-protected-areas/our-work/geoheritage

On the Trail of Scotland's Shale

Dr Robin Chesters, Director, Almond Valley Heritage Trust

Beneath the fields of West Lothian lie seams of a rather unusual mineral that for almost a century supported a remarkable and important industry. Oil shale is found across an area centred in West Lothian that extends north to Fife and south into Lanarkshire. The area over which oil shale is found corresponds generally to the boundaries of Lake Cadell, a freshwater lake that existed at various times during the Carboniferous period. Something rather unusual about the geography and biology of the lake resulted in occasional blooms of microscopic algae that became buried within anaerobic muds on the lake floor. These deposits have matured into seams of oil shale in which the carbon of ancient algae survives chemically bonded to the mineral matrix. When heated within the controlled conditions of a shale retort, a crude oil very similar to liquid petroleum is released.

Oil shale was first mined and processed in the early 1860s and gave rise to an industry that continued for a century. Activity was initially focussed on the West Calder and Broxburn areas, where the richest seams cropped out at the surface. As the scale of operations grew, mining pushed out into less accessible areas and exploited deeper seams.

Following the First World War, the shale industry ceased to make any economic sense, but was sustained by a combination of national pride and strategic interest. After a long period of decline, the final oil shale mines and works were closed in 1962. The industry has however left its mark on

The section of the Shale Trail that follows the Union Canal towpath, overshadowed by one of the bings of Broxburn Oil Works.

Waymarker No.5 on the Shale Trail at Gavieside, with a view across to the surviving buildings of Westwood Oil Works and the Five Sisters bing beyond. This giant bing, which is both a memorial to the shale-oil industry and symbol of West Lothian, is a scheduled monument.

All photos by Dr Robin Chesters

The southern terminus of the Shale Trail, facing the former Cooperative drapery shop at Union Square West Calder in West Lothian, an important centre for the shale-oil economy in the 19th and 20th centuries.

the landscape. In many areas the pattern of settlement was shaped by shale-oil interests, and many houses built to house the workforce of pits and works still provide solid homes. In country areas the informed eye can still make out traces of pitheads, mines and mineral railways, however the most prominent and impressive monument to the industry are the giant 'bings' of spent shale.

For every ten tons of shale extracted, over eight tons remained as waste once the oil and ammonium sulphate had been extracted. Huge man-made mountains of this 'spent blaes' grew up around each oil works, engulfing farms, fields and countryside. As these have aged, iron compounds in the waste shale have gradually oxidised to produce the distinctive rusty pink colour. Many great bings have been quarried for use in road building, paths and playing fields and others have been reshaped and disguised in greenery. However two of the most distinctive bings have now been protected as scheduled monuments. The Greendykes bing, visible from the Winchburgh end of the Shale Trail, is an amalgam of bings from several works that accumulated between the very start of the industry in 1860s through to the 1950s. The other scheduled monument, the Five Sisters bing, is a landmark at the West Calder end of the Shale Trail. It is just a youngster in bing terms, having been built up between 1942 and 1962. Its unique shape is a consequence of a mechanised tipping system used nowhere else in the shale fields.

Between these two great landmarks runs the Shale Trail, a walking and cycling route running for 16 miles and linking the shale villages of Winchburgh and West Calder. The work of creating the trail is down to a collaboration between a greenspace trust, a local authority, a number of community development trusts, and a museum. It was funded through the West Lothian LEADER programme and the National Lottery Heritage Fund.

The project linked a sequence of using existing footpaths, undertaking improvement works where required, and fully signposting the route. The route snakes its way through many of the old shale mining centres, starting at the shale-oil village of Winchburgh, following the canal towpath through the shadow of the Broxburn bings, past the site of the Pumpherston refinery, and eventually reaching West Calder—the capital of the southern shale fields. Geology has not always been cooperative along the route, with the Trail needing to cross a couple of miles of shale-free land where volcanic rocks intruded later in the Carboniferous Period. The absence of mining in this gap was one reason why, in the 1960s, Livingston was chosen as the site of a new town. The Trail follows a pleasant green riverside route through the heart of the modern town.

The end points and a mid-way point of the Trail are marked by interpretative panels and artworks, while waymarkers are placed at points along the journey. Every waymarker has a story to tell. QR codes on each post link directly to pages on the Shale Trail website and provide a little insight into a particular aspect of the shale-oil story, from geology and technology through to tales from the communities that served the industry. There are separate QR codes linking to a children's Shale Trail featuring interesting activities and classroom resources.

For those who want to dig a little deeper, the Shale Trail website links directly to ScottishShale; the online resource maintained by the Museum of the Scottish Shale Oil industry, which gives access to the museum's collections and archives, and provides a seemly endless source of insight into shale and everything associated with it

COVID restrictions put paid to plans for a high-profile launch of the Trail, but the new route has nevertheless captured the public imagination and attracted great attention. For local folk it is a reminder of the history behind familiar places, while shale trail-ers come from many parts to walk or cycle the route and breathe in its special heritage

The project has also awakened an appetite to do more and plans are afoot for further partnerships to explore the wonders and heritage of West Lothian.

www.shaletrail.co.uk
www.scottishshale.co.uk

***Right*: The Five Sisters bing (or at least some of it) formed from the spent shale produced by Westwood Oil Works between 1942 and 1962. The mechanised tipping system used only at Westwood resulted in the unique shape of this gigantic pile, or bing, of spent shale.**

***Below*: An alternative way of enjoying the Shale Trail. Passing waymaker No.16, close to the site of the refinery at Broxburn Oil Works.**

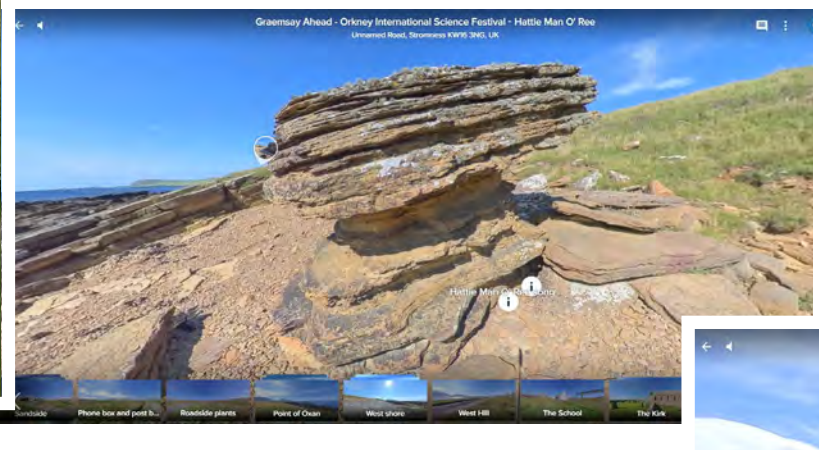
Graemsay Ahead: a virtual geological tour of a small Orcadian island brought to a global audience

Katy Firth, Stromness Museum, Orkney

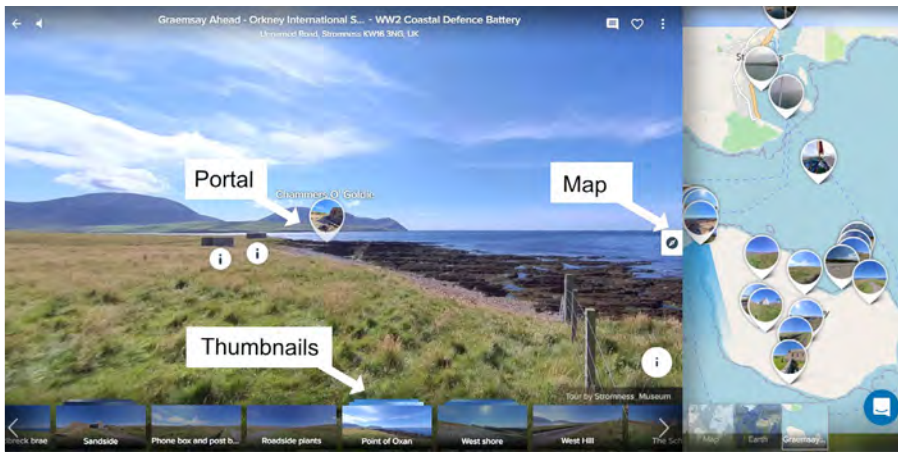
Stromness Museum (Orkney Natural History Society) is one of the oldest independent museums in Scotland. Founded in 1837, the collection is housed in a Victorian building with its own pier on the seafront in Stromness, on the Mainland of Orkney. Artefacts belonging to the town's maritime heritage; archaeology; ethnography and Arctic exploration sit alongside a varied natural history collection.

The COVID-19 pandemic forced Stromness Museum, like many others, to 'go digital' in the events that it offered to the public in 2020. With an in-person *Orkney International Science Festival* guided excursion to Graemsay cancelled, Katy Firth, Exhibition Assistant, found herself getting to grips with cutting-edge digital technology and creating a virtual tour of the island. Katy borrowed a 360-degree camera and learnt to use the online platform Roundme.com and set off for Graemsay which lies between mainland Orkney and the island of Hoy.

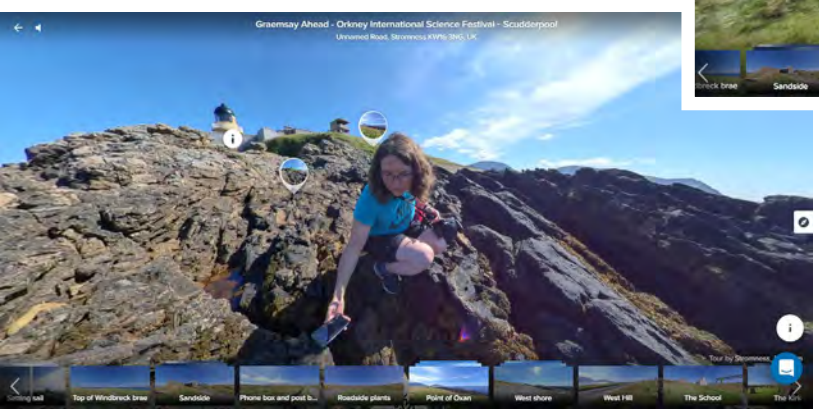
The 360-degree camera uses two domed lenses to capture an instant 'photosphere' which can be uploaded to the Roundme® site. A Roundme® tour can be set up free of charge, although a pro-version is available with some further benefits. Once back at the computer, the creativity starts. 'Hotspots' are added to the captured 'photosphere' which can provide a wealth of diverse information



***Left*: The intriguingly shaped sandstone rock stack the 'Hattie Man O' Ree' in a screenshot from the Graemsay tour. The formation of the stack, which has been fashioned by the sea from the Devonian sedimentary rock sequence, has another origin according to local folklore—a story captured by the Graemsay virtual tour. All images by Katy Firth**



***Right*: A screenshot illustrating the three methods of navigating between the different panorama locations in the Graemsay tour: portals, thumbnails and the map, which can be opened by clicking on the compass icon.**



***Left*: A screenshot from the Graemsay tour showing Katy photographing a rock pool in the basal breccia below Hoy Low lighthouse. (The breccia represents the basal beds of the Lower Stromness Flags of Middle Devonian age). Behind her, two 'portals' can be seen which take the viewer to different panorama locations.**

for the user about natural and man-made features in the landscape. Hotspots may include: snippets of text; supplementary images and videos; and audio narratives, all of which can be added to each 'photosphere' location.

Content to populate the tour was sought from island residents, Orkney 'ex-pats' and family descendants. A Graemsay teenager presented some of her original artworks to be included. Others gave oral history interviews or sent photographs and written memories. For an island of only 22 inhabitants it was fantastic to have over a quarter of the population engaged in the project. The diverse content included information on local wildflowers, birds, geology, social history and more.

Graemsay's history abounds with fascinating stories: from shipwrecks to selkies (mythical creatures that resemble seals in the water but assume human form on land), labradorite (shipped as ballast from Labrador) to lighthouses. The tour features oral histories which relate some of these now ancient tales. It became apparent that geology, and the way people interact with it, was at the heart of many of the stories. For example, Bryce Wilson, local writer and historian, explains the origin of the name 'Hattie Man O' Ree', a natural sandstone stack on Graemsay's west shore:

> *"The Hattie Man O' Ree is a little bit of a stone tower, it's about 8ft high I suppose, and it was difficult to get on top of it...kids were always trying to show off and get on top of the Hattie Man. The story about the Hattie Man was: there was a chapel, dedicated to St Colm just near where the lighthouse is now on the west end of the island...and the story goes that some guy in Hoy was dead against this Christianity that was coming in and he was going to Graemsay to destroy the Chapel and kill the priest...But on the way to the chapel he was turned into a pillar of stone, and he's still there. Because he had a great big top on the stone like a great big hat, he was the 'Hattie Man O' Ree'….I've never been on it, I did try once!"*
>
> Bryce Wilson.

When visiting Graemsay to research and create the tour, Katy became most fond of the north-western tip of the island, below Hoy Sound Low lighthouse. The area is fascinating geologically, because within a very small area there is a great variety of rock types: granite-gneiss basement rock; breccia, flagstones and nearby, an igneous dyke intrusion. Katy's favourite feature of this landscape were some channels in the rock which forced the sea to make some interesting sounds when it washed in. One of the contributors, Norman Davidson, was also fond of this area as a boy growing up in Graemsay and the tour includes his story:

> *"Even as boys we used to wonder at the abrupt changes in rock below the lighthouse from placid layered flagstone to tortured granitic conglomerates or where narrow igneous dykes arrowed their way from the land out to sea. Running and hiding among the many ridges, holes and sea-torn rock channels was a great pastime when a group of kids had gathered together."*
>
> Norman Davidson.

Why not head along to Roundme.com to see the tour for yourself. Navigation through the tour is either via portals embedded in the 360-degree photos; or by using a map, located on the right hand side; or by using the thumbnails at the bottom of the screen. https://bit.ly/graemsaytour

To watch the YouTube Science Festival event where Graemsay residents joined Katy to introduce the tour, click here: https://bit.ly/graemsaytalk
For further information please contact Katy at: k.firth@stromnessmuseum.org.uk
Website of Stromness Museum: www.stromnessmuseum.org.uk

Essential geodiversity variables (EGVs) for measuring and monitoring the changing Earth

Dr Joseph J. Bailey, York St John University, UK.
Email j.bailey@yorksj.ac.uk. Twitter: @josephjbailey.

The Earth and its systems have always been changing in one way or another, but recent changes in biodiversity, climate, and the Earth's surface and subsurface have been and continue to be rapid and unsustainable, owing to increasing human population and associated consumption and (over) exploitation. The climate and ecological emergency is widely reported, for example, in the most recent paper of a series in which the world's scientists call on political leaders for transformative change, by William Ripple and colleagues (this is freely available for anyone to read [1]). This '*Scientists' Warning of a Climate Emergency*' has been signed by thousands of scientists from most countries in the world.

But, how do we know that the Earth is changing? Everyone knows that it is, but it is useful to consider how we know this. The main answer to this question is: data. Of course, we know of some changes because we have witnessed them in our own lifetime (though, this can be unreliable because of an individual's limited experience: look up 'shifting baseline syndrome' [2]), have heard previous generations talking about how things are different now, or we have read about or seen what the world used to be like in various forms of literature and art. These sources of information are very useful but most of our reliable and robust knowledge of recent change comes from data collected on the Earth's systems and processes across (and between) the biosphere, atmosphere, oceans, and geosphere.

Climate change is having an impact on geomorphological and hydrological processes and features in many environments, especially montane. This photograph is from near Samoëns in the French Alps and was taken in the winter of 2018. We experienced a lot of rain, rather than snow, which clearly had an effect on slope activity, causing a lot of landslides.

All photos by Joe Bailey

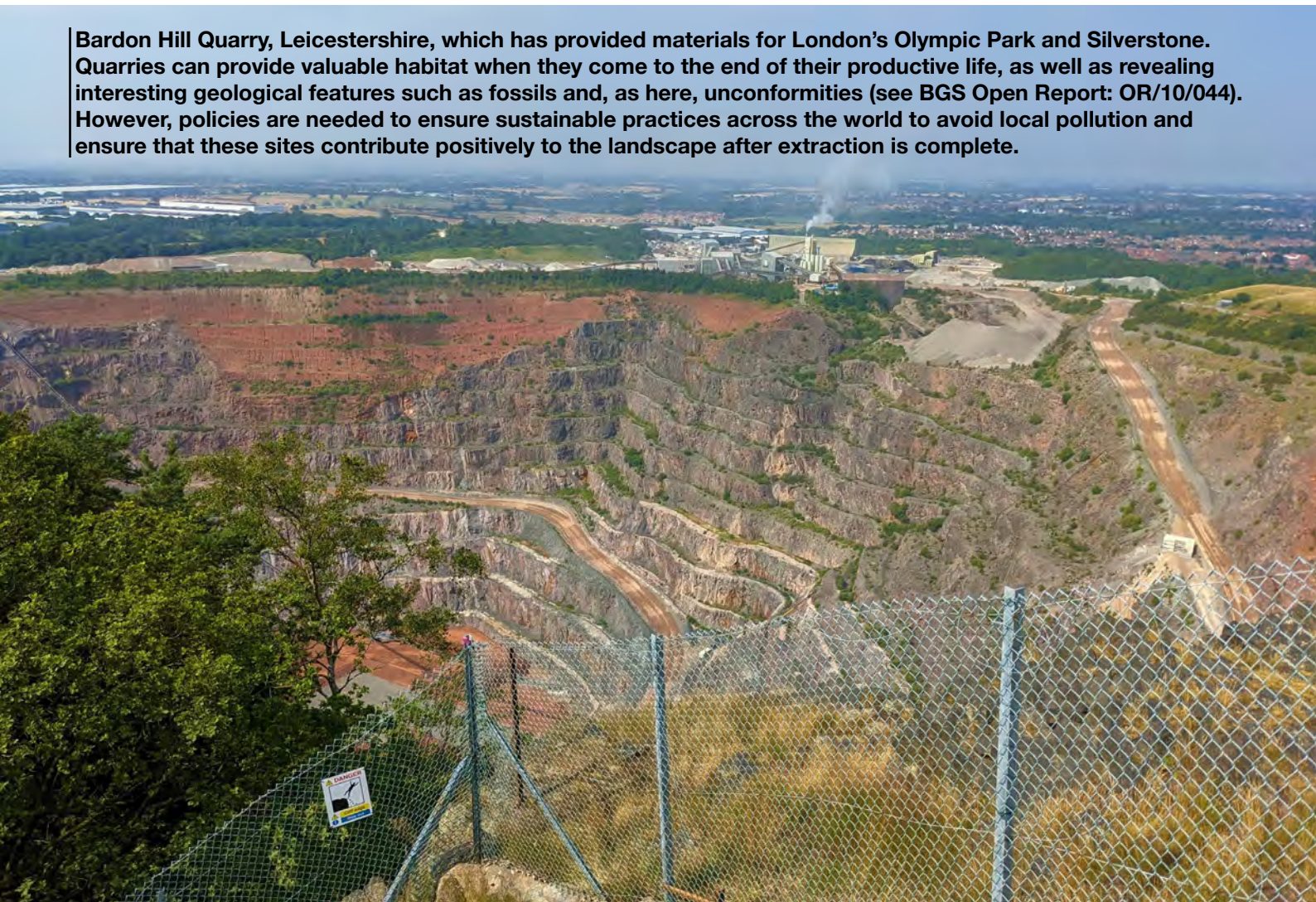
We have quite good datasets on Earth's climate, for example, which allow scientists to monitor this system with accuracy, and to model the future across different scenarios of human behaviour (for example, whether we carry on 'business as usual' or move to 100% renewables very quickly). Data is essential for understanding of how the world is changing and, when combined with theory, why. This allows scientists to communicate with non-scientists accurately and reliably and, hopefully, improve the situation of those currently alive and of future generations towards a sustainable world.

In fact, we have more data than ever before because of monitoring stations (e.g., for temperature and humidity) and information derived by means of 'remote sensing' aircraft and satellites. An abundance of data will never solve the world's problems, but it provides us with a mechanism to monitor the world and communicate these changes.

Organising the collection, processing, and storage of this huge volume of data is a challenge. Amongst others, a solution to organising all of these different datasets has been the development of 'Essential Variable' (EV) frameworks. EVs allow us to measure different Earth systems in a consistent and standardised way. They share certain principles, such as having a standardised terminology, data being well documented (i.e., each dataset must have good information attached to it about its location and collection method, or 'metadata') and 'interoperable', which means that they are easy to share between different computer systems and organisations, and the variables themselves must be sensitive to change and technically and economically feasible to assess through time.

EV frameworks previously existed for biodiversity (essential biodiversity variables; EBVs [3]), oceans (EOVs [4]), climate (ECVs [5]), and sustainable development goals (ESDGVs [6]), and we added EGVs for geodiversity. Variables from other frameworks include, for example: species abundances (EBV), sea surface temperature (EOV), precipitation (ECV), and energy supply (ESDGV).

Bardon Hill Quarry, Leicestershire, which has provided materials for London's Olympic Park and Silverstone. Quarries can provide valuable habitat when they come to the end of their productive life, as well as revealing interesting geological features such as fossils and, as here, unconformities (see BGS Open Report: OR/10/044). However, policies are needed to ensure sustainable practices across the world to avoid local pollution and ensure that these sites contribute positively to the landscape after extraction is complete.



We, an international group of 29 scientists, added the Essential Geodiversity Variables framework to augment these existing EV frameworks, publishing our first article in *Proceedings of the National Academy of Science* [7]. In our article, which is freely available, we discuss how we hope EGVs will "improve global coordination of monitoring strategies [and] advance communication between policymakers and geoscientists", defining geodiversity as "the variety of abiotic features and processes of the land surface and subsurface". Figure 1 in our paper demonstrates how EGVs integrate with other EV frameworks.

In particular, we define EGVs as relating to states or processes of non-living nature (geology, geomorphology, soils, and hydrology) that are: relevant to natural resource management and human wellbeing, conservation, or ecology; complement other EVs; and are feasible and cost effective to measure. We discuss a large number of candidate variables in the paper and identify their relevance to both sustainable development goals (SDGs) and policy more generally. For example, monitoring of 'unconsolidated deposits' from geomorphological processes (e.g., distribution and abundance of these deposits or dynamics of surface materials and sedimentation) may have policy relevance because of their economic and social value in construction, the significance for habitats in fluvial systems (and associated risks of over-exploitation), or risks posed by flooding. Meanwhile, consistent monitoring of soil chemistry properties will be important for agriculture and human health due to identification of the presence of pollutants. Monitoring landform distribution and change is important for the understanding of erosion and conservation (both geoconservation and biodiversity conservation where landforms provide habitats). Just a few of many examples.

How will this actually help, though, and why do we need EGVs? Well, we often hear about over-exploitation of the biosphere through deforestation (or land-use change more generally), overfishing, and wildlife trafficking, for example. Degrading these systems threatens millions of years of evolution, irreplaceable species, and the ecosystems associated with them—systems that we humans rely on for our wellbeing and, ultimately, existence. Less widely appreciated is the degradation of non-living

A sandy riverbed in north-west Madagascar (dry season). Sand from this riverbed is thought to be extracted for construction in growing nearby cities, but is not controlled in any way, so may be or become unsustainable, affecting hydrology and ecosystems.

nature (geodiversity), which underlies living nature in an almost inconceivable number of ways (to read more on the links between geodiversity and biodiversity, please see *Earth Heritage* Issue 53, pages 55–58).

Over-exploiting Earth's geodiversity therefore threatens sustainability goals and we need more consistent international monitoring. We discussed some of the ways in which geodiversity is over-exploited and the threats this poses to human health (and sometimes human rights) in our article in *The Conversation* [8] including examples such as sapphire mining in Madagascar and bauxite extraction in Ghana. Some minerals, e.g., the '3T minerals' (tin, tungsten, and tantalum; fundamental in many electronics that you are likely to own), have also been linked to conflict. Meanwhile, soil erosion is a threat in many places around the world and over-exploitation of sand for construction has been deemed a 'crisis' [9]. Knowing about the distribution of sand and how it is moving around is currently very difficult, but a formalised monitoring system would help with the management of this valuable resource (valuable for humans, as well as natural systems).

The next steps for us are to integrate EGVs better with other EV frameworks and to draw on the international community towards defining a suite of EGVs for implementation. This is alongside continued efforts to ensure that the importance of geodiversity is recognised. Indeed, fundamentally, geodiversity is essential towards a holistic understanding and appreciation of the natural world, as well as human wellbeing. Therefore, we must monitor it, detect change, and encourage policy towards sustainable use of the Earth's systems and resources. Essential Geodiversity Variables will help us do that.

Further Reading

[1] World Scientists' Warning of a Climate Emergency
https://academic.oup.com/bioscience/article/71/9/894/6325731

[2] "Young people can't remember how much more wildlife there used to be"
https://www.newscientist.com/article/2226898-young-people-cant-remember-how-much-more-wildlife-there-used-to-be/

[3] An introduction to EBVs? https://geobon.org/ebvs/what-are-ebvs/

[4] Essential Ocean Variables
https://www.goosocean.org/index.php?option=com_content&view=article&id=14&Itemid=114

[5] Essential Climate Variables https://gcos.wmo.int/en/essential-climate-variables

[6] "Essential Variables help to focus Sustainable Development Goals monitoring"
https://www.sciencedirect.com/science/article/pii/S1877343517300945

[7] "Opinion: To advance sustainable stewardship, we must document not only biodiversity but geodiversity" http://www.pnas.org/lookup/doi/10.1073/pnas.1911799116

[8] "Our new research is tracing the development of the world's vital non-living nature"
https://theconversation.com/our-new-research-is-tracing-the-development-of-the-worlds-vital-non-living-nature-125664

[9] "The world is facing a global sand crisis"
https://theconversation.com/the-world-is-facing-a-global-sand-crisis-83557

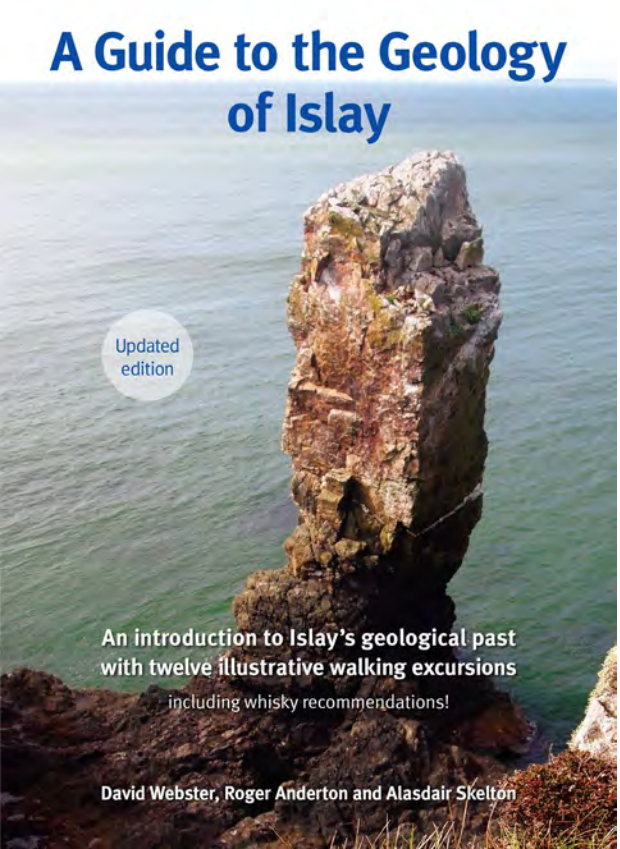
Writing a Geological Guidebook – Not for the Money!

David Webster

You will not get rich writing a geological guidebook. That much I knew before I embarked on writing *A Guide to the Geology of Islay*. From the outset the royalties were to go to the Islay Natural History Trust. So, if not money, what motivated me to write it and how did it come about?

I had been visiting Islay regularly on holiday for a number of years and, on taking early retirement, decided to learn more about its geology. There was an existing geological guide written by Alex Maltman and others from Aberystwyth University in 1990, but it was brief, focussed on exposures close to roads and had no photographs or excursion maps. I thought that an up-to-date guidebook would be a good idea and researching it was a way to focus on the geology and explore the island. I wanted the book to include walks away from the roads, to have an immediate visual appeal with lots of coloured maps and photographs and to be accessible to a wide audience.

Serendipitously I met Alasdair Skelton (Professor at Stockholm University) in 2010 when he was giving a public talk at the Islay Natural History Trust on the one night that I was on the island looking at a plot on which to build a house. Over a whisky or two afterwards in the Port Charlotte Hotel he endorsed the guidebook idea and said he'd help with it—for him it would provide good background reading for the Swedish students he regularly brings to the island. Indeed, some of the Islay rocks (in particular the Rhinns Complex) have geological links with Sweden. Alasdair is a metamorphic petrologist who did his PhD on Islay. I knew I also needed the help of Roger Anderton—a well-respected sedimentologist —to give the book the right hard/soft rock balance. I knew Roger from our days in BP, he is an expert on the Dalradian rocks of Argyll, and he was keen to make sure the book accurately reflected the current views on the development of the basin in which the Dalradian Supergroup was deposited and its subsequent inversion.



It took five long but (mostly) pleasurable years to research and write the book because I enjoyed it and wanted to share the joy of Islay's geological wonders. The challenge was to do this whilst simultaneously undertaking the self-build house project. It all worked out well and coincidentally the building control sign-off and the book launch were within a few weeks of each other.

Islay has just about every aspect of the science represented. It is also the focus for a major research project on the world-

Front cover of *A Guide to the Geology of Islay* featuring 'Soldier's Rock' near Kintra on the southern coast of Islay. This quartzite sea stack features in the sixth of the 12 excursions in Volume I of the guide. A further four excursions on Islay are included in Volume II, *A Guide to the Geology of Islay, Jura and Colonsay* that features three excursions on Colonsay and six on the Isle of Jura.

All photos by David Webster

famous Port Askaig Tillite, a 700-million-year-old glacial succession likely deposited during a period of world-wide glaciation at that time, often referred to as 'Snowball Earth'

It is (relatively) easier to write for a specialist technical audience than one with a general interest in the subject or other aspects of nature. Getting the balance right is tricky! We decided that there wasn't a market for two books, i.e. one for 'experts' and one for 'beginners'. To enhance its appeal to those with a geological background I deliberately followed the style of the recent BGS Excursion Guides (e.g. *The NW Highlands Guide*), but early on decided to be a little different and separate out the route descriptions from the geological explanations by using separate paragraphs and an italic font for the latter. I imagined a couple using the book, with both enjoying the walk but only one interested in the geology! I understand that some academic authors writing on the subject of geotourism and geo-interpretation say that its purpose is to generate interest in geoconservation. I tend to disagree with that, believing that an interest in geoconservation comes after having had visited many geological localities—often by using guidebooks such as these.

In the modern idiom I also wanted the book and its excursions to be available in a variety of formats. Hence the effort to produce an ebook version (available as a Kindle version on Amazon) and also to make each excursion available on a smartphone (using the viewranger/outdooractive platform).

Islay is justifiably famous for its whiskies, and there seems to be a trend for pairing or matching the whiskies with all manner of things, so I jumped on the bandwagon and in the book selected a whisky (which in the main had some connection with the excursion) to be enjoyed after each walk. A bit tongue-in-cheek but nevertheless this was generally favourably commented upon. I have taken the whisky and geology connections a little further since, with an attempt to link the waters used in fermentation with the geology; a couple of distilleries use relatively hard water (from the areas of carbonate outcrop) whereas the majority use very soft water from the quartzite-dominated hills. Whether these pH differences make any discernible difference to the final whisky is a moot point, but I like to think it does. Apparently harder waters produce more esters and higher alcohols during a slower fermentation—so now you know!

So, what else motivated me to write a book apart from personal learning, whisky appreciation and providing introductory material for visiting students from Sweden. Well, I quickly realised that, through the Islay Natural History Trust, there was enthusiasm from those visitors and locals who are interested in all aspects of their natural surroundings for regular geology-themed walks (sometimes with whisky connections). I always enjoyed talking about geology and like to enthuse my audience about its wonders (sells a few books too!). I redid the geological displays in the Natural History Trust's Nature Centre, which provided another selling outlet too.

Niche books like this depend on authors doing their own promotion and I have given many talks to other societies, used social media extensively and struck up a good relationship with the excellent local bookshop (The Celtic House) in Bowmore, which is one of my best-selling outlets. I did some minor updates in 2017 and reprinted it. During lockdown I took the opportunity to thoroughly review the book and produced a third edition. My main lockdown project was, however, to produce a Volume II of the book to include the geologically related islands of Jura and Colonsay as well as some more excursions on Islay, concentrating particularly on the Port Askaig Tillite and the developing and ever-changing Snowball Earth story. Luckily, I had done all the field work prior to lockdown so I just had to sit down, draw the maps and write the text and get Roger and Alasdair to comment, edit and check my ramblings.

Volume II was launched in Summer 2021 at an Islay Book Festival outdoor event looking at the geology around the Lagavulin distillery. More geology and whisky connections here too, as the many

illicit stills (some of which became legal) were well hidden from the excisemen in the wooded glens eroded into soft metamudstones with hard metadolerite sills forming extensive intervening ridges.

I did all the layouts of the books myself, using Adobe Indesign and drew all the maps using the linked Abode Illustrator and also did the ebook versions. Ringwood Publishing provided proof-reading resources and friends and family also read and tested the walks. For all this help I am eternally grateful. Through Ringwood the books get into the trade distribution network and are available on their website and from Amazon.

Thus far I have sold about 1500 copies of the first book and over 200 of Volume II. That does not make me rich but hopefully I have provided some enjoyment and learning to the buyers of the books as well as learning so much personally about our wonderful science of geology.

Writing and researching the guide has resulted in getting involved with ongoing academic research on the island, in particular with Tony Spencer and Ian Fairchild on the Port Askaig Tillite Formation. The book has also led to many requests from local schools on Islay to do some geological activities with schoolchildren, often on some of the lovely beaches where the pebbles give us fascinating insights into the island's geology and geography. As a result of the books I have also been asked to give 'Zoom' talks to a number of geological societies both in the UK and Canada.

Fame (but not fortune) I never dreamt of when I started out with that dram with Alasdair in Port Charlotte.

***Right*: The author explaining the geological terms 'bedding' and 'cleavage' and their relationship on a geological walk at Kilchiaran Bay on the west coast of Islay. These rocks are part of the Colonsay Group: a sequence of metasedimentary rocks deposited about 750 million years ago and which are tectonically distinct and isolated from Islay's other Precambrian rocks.**

***Left*: Exposures of the Port Askaig Tillite on Islay with the quartzite peaks of the Paps of Jura in the distance. The Dalradian geology in this area is not only an excellent teaching resource but provides insights into late Precambrian geology, covering a fascinating period of time corresponding to a 'Snowball Earth' glaciation. Consequently the tillite is of major significance, and the subject of ongoing research, in the global context.**

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.

It can be downloaded free as a pdf file from www.earthheritage.org.uk. You can also purchase a hard copy of any issue via www.geologistsassociation.org.uk/earthheritage. Subscribe to notifications of new issues at www.earthheritage.org.uk/subscribe.

We thank all those who have assisted in preparing the publication, including the voluntary geoconservation sector who are major contributors. The opinions expressed by contributors are not necessarily those of the above organisations.

Until July 2022, the James Hutton Institute's Aberdeen site will host *COMPASS*, a sculpture by Scottish artist Annie Cattrell that draws inspiration from Scottish geology and James Hutton's *Theory of the Earth*, specifically Siccar Point's Unconformity.

***COMPASS* won the Scottish heat of Sky Arts' Landmark series, which sees artists from Glasgow to Guildford create a new wave of Great British public art. Find out more about Annie Cattrell's geologically inspired artwork on p.21.**

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