

th heritage **HERITAGE**
Earth **HERITAGE**
heritage

The geological and landscape conservation magazine



Watershed

New legislation will bring protection for marine geology

Issue
31

Winter 2008-09

Champions

New approach involves community in geoconservation

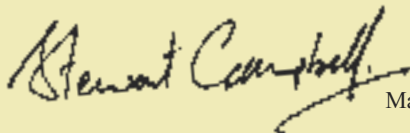
People power is the key

Geology and Geodiversity are often daunting subjects for people. Geoconservationists can gain much wider public support and enthusiasm for the subjects by drawing back the technical veil that shrouds them. Education and community working are two of the most effective tools, and reports in Earth Heritage 31 show we are using them adeptly. What better way to protect sites than letting local communities adopt them (p8)? How better to enthuse and engage children than to create free Powerpoint presentations for their teachers – on imagination-grabbing subjects like Plate Tectonics, the Ice Age, Dinosaurs, Volcanoes and Climate Change (p7)? How better to explain the origins of our landscape than through a free, web-based service that integrates cultural, historical, habitat, visual and geological information in a GIS-based system (p16)?

Protection of geological heritage is always at the forefront of our agenda. Big opportunities are provided by the Marine and Coastal Access Act (expected to become law in the summer; p3) and National Indicator 197 (p13). The legal proceedings concerning the Pakefield to Easton Bavents SSSI in Suffolk (p4) have received widespread but sometimes inaccurate media coverage. This landmark case has potentially massive implications for how we conserve coastal Earth Science SSSI. We will keep you posted!

Finally, as you might expect in this economic climate, Earth Heritage magazine is under scrutiny. We hope we shall still be able to publish it for you, but whether electronically or on paper is a matter for debate. I would be pleased to know readers' views.

Enjoy your reading!



Managing Editor

Earth heritage

Earth Heritage is a twice-yearly magazine produced by the Joint Nature Conservation Committee, Natural England, Scottish Natural Heritage and the Countryside Council for Wales. The voluntary geoconservation sector is a major contributor. We would like to thank all those who

have assisted with the preparation of the magazine. However, the opinions expressed by the contributors are not necessarily those of the above organisations.

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Offers of articles should go to the relevant members of the editorial board, who are:

Managing Editor

STEWART CAMPBELL, Countryside Council for Wales, Maes-y-Ffynnon, Ffordd Penrhos, Bangor, Gwynedd LL57 2DN.
Telephone 01248 387254,
e-mail: s.campbell@ccw.gov.uk

Editors

DAVID EVANS, Natural England, Northminster House, Peterborough PE1 1UA.
Telephone 01733 455204, e-mail: david.evans@naturalengland.org.uk

COLIN MACFADYEN, Scottish Natural Heritage, Silvan House, 231 Corstorphine Road, Edinburgh EH12 7AT.
Telephone 0131 316 2616,
e-mail: colin.macfadyen@snh.gov.uk

NEIL ELLIS, Joint Nature Conservation Committee, Monkstone House, City Road, Peterborough PE1 1JY. Telephone 01733 562626,
e-mail: neil.ellis@jncc.gov.uk

MICK STANLEY, Geodiversity Consulting, Park House, 8 King Street, Ripon, North Yorkshire HG4 1PJ.
Telephone 01765 609479,
e-mail: mick.stanley1@btinternet.com

CYNTHIA BUREK, UKRIGS Geoconservation Association, Centre for Science Communication, University of Chester, Parkgate Road, Chester CH1 4BJ.
Telephone 01244 513051,
e-mail: c.burek@chester.ac.uk

Production

Seabury Salmon, Seabury Salmon & Associates, The Old Pound, Ludford, Ludlow, Shropshire SY8 1PP.
Telephone 01584 877442,
e-mail: eheritage@seaburysalmon.com

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Limestone pavements: Seeing the whole picture – p18



Marble Arch Caves Global Geopark: Earth Science without borders! – p20

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Cover photo



Cwm Idwal is one of the best-developed features of glacial erosion in Wales. It is a large, north-east-facing cirque occupied by Llyn Idwal and a complex of glacial and periglacial deposits. Its multiple designations (European Special Area of Conservation, Ramsar Wetland of International Importance, National Nature Reserve and Site of Special Scientific Interest) reflect its outstanding importance for scientific research. Little wonder then that Cwm Idwal figured in the seminal works of Charles Darwin and was fundamental to the establishment of the Glacial Theory in Great Britain. Although Darwin is best known for his book *The Origin of Species*, his life and his theory of evolution are inextricably linked with geology. To mark the bicentenary of Darwin's birth, the Geological Society is offering open access throughout 2009 to the 10 papers he published with it – three in the *Transactions of the Geological Society of London* and seven in the *Quarterly Journal of the Geological Society*. See www.geolsoc.org.uk The Natural History Museum is also hosting the biggest ever Darwin exhibition. See www.nhm.ac.uk

Photo by Stewart Campbell

New protection for marine geology



Geology heads out to sea – Redcar Rocks, Redcar and Cleveland

Photo by Jonathan Larwood/Natural England

The Marine and Coastal Access Act, announced as a Bill by the Queen at the State Opening of Parliament in December 2008, is expected to become law by summer 2009.

The Bill introduces a new mechanism for the designation of a network of marine conservation zones (MCZs). Although primarily for conservation of marine flora and fauna, geological and geomorphological features may be designated as part of offshore MCZs. The Bill may also give powers to extend some coastal SSSIs below mean low water to protect important features or processes further.

Overall, the Bill sets out the Government's new approach to the better management and protection of our seas. It is intended to make a major contribution to delivering the Government's vision for clean, healthy, safe, productive and biologically diverse oceans and seas.

The Bill covers the English and Welsh Territorial Sea (waters out to 12 miles offshore) and in UK seas from 12 miles offshore to the edge of the continental shelf or to the extent of British Fishery limits (200 miles offshore).

MCZs will be selected by four Regional Marine Conservation Zone projects. These partnership projects will work with stakeholders to identify possible MCZs which are based on sound science, and to

minimise socio-economic costs. The projects have the support of regional maritime stakeholders.

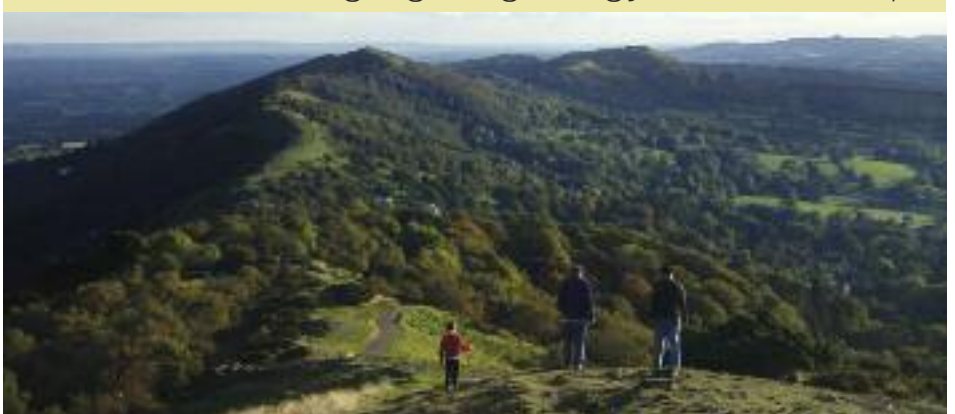
The projects will plan the location, size, shape and protection level of MCZs around the coasts and seas of England and Wales from high-water mark out to the edge of the continental shelf. The first of these projects to be established is *Finding Sanctuary*, in the south-west. Other projects are planned to include the Eastern Channel, the North Sea and the Irish Sea.

The Bill will also introduce new powers to extend recreational access to the English coast. It will give people the right to walk around the whole of the English coast (subject to some exceptions) with access to areas such as beaches, headlands and cliffs.

Find out more at www.finding-sanctuary.org/ and www.defra.gov.uk/marine/legislation/

– *Hannah Townley,*
Natural England

Malvern festival highlights geology and landscape



The Malverns

Photo by Natalie Watkins

The flagship event of the 2009 Malvern Walking Festival will be the first guided walk along the full 109 miles of the Abberley and Malvern Hills Geopark Way (pictured above – see *issue 30*), running from Bridgnorth, Shropshire, to Gloucester. Also among the 36 walks planned for the festival (30 May - 7 June) are nine that cover individual sections of the route. This is the first long-distance trail in the UK to introduce walkers to geology and landscape. The organisers are providing transport where necessary but all walkers must pre-register. For more information go to www.malvern-hills.info or phone 01684 892289.



Bill Dalgarno and Janet Trythall, Elgin Museum volunteers, with a reconstruction of an Elgin reptile, *Elginia mirabilis*, and the plaque.
Photo by Elgin Museum

Significant accolade for fossil collection

The fossil collection of Elgin Museum, Moray, has won the accolade 'Recognised Collection of National Significance to Scotland' from the Scottish Government.

The award helps raise the profile of Elgin Museum and also allows it access to the Recognition Fund. Funding is being sought to improve the Geology Store and provide new interpretation of specimens following recent research. It is hoped that better lighting of the reptile footprints and additional models will make the collection even more accessible.

Elgin's collection has long been recognised, both near and far, for example by T. H. Huxley in London and Louis Agassiz in Switzerland, back in the mid-19th Century.

In 2007, the Devonian fish and the Permian and Triassic reptiles were the focus of the conference 'Sea to Sand', when the speakers were all eminent palaeontologists with a long association with Elgin's fossils. It was the general enthusiasm during the conference that encouraged two of the Museum's volunteers to submit the successful application for Recognition, one of only 33 in Scotland, and the first for a fossil collection.

Elgin Museum is 'closed' for the winter, but still open by appointment: telephone first (01343 543675) or e-mail: curator@elginmuseum.org.uk.

There will usually be staff or volunteers working who can let you in – and donations are always welcome, as are new volunteers who would like to help in the Museum.

– Janet Trythall, Elgin Museum

Shetland growing in

Shetland's bid to become a UNESCO European Geopark is progressing well. Geopark Shetland's application has been favourably received by the European Geoparks Network, while on the ground the programme of Earth Science

interpretation is well under way, with the development of a series of geo-art exhibits, panels and trails.

Geological walls created by local craftsmen on Fetlar and at Mavis Grind are the first of a series of



One of the geo-art exhibits at Eshaness. This work by Alan Hart represents an eruption of a vesicular lava flow and later growth of agates within the vesicles.
Photo by Robina Barton, Shetland Amenity Trust

Conservation judgement open to appeal

On 5 December, 2008, Mr Justice Blair gave his judgement on a challenge to the notification and confirmation of part of the Pakefield to Easton Bavents SSSI in Suffolk.

The case, involving attempts by a local resident to construct a 'home made' coast protection scheme to protect his property from natural erosion, is extremely complex, and occupied three days of court time.

The judge agreed with Natural England that the site was of national geological importance and endorsed Natural England's approach to the notification of such coastal sites that are being eroded.

He did, however, uphold the challenge that the notification was a 'plan or project' under the Habitat Regulations and therefore needed an 'appropriate assessment' of the impacts of the SSSI designation on other wildlife interests.

Although the case has received wide and, at times, inaccurate media coverage, the judge has given both parties the opportunity to appeal. Further comment is reserved until the judicial proceedings have taken their full course. The full judgement is available at www.geoconservation.com/findoutmore/news.htm

– Colin Prosser, Natural England

to European Geopark



The Eshaness coast (cliffs and stacks in late Devonian andesite lava and tuffs) with coastal erosion in progress. Photo by Jonathan Swale/Scottish Natural Heritage

geological exhibits planned throughout Shetland to introduce visitors to the rocks and geological structures of Shetland's main islands.

Interpretative panels have been set up to provide more detailed information at many other key sites, whilst the first of several planned trails will soon be launched, taking visitors on a self-guided tour around the stunning volcanic coastline of Eshaness.

These developments are only the start of the process of making Shetland a world-class area for geotourism, to mirror its fame as a wildlife-watching destination.

The geopark's website, www.geoparkshetland.org will be launched early in 2009. You can also contact robina@shetlandamenity.org for more information.

Successful geodiversity poster series to be extended

A series of 12 posters produced by Scottish Natural Heritage to raise interest in, and awareness of, Scotland's remarkable geodiversity (*issue 28*) has been so successful that it has been reprinted and will be extended by a further eight posters.

The additional posters will be produced under the new SNH brand and will include explanations of dynamic river systems, coastal landscapes and glacial landforms featuring famous locations such as the Carstairs Kames. As with the first posters, they will be targeted mainly at a young audience. The extended series of geodiversity posters will be available free to schools and other educational establishments on request during the summer of 2009. Contact colin.macfadyen@snh.gov.uk.



Transformation of the Royal Museum

Exhibits focusing on geological processes will be featured in two new galleries currently being planned by National Museums Scotland. The major renovation of the Royal Museum of Scotland building in Edinburgh, due to open in 2011, will bring geology to life in an exciting and innovative way. Learn more about these new exhibits in the next issue of *Earth Heritage*.

Seminar will probe geology and climate-change impacts

The Geoconservation Commission of the Geological Society of London and the UK's conservation agencies are convening a seminar to consider the best options for conserving geodiversity in a changing climate.

The day-long event is scheduled for the University of Chester on 4 June 2009 and will examine:

- the impacts of climate change and how they will affect sites that are valued for their geological and geomorphological interests;
- the implications for the future management of sites; and
- how geomorphological processes in the wider landscape will adapt under this changing regime.

Participants will be geoconservation practitioners (the national conservation agencies, RIGS groups, geology trusts, geodiversity academics, conservation bodies and others) and the seminar will contribute to the UK Geodiversity Action Plan.

Keynote speeches will cover future climate-change scenarios from the UK Climate Impacts Programme (UKCIP), likely social and economic changes and the impacts on physical processes. A summary of the work done to date in relation to impacts on geodiversity will also be provided.

Workshops which follow will apply this information to a number of broad geodiversity types, including exposures, active processes, integrity sites and soils. The workshops will identify key issues, research and monitoring requirements, and communication needs to promote a wider understanding of conserving geodiversity in a changing climate.

Further details including venue and programme are available on www.geoconservation.com/findoutmore/events.htm or by contacting Naomi Stevenson tel: 01733 455229

There's a rich seam of new material to generate enthusiasm for geology and geological conservation among teachers and pupils alike, as *Earth Heritage* contributors point out.

Earthlearningidea growing fast

www.earthlearningidea.com, the website of free ideas for innovative geological teaching, had received almost 10,000 visits from 120 countries by the end of 2008 and is seeking contributions which will continue to build the site throughout 2009.

The site (run by Chris King, Peter Kennett and Elizabeth Devon, all from the Earth Science Education Unit, Keele University) is aiming to publish one new activity per month in 2009.

The site is available in English, Spanish, Italian and Norwegian and the organisers want to hear from anyone willing to translate the material into other languages.

A new page, 'ELI around the world', shows the countries and cities where Earthlearningidea is most used.

Visitors are also invited to evaluate the ideas in the site; the results of these evaluations should help future educators to use their time and resources most effectively to support global learning.

The posts on the blog earthlearningidea.blogspot.com reveal enthusiastic endorsement of the materials from all over the world.

Learning at Loggerheads

Loggerheads Country Park, near Mold, Flintshire, is the subject of new material to help teachers use Earth Science as a vehicle to teach the National Curriculum Key Stages 2-3. The material focuses on the Carboniferous limestone, limestone pavements and building materials found at Loggerheads. It encourages teachers and pupils to try to understand the landscape, how it was formed and the changes that have happened over time. The pupils are encouraged to observe, record, compare and interpret the geodiversity and biodiversity at different localities.

The resources have already been trialled and are

endorsed by the Primary Science Advisor for Flintshire, Denbighshire and Conwy County Councils. The material is available in both English and Welsh and downloadable at www.ardenel.co.uk

More details and site bookings via: Jacqui Malpas jmalpas@geodiversity.co.uk or Gail Bale enquiries@ardenel.co.uk



This photo is from Earthlearningidea 'High flow, low flow: atmosphere and ocean in a tank. Hot, cold and particle-filled density currents as they flow in the atmosphere and ocean'. Photo by Peter Kennett

Inspira for

Progressing opportunities in Scotland

This is an exciting time in Scottish education with the new curriculum framework, 'A Curriculum for Excellence', being implemented from August 2010. One aspiration is to broaden the range of learning experiences and to recognise achievements beyond exams. In secondary schools, the new curriculum will provide opportunities for interdisciplinary work, encouraging teachers from different curricular areas to work collaboratively. The new curriculum will also be less prescriptive, allowing teachers more flexibility in what they teach.

In this crucial development phase of the Curriculum for Excellence, the Scottish Earth Science Education Forum (SESEF) has been engaged with teachers in reviewing and commenting on the content and in preparing new teaching resources. Because Earth and environmental sciences are fundamentally interdisciplinary, they play a key role in bringing the sciences, chemistry, physics and biology together with mathematics, geography and technology. The most recent of SESEF's resources provide exemplars of cross-curricular working for teachers.

The curricular developments run alongside increased recognition of the value of outdoor learning in the development of young people. The 'Learning Outside the Classroom' manifesto highlights such benefits.

Earth Science Outdoors

The Earth Science Outdoors project aims to support outdoor education by encouraging teachers and group leaders to explore their local geology and discover the connections between the rocks and the landscape, and links with resources, history, land use and climate change. In the pilot phase, we are developing teachers' guides at different educational levels for 10 geological sites in two areas of Scotland. Several of these guides are available on our website, www.scottishgeology.com/SESEF/ and more will follow.

SESEF is also promoting lifelong learning by working with partners such as countryside rangers, RIGS groups and science centres to



Edinburgh school pupils get to grips with an outcrop at Arthur's Seat. Photo by Paula Mouton-Sinclair

ations education



produce resources that will encourage families, groups and individuals to find out more about their local area. We want to bring the landscape 'background' to life. It is integral to the beauty and diversity of Scotland, and to people's enjoyment. This landscape has been billions of years in the making and there is an incredible story to tell. The story runs from the formation of rocks to the way that people have used the land and its materials, changed the landscape, and been influenced by it.

SESEF is working with Our Dynamic Earth Science Centre in Edinburgh on a unique continuing professional development (CPD) event for primary school teachers. 'Ice Age Free – A Mammoth Adventure into Scotland's Past, Present and Future', aims to enable participants to deliver the new science curriculum in a fun, refreshing way. The events take place in February and March 2009 and all Scottish primary teachers can attend.

In partnership with the Scottish Qualifications Authority and the Higher Education Institute for Geography, Earth and Environmental Sciences (GEES), SESEF held a successful secondary teacher conference in Aberdeen in May 2008 that attracted a large number of teachers from across Scotland. Many expressed interest in starting to teach geology at qualifications level. In response, SESEF aims to expand its programme for secondary teachers who are – or plan to – teach geology at qualifications level. The Earth Science Outdoors resources will play an important part in this support.

SESEF has ambitious plans to develop further novel resources and events in 2009 and beyond. We invite anyone with an interest in Earth Science and education in Scotland to join us – for free – and be part of this dynamic movement.

Further information:

[SESEF www.scottishgeology.com/SESEF/](http://www.scottishgeology.com/SESEF/)
www.ltscotland.org.uk/curriculumforexcellence/
www.lotc.org.uk
www.dynamicearth.co.uk/index.asp?pg=125

– Catherine Morgan and Angus Miller,
Scottish Earth Science Education Forum

Powerpoint to the pupils...

Radiometric dating (8): Meteorites

Canyon Diablo meteorite

Crab Nebula

• Radiometric age of meteorites date the formation of the Solar System and Earth (4550 million years old)

Five new talks for free use in engaging children with the Earth Sciences are available from the Your Planet Earth site, www.earth4567.com

The new themes are: Oil and gas; Geological Time; Ice ages; The history of life; and Evolution. These sit alongside the first five talks, on Volcanoes, Dinosaurs, Natural hazards, Plate tectonics, and Climate change.

Earth4567 (named after the current best estimate of the age of the Earth, in millions of years) is aimed at students, teachers, and others who want to present talks on key Earth Science themes.

The talks are standard Powerpoint packages, designed to last from 45 to 50 minutes. Each is divided into three segments – an introduction with striking observations, and two additional themes. The two pauses in each talk allow the presenter to insert discussion topics. For some of the talks, we offer simple calculations or puzzles that the children can think about and discuss in groups, before the talk resumes.

The talks are copyright-free, so they can be used freely by anyone, in any form. The photographs have all come from public sources, or from individuals and organisations that are happy to share their

images freely. Most of the diagrams have been prepared specially for the talks, so we simply donate them to the world. This means that educators and others are free to edit the talks, personalise them with their own logos or additions, or even translate them into another language.

There is also a training module. If an Outreach/Engagement Co-ordinator wants to train a group of students to give effective talks in schools, a short Powerpoint talk, with exercises, can be used for training. This training module is based on the combined experience of people who have delivered geology talks in schools for many years. It reminds students of the need to prepare, to be engaging, and to pitch the talk appropriately. There's nothing worse than a poorly presented talk: the children are keyed up and excited about the visiting speaker, and then they can be badly let down if it is not well done. Universities and colleges can help their students acquire valuable communication skills through such a scheme.

The earth4567 initiative is a part of the educational programme of the Geologists' Association and the Geological Society, with initial funding from Shell.

– Mike Benton
University of Bristol

Innovative project aims to involve com

One of the most innovative projects in UK geoconservation is now six months into a three-year programme. The pioneering 'Champions' initiative funded by the Heritage Lottery Fund to set up a network of Community Earth Heritage Champions, is making excellent progress.

Eve Miles

Herefordshire and Worcestershire
Earth Heritage Trust

The project aims to involve the people of local communities in Herefordshire and Worcestershire in monitoring, conserving and utilising their own local sites of geological and landscape importance. Partnerships are being created that will ensure the continuing conservation of these sites. Twenty Local Geology Sites (RIGS) have been selected throughout the two counties and local public meetings are spreading the word about the geological importance of the sites and the importance of their conservation. Local people are being invited to volunteer to monitor the sites and 'champion' them.



Schoolchildren fossil hunting at Whitman's Hill Quarry, one of the sites short-listed for the Project.

Champi



Working with the National Trust at the Green Festival in the Clent Hills to let people know about the Champions Project.

Through the project, the Earth Heritage Trust will offer and run training courses for the 'champions' about conservation topics, including understanding geology, health and safety, site recording and specimen curation. The project will also develop working partnerships with Herefordshire Heritage Services and the University of Worcester to deliver the sessions, as well as offering general support. It is hoped to have at least 200 local people involved in the overall programme with many of these participating in the training courses.

The Trust will also encourage the 'champions' to persuade local groups (youth, heritage, schools, WIs, clubs, etc.)

to adopt a site and become actively involved in conserving and using it for educational and/or recreational purposes. Since starting in April 2008, there has been much enthusiasm and support, not only from local communities, but also from other county geoconservation groups as well as national agencies such as the Forestry Commission and Natural England. Communities will be encouraged to develop their own ideas for the sites. So far suggestions include photo competitions, fossil and bug hunts, landscape painting, guided walks, exhibitions, displays and talks.

The 20 sites (with a few in reserve) were chosen according to the following criteria: active community, interesting geology, good accessibility and safe access. Sites that met these criteria were short-listed, and the Trust made the final selections. The locations are spread across the two counties. They also take in a variety of geological periods, from the Precambrian of the Malvern Hills and the Ordovician quartzites of the Lickey Hills, to the Silurian fossil-rich limestones

of the Woolhope Dome and the Carboniferous limestone pavement in the Wye Valley. Many of the sites are in the Abberley and Malvern Hills Geopark, which is providing considerable support. Geopark partners actively participating in the project are Bewdley Museum, the Forestry Commission, Malvern Hills Conservators and the University of Worcester.

Herefordshire Champions

Despite most of Herefordshire being underlain by Devonian Old Red Sandstone, we have ensured that the sites cover a wide range of geology as well as a large geographical area. One of the short-listed 'Champions' sites in Herefordshire is Linton Quarry, near Ross-on-Wye, a



Nearly all the sites have a building stones link. A barn wall makes an interesting study.

All photos by Herefordshire and Worcestershire Earth Heritage Trust





An exposure of Permian Bridgnorth Sandstone at the Severn Valley Railway Station in Bewdley.

on idea

Silurian limestone quarry where the Gorsley Limestone, Ludlow Shales and the Downton Castle Sandstone formations are exposed. Since being abandoned, this site has become a great example of how wildlife and geology interact. Lime-loving plants now colonise the quarry, and marsh species occupy boggy areas. The quarry needs a lot of work to make it accessible to the public and one of the first goals for the Champions will be removing vegetation from parts of the rock face to re-expose the geology.

This site has involved an enthusiastic Parish Council and support from the local Natural England office.

Linton Quarry, Herefordshire – ready for a facelift through removing some of the vegetation.



Worcestershire Champions

Worcestershire covers a wide range of geological ages and rock types, and as such we have attempted to reflect this in the sites short-listed for the project.

The grey Aymestrey Limestone of Shavers End Quarry in the Abberley Hills, with red Raglan Mudstone Formation forming the low ground beyond.



One of the short-listed sites for Worcestershire is Bewdley Town. Unlike other ‘Champions’ sites, Bewdley is a collection of smaller geological exposures and building stones. Among these small sites are the building stones of Bewdley, such as Bewdley Bridge and St Anne’s Church, and geological exposures including those at the Severn Valley Railway Station and viaduct and an exposure near the Ramada Hotel. This site demonstrates the inextricable links between the varied geology and building stones around Bewdley.

And finally...

The project itself is progressing very quickly, with local landowners signing up to be involved and even suggesting potential events to be run at the sites. It is good to see that people outside of the geological community appreciate the geology and the importance of conserving these precious sites. This is one of the great outcomes of the project so far.

We are now actively looking for people in the local communities around these sites to become ‘Champions’. If anyone is interested in becoming involved with the project or would like to know more about the sites in their local area, contact me.

I work as the Champions Project Manager at the Trust, tel: 01905 542014, or e-mail e.miles@worc.ac.uk. ■

Exemplary collaboration uncovers new information



If one were asked which industry had most influenced the Dundee area of the Midland Valley of Scotland, jam, jute and journalism would all be passable answers. However many of the factory buildings which housed these industries owed their existence to a less appreciated, but equally significant, 19th Century trade that uncovered a wealth of fossils.

In the 1800s, the Dundee to Montrose area was pock marked with pits and quarries. These supplied building stone ranging from massive sandstones for building blocks to layered stone which could be cut for doorsteps and lintels, and thinner laminated slabs which were used as paving stone. This laminated flagstone was used so widely, perhaps paving entire towns, that it became known as Arbroath Pavement.

As they worked the stone, the quarrymen noticed the fossil remains of strange

Robert Davidson Aberdeen University

creatures in the rocks and gave them names, on occasion reflecting romantic notions. Fragments of an ancient crustacean were called seraphim due to surface details being reminiscent of cherubs' wings. A fossil plant with round spore capsules was dubbed 'puddock spawn' due to its similarity to frog eggs. Remains of a curious fish with a horseshoe-shaped skull were also occasionally found. These primeval fish and crustaceans lived in a river-fed lake environment that existed during the Lower Devonian, around 410 million years ago.

Dundee's Fossil Quarries

Several small 19th Century quarries can still be seen today in the Den of Balruddery, east of Dundee. These were probably quarried

The 'Balruddery Fossil Team' consisting of researchers from Aberdeen University, staff from the National Museums Scotland, and amateur collectors and researchers.

for walling stone, and, according to the farm owner, perhaps used to build the farmhouse.

In 1840, the then landowner, Mr Robert Webster, assembled a large array of fossils collected during quarrying. In Edinburgh, these were examined by a gathering of the most eminent fossil experts of the day, including the celebrated Swiss naturalist, Professor Louis Agassiz, who pronounced that some of the remains were from a huge lobster! This event was recorded by Hugh Miller, in his best-selling 1841 book 'The Old Red Sandstone' where he describes the Den of Balruddery as a beautifully wooded dell where the horseshoe-headed fish *Cephalaspis* is found in association with the remains of a giant crustacean.

The head of a cephalaspid fish, now known to be new to science, found at Balruddery. This is one of the new finds from the old quarries, where important discoveries were made in the 1800s.

Photos by Robert Davidson



James Powrie Laird of Reswallie, a pioneer of 19th Century palaeontology and a leading figure in early Scottish geology, published at least 15 papers on the geology and fossils of the area from 1860 onwards. However, the collecting of fossil material and associated scientific work came to an end in the late 1800s as quarrying ceased. After Powrie's death in 1895, his collection was deposited in the National Museum of Scotland.

Collaboration, Rediscovery and New Research

After at least a century in which nothing was collected from the Balruddery quarries, a team from Aberdeen University embarked on a search for these once prolific fossil beds and since 1990 these localities are being rediscovered.

The first of the Balruddery quarries was reopened in 1999, the second in 2004. Balruddery Den is the latest site to be reopened and its fossil resource once again revealed. The specimens from here are now yielding exciting new evidence not only about the fossils but also about the fossil beds and the environment in which they were deposited.

This work represents a successful collaboration between amateur and professional palaeontologists and has received help and support from the owners of the quarry land. When the land changed hands, the new owner also embraced the importance of the site and its fossils and sanctioned further excavations by the National Museum of Scotland and the Aberdeen University team. This has yielded specimens of a new species of zenaspid fish, fin spines of undescribed acanthodian

fish and new information on the nature of the ancient environment and palaeogeographic connections.

All the area's fish beds contain thin bands of clay that James Powrie had used, erroneously it is now known, to correlate the beds as a single stratigraphic horizon. The new research published by the Aberdeen team has identified these as preserved volcanic ash falls. The volcanic clasts in the underlying sandstone and clay bands in the fish bed at Balruddery present a picture of violent volcanic activity that affected the river and lake system environment from time to time. This new evidence and its impacts on the Midland Valley environment and connections to other areas will shortly be published.

The Future

After a break of over 100 years the old stone quarries are again yielding valuable information. The Balruddery Den locality has added significant new insight to our understanding of the Lower Devonian fauna and environment of Scotland. The new landowner has continued his support of the work that the Aberdeen team is performing and has set aside some 100 square metres of new exposure for future research. All concerned have approached the excavation of this fossil resource in accordance with the guidance contained in the Scottish Fossil Code (www.snh.org.uk/fossilcode). The collaborative effort is set to continue and Balruddery's potential for research and education therefore seems assured. The work underscores the conservation value of old quarries and their importance to modern geological research. ■

BALRUDDERY – A SEMI-DESERT WITH A LAKE

Based on the work at the rediscovered sites it is now possible to reconstruct the early Devonian environment and habitat of the Balruddery fish that existed around 410 million years ago.

The landscape would have been semi-desert with meandering rivers. As few plants had evolved, the only land animals would have been arthropods. The dominant higher life forms were predatory fish that coexisted with crustaceans varying in size from tiny to true giants. The creatures lived in rivers that fed a large lake and in the lake shallows.

The ancient lake, named Lake Forfar by the Aberdeen-led team, may have stretched for 32 miles from Dundee to Montrose and was under ever-present threat from active volcanoes. The evidence shows that Lake Forfar was formed suddenly and may have been caused by a lava flow damming a river or by the ground tilting during tectonic activity. Successive volcanic eruptions were recorded by the presence of volcanic clasts in the sandstones and ash falls, which can be seen today as clay bands in the shales. Life in the Scottish Lower Devonian was therefore precarious and under constant peril from its own environment.

Rock art – captive or free-range?

One of the rewards of walking in England's uplands is to come across rock-art sites. Even though we don't have much idea what cupmarks and ringmarks mean, they communicate from the distant past in a very direct way. But how much longer will they survive? Should we leave them unprotected?

Prehistoric rock art dating from the Neolithic and Bronze Age (between 6,000 and 3,000 years old), is found in many upland areas in England where rocks are reasonably hard and resistant to erosion; new discoveries are turning up all the time.

The individual elements are usually fairly simple and abstract, but they are often combined in patterns and sometimes in large complex panels; in some areas, like Ilkley Moor, dozens of rock-art sites have been recorded. They are often hard to spot now, but when freshly made, the pale freshly pecked cupmarks, ringmarks and grooves would have stood out and been visible from a long way off – perhaps one reason why signs of re-cutting can often be seen was to make them stand out clearly again once they had become a little weathered.

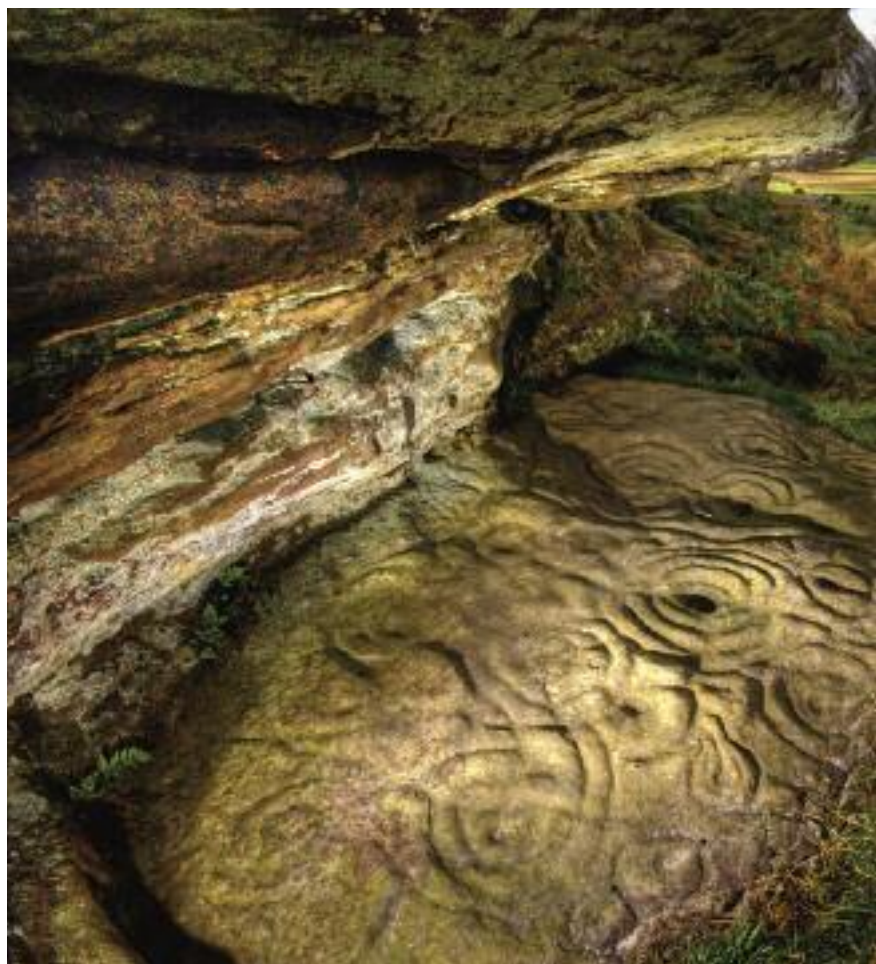
The romantic in most of us wants to leave rock art to be seen in its context, without the clutter of protective screening, interpretative signs, or restrictive walkways. Rock art removed from its setting is all too often a sad sight. But heritage managers (awful phrase) want to make rock art more accessible; and are concerned that it may be damaged by vandals, vehicles, animals and plants, and from chemical and physical erosion; and there is evidence suggesting that erosion rates may have increased recently. At the moment we don't know how serious the problem is: we don't know how quickly rock-art sites are deteriorating, and don't have any reliable way of telling which sites are most vulnerable.

A recent pilot project, the Northumberland and Durham Rock Art Pilot Project (NADRAP), has made a start by recording rock art in those counties in detail to establish a baseline against which to be able to measure future damage. For more information see:

<http://archaeologydataservice.ac.uk/era/>

One idea is that vulnerability depends on cracks and voids behind the rock surface; a second project, which will be advertising shortly for a research student, plans to use nuclear magnetic resonance and other advanced imaging techniques to try to detect and measure these voids and cracks in the field. ■

For further information contact
sebastian.payne@english-heritage.org.uk.



Above: The location of this rock-art panel is unusual. Ketley Crag Rock Shelter is about two-thirds down a steep, bracken-covered slope of the Fell Sandstone Group. The decorated panel is the base of a small, shallow shelter formed from the crag. *Photo by Brian Kerr*

Right: This attractive, distinct pair of side by side cup and ring motifs has distinct radial grooves. The bottom halves of both motifs were covered in pine needles. The work is at its original location, on private land near Berwick upon Tweed. *Photo by NADRAP*

Below right: This panel was discovered around 2004 near Belsay, where a contractor saved it from destruction by transporting it on his JCB and dropping it onto an old sofa in the grounds of his farm. It has now been placed as a feature on a gravel base outside the farmhouse near Gateshead. The actual find site is not known. It may have originally been outcropping rock or a detached slab, possibly from a cist. *Photo by NADRAP*

Below: This carved sandstone boulder on open-access land at West Lordenshaw, near Alnwick, Northumberland is on a dominant viewpoint, with the whole range of Simonside and Cheviots visible, and to the north-east the land rises gently to a hillfort. It is unlikely to have been the only marked outcrop along this ridge; nearby is a massive quarry hole from which a similar-sized block has been removed. *Photo by NADRAP*



**Sebastian
Payne**
English Heritage



Opportunities knock for geoconservation

Jonathan Larwood, Natural England

In 2006 Defra issued *Local Sites – guidance on their identification, selection and management*. It emphasised that ‘Local Sites’ should include both geology and wildlife, both of which should be given equal priority. This has raised the profile and importance of Local Geological Sites, but where has this led?

The Defra Local Sites guidance can be found at:

www.defra.gov.uk/wildlife-countryside/pdf/protected-areas/localsites.pdf

NI 197 – improved local biodiversity

With a new, more streamlined local government performance framework in place, a 198-strong national indicator set now measures progress made on national priorities under local area agreements.

The important one for us is National Indicator 197 – Improved Local Biodiversity. Whilst the headline is on biodiversity, the importance for geology is this: local authorities are obliged to show whether positive conservation is being carried out on Local Geological Sites. NI 197 is measured as a simple percentage – the proportion of Local Sites in a local authority area where conservation management has been implemented during the last five years, or is being undertaken.

NI 197 is a further opportunity for geoconservation groups to offer their local authorities and local site partnerships information about managing Local Geological Sites and, where appropriate, to guide and support that management. NI 197 will also contribute to the overall delivery of Local Area Agreements and the local government performance framework.

More information about NI 197 can be found at:

www.defra.gov.uk/environment/localgovindicators/ni197.htm

Condition monitoring

In 2008 Herefordshire and Worcestershire Earth Heritage Trust, supported by UKRIGS and Natural England and after consulting RIGS Groups and Geology Trusts, developed a standard condition monitoring form (and guidance notes) for Local Geological Sites. It sets out a range of condition categories from ‘good’ to ‘poor, declining or lost’ and includes a section for users to record what management is required to establish or maintain a site’s desired condition.

Consistent reporting of the condition of Local Geological Sites is long overdue and hopefully this standard will be widely adopted. It should be ideal for reporting on NI 197’s conservation management details, with categories directly relating to whether management is planned or is being undertaken.

Downloads of the condition monitoring form and guidance notes are at: www.ukrigs.org.uk/html/ukrigs.php?page=downloads&menu=main

And finally – LGAPS...

Issue 30 of Earth Heritage reported on Natural England’s review of Local Geodiversity Action Plans in England. The full report – *NERR 027 – Local Geodiversity Action Plans – a review of progress in England* is available now on the Natural England website: www.naturalengland.org.uk/research/default.htm

More information from Jonathan Larwood,
Jonathan.Larwood@naturalengland.org.uk

Flooding and geology conservation add Co-ordination in action

E. Alice Johnson

Royal Haskoning

Colin MacFadyen

Scottish Natural Heritage

The development of a flood protection scheme on the Ayrshire coast demonstrates that safeguarding a town from flooding need not necessarily lead to the loss of its nationally important coastal rock exposures.

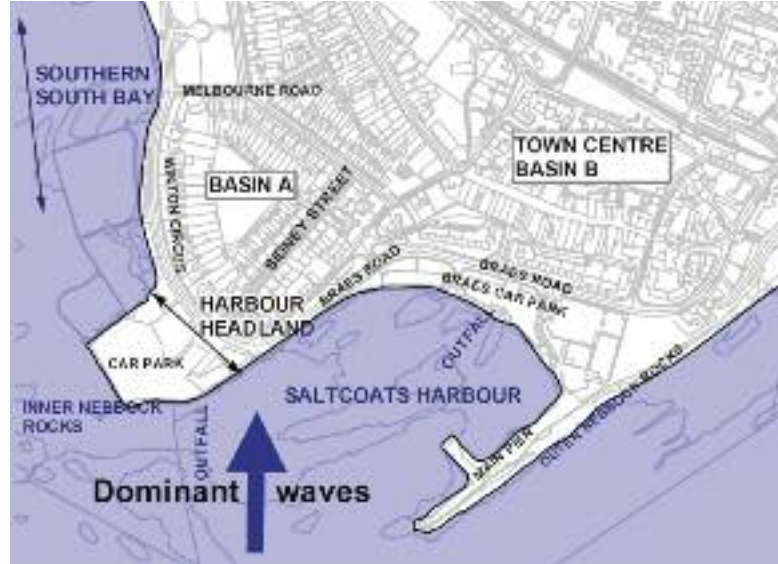
The town of Saltcoats began as a late medieval salt-producing and fish-curing village. Abundant supplies of coal, originally exposed at outcrop, were burned to boil seawater to produce the all-important salt. However, its low-lying coastal location has meant that Saltcoats has suffered a long history of flooding, with 345 homes and businesses at risk.

South-westerly waves hit the top of the harbour and sea walls at angles that cause both incoming and reflected waves to combine, increasing the wave height and the volume of water coming over the wall. The problem is exacerbated by land behind the walls which gently slopes away from the coast [into the town centre (Basin B) and towards the headland (Basin A) – see map] so the incoming water floods these basins, causing widespread damage to property and shops. This flooding would be expected to increase with the predicted increase in sea levels.

North Ayrshire Council employed Royal Haskoning (Civil Engineers and Environmental Consultants) to examine the flooding issue and to develop an appropriate solution. A wide range of initial options was narrowed down to three feasible solutions:

- raising the height of the seawalls;
- construction of a rock revetment to break up the waves just before they hit the

- harbour walls; and
- construction of rock breakwaters to break up the waves and create more sheltered areas behind.



An initial consultation with Scottish Natural Heritage (SNH) highlighted the geological significance of the area, which is a designated Site of Special Scientific Interest (SSSI) for the occurrence of Permo-Carboniferous igneous intrusions. Several stands of fossil tree stumps augmented the geological interest of this nationally important site.

Although effective in flood prevention, each of the three options inevitably had detrimental aspects, including: damage to and loss of the nationally important rock exposure; loss of sea views for residents

and visitors; appearance of the rock defence structures; and future adaptability of the scheme. Further consultation established that the construction of three rock breakwaters was the preferred option, just edging out increasing the height of the sea walls, with rock revetment being the least preferred option. Further modelling and design work reduced the number of breakwaters to two.

SNH recognised that the flood prevention scheme was necessary due to the severity and impact of flooding on the local community. In further discussions, it was



The seawall at Saltcoats Harbour and intertidal exposure before construction begins. Waves overtopping the wall here have flooded the town. All photos by Colin MacFadyen unless stated otherwise

ressed at Saltcoats



A view of the outer breakwater under construction in a gap between geological features of interest within the SSSI. Photo by E. Alice Johnson

agreed to conserve the actual geofeatures of the SSSI and to minimise damage to their surroundings. In addition to these conservation issues, there was a request to improve access to the foreshore for research and education and to provide interpretation to increase awareness of the SSSI's geological features. Consequently the detailed design of the scheme incorporated a number of geological conservation considerations, including:

- ensuring that the breakwater rocks were kept in place by specially developed concrete ground beams that were secured to the intertidal rock exposure, rather than by entrenching the bottom rocks of the structure. Entrenchment would have caused significant disturbance of the rock over a large area beyond the 'footprint' of the breakwaters;
- locating the outer breakwater in a gap just between key exposures;
- having a short Y-shaped inner breakwater that would not disturb the fossilised tree stumps in the middle of the harbour but would still offer maximum protection from the waves;

- prevention of construction machines tracking over much of the important geology;
- construction of additional steps and viewing areas on the inside of the breakwaters to improve amenity and access on the foreshore; and
- development of a plan for geological interpretation panels.

The local regeneration company has contributed to the design of the interpretation. It has also contributed a number of white marble rocks from Ullapool in the Northwest Highlands that have been included in the breakwaters. The contrast of the white marble against the dark igneous rock forming the bulk of the breakwaters (see image above) represents salt and coal, the basis of the town's economy in medieval times.

In an engineering project such as this, several consents and licences are required before construction can start. These include planning permission, Coastal Protection Licence and a Food and Environment



Two of the fossil tree stumps in Saltcoats Harbour. Demonstrating tree growth density in a Carboniferous forest environment, these fossils continue to be a valuable research and educational resource.

Protection Act (FEPA) licence. The FEPA licence ensures that the wider environment is properly considered and any impact is minimised. In the Saltcoats scheme, early and thorough consultation and detailed design ensured construction went ahead smoothly. The project demonstrates that following these procedures faithfully can produce solutions to problems and issues well ahead of the construction phase. Careful consideration of all the issues in co-operation with different areas of expertise can deliver a wider benefit. ■

Saltcoats' special geology

The Saltcoats site was selected for its nationally important late Palaeozoic basic intrusive and extrusive igneous rocks, a key feature of which is the Saltcoats Main Sill, an 18m-thick mafic to ultramafic composite intrusion. Consisting of analcime-dolerite (teschenite), the upper part of the sill has well-developed flow banding roughly parallel to its contact with mudstones that form part of the Upper Carboniferous Coal Measures which encompass the sill. The mudstones have been baked and hardened. Several stands of fossil tree stumps (found by an amateur geologist in the 1960s) add to the interest, as do dykes dating from the Palaeogene associated with the development of the Arran volcano.

The Saltcoats Harbour area is an excellent teaching locality, showing dykes and sills and their relations with one another and the host sedimentary rock. The fossil tree stumps exposed at low tide are as important as Fossil Grove in Glasgow for aiding an understanding of tree density in a Carboniferous forest.



The finished outer breakwater. Impact upon the key geofeatures and contextual exposure has been kept to a minimum by breakwater location and method of construction.

LANDMAP:

Joined-up thinking makes vital data available to all

Jill Bullen Countryside Council for Wales

with contributions from

Jacqui Malpas Clwydian Range AONB

Raymond Roberts & Stewart Campbell Countryside Council for Wales

When the Countryside Council for Wales (CCW) was formed in 1991, its remit included the statutory protection of sites (e.g. SSSI and NNR), facilitating greater access to, and enjoyment of, the countryside and a responsibility for promoting, understanding and protecting the landscapes of Wales.

A key tool in achieving this is LANDMAP, a national information system, devised by CCW to enable landscape to be considered in decision-making by CCW itself, local authorities and their planning departments. It is also used by the Welsh Assembly Government, which sets the agenda for sustainable development in Wales.

What is LANDMAP?

LANDMAP is an all-Wales GIS-based landscape resource, where landscape characteristics and qualities and influences on the landscape are recorded and evaluated into a nationally consistent dataset. All quality-assured LANDMAP information is now available on the LANDMAP website www.ccw.gov.uk/landmap. Anyone can access the geological landscape maps and survey information by using the online GIS in the 'Maps' section, or users can download the survey and map information from the LOGIN section for use on their own computers.

LANDMAP assesses the diversity of landscapes in Wales using five categories of information: Geological Landscape; Landscape Habitats; Visual and Sensory Landscape; Historic Landscape; and Cultural Landscape. These are known as the five different 'aspects' of LANDMAP, and each forms a separate 'layer' in the GIS. This provides users with the invaluable facility of being able to gain a pan-Wales picture of any combination of the five aspects.

Geological Landscape

Geological and geomorphological factors that have shaped the landscape underpin the whole concept of LANDMAP. The data identify the intrinsic landscape qualities controlled by bedrock geology (lithology) and structure, and geomorphology – principally the distribution of Quaternary deposits ('drift') and landforms. Hydrological factors are also taken into account. Emphasis is placed on those elements of geology and geomorphology which have exerted the strongest influence in the formation of the landscape (for example, major faultlines which have guided subsequent erosion; prominent escarpments; landform assemblages of glacial erosion and deposition; river valleys and floodplains – and combinations thereof). The additional 'layers' or 'aspects' are overlain on this fundamental block.

For a given LANDMAP study area, usually

How it works in Denbighshire

The Geological Landscape 'layer' for Denbighshire has been completely revised recently, incorporating changes to the methodology since the first survey. The work drew heavily on digital aerial photography and, where available, stereo aerial photographs (overlapping image pairs viewed through a stereoscope to give a 3-D impression) were used to interpret more subtle topographical and landform features.

The preliminary aspect areas were marked onto a 1:25,000 base map, along with details of solid and drift geology, gleaned from BGS 1:50,000 maps and memoirs. Changes in topography were thus linked to the underlying rocks and drift. Other information, such as the location and nature of Geological Conservation Review (GCR) sites, RIGS and mines and quarries was also incorporated.

The result is a comprehensive, holistic view of the Geological Landscape. Each of the 133 aspect areas was described and evaluated and management recommendations were made where appropriate.

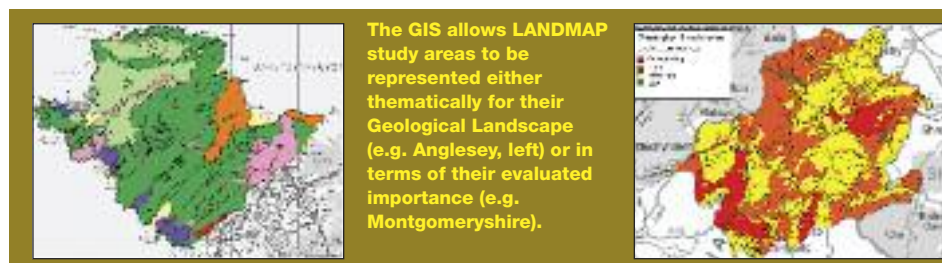
Dinas Bran is a large hill, just north of Llangollen, surmounted by an Iron Age hillfort and a 13th Century Welsh castle. Marked by the white 'X' on the aerial photograph, it provides a magnificent vantage point for appreciating (and photographing) the stunning landscape of the Vale of Llangollen.

defined by the administrative boundary of a local planning authority, Geological Landscape aspect areas (polygons in the GIS) are identified as discrete geographical areas which exhibit common characteristics and qualities. The aspect areas are mapped and a survey record is compiled for each of the identified areas. The information collected for the Geological Landscape is defined by the LANDMAP methodology (available online) which specifies the approach, the information to be collected and the definitions to be used to ensure accuracy and consistency.

Each survey record for an aspect area addresses characteristic components (features), geological and topographical character, current processes, educational value, rarity (rock types/fossils), mineral extraction (past and present) and current protected areas and designations.

National evaluation

All mapped Geological Landscape aspect areas are compared and evaluated to provide a nationally consistent dataset. Evaluation scores range from Outstanding (international/national importance), through



The GIS allows LANDMAP study areas to be represented either thematically for their Geological Landscape (e.g. Anglesey, left) or in terms of their evaluated importance (e.g. Montgomeryshire).



Photos by Stewart Campbell



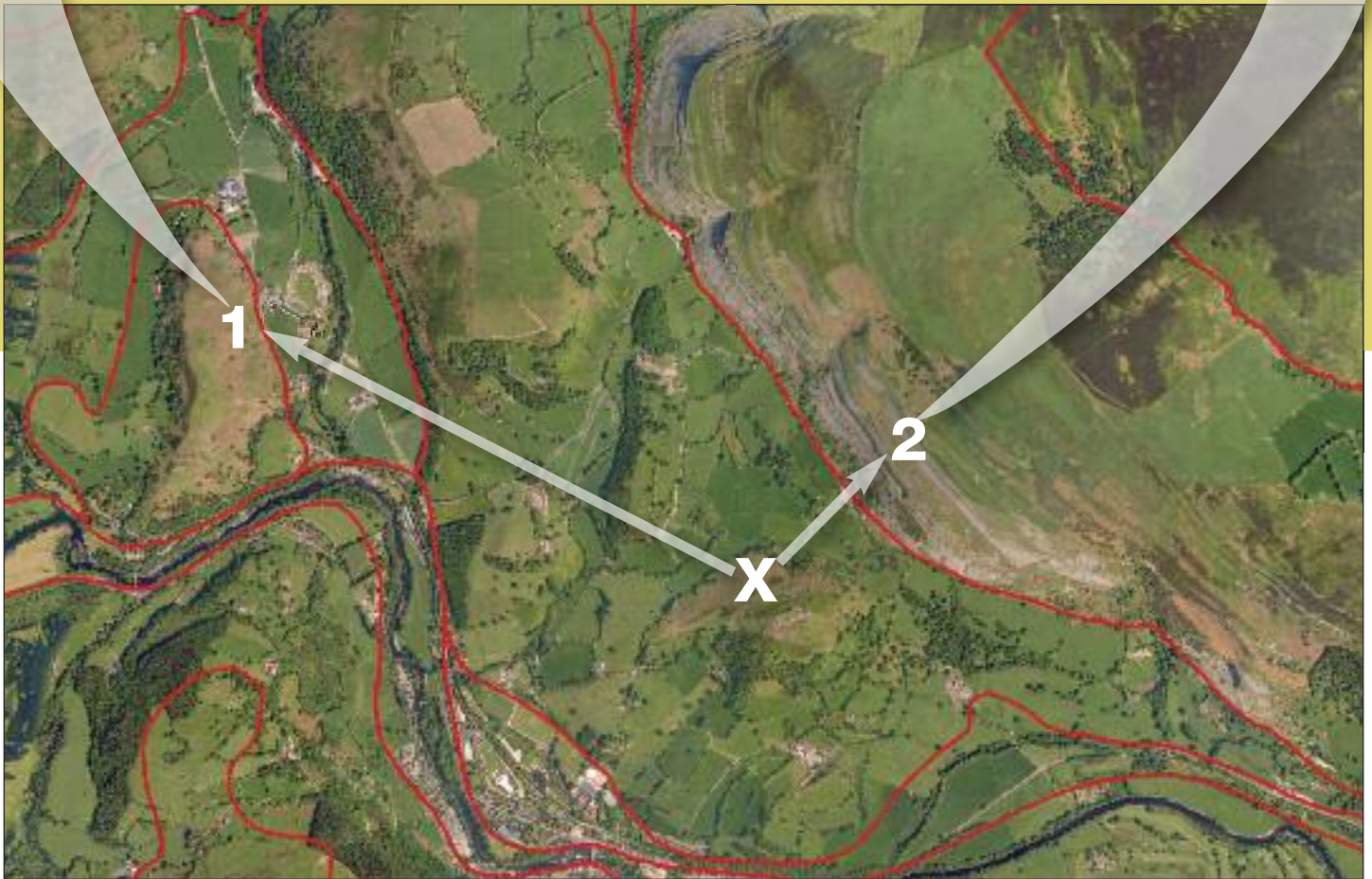
Looking north-west from the castle (left-hand arrow below), the landscape is dominated by Silurian strata, by the strong imprint of glaciation and by the protracted development of the River Dee and its tributaries. In the far distance can be seen Llantisilio Mountain, with the steeply dipping Silurian strata of Velvet Hill (1 below) appearing rib-like in the middle distance. Velvet Hill forms a

discrete aspect area in the Denbighshire LANDMAP study, and is notable for its historical association with Charles Darwin.

Looking north and eastward from Castell Dinas Bran, the juxtaposition of Silurian rocks with the spectacular Carboniferous limestone escarpment of Mynydd Eglwyseg is seen (2 below).

The escarpment and its related features form another of the 133 discrete aspect

areas in the LANDMAP classification of Denbighshire's Geological Landscape. It has been evaluated as 'outstanding' for its combination of Geological Conservation Review sites (for Dinantian stratigraphy and mass movement), RIGS (for soils, fossils, education, limestone pavement) and landscape-scale features.



An aerial photograph of part of the Denbighshire LANDMAP study. The landscape photographs at the top were taken from the 'X' vantage point. OS base maps reproduced with permission of HMSO. Crown copyright reserved. CCW licence 100018813

High (national/regional importance) to Low (local importance). The other LANDMAP layers are treated in a similar way, using their own defined methodologies to produce nationally consistent comparisons.

Uses of LANDMAP

LANDMAP information is primarily used for planning purposes, in particular

development control and development plans. It can be used to support the protection of landscape at public inquiries. The information has been used to help designate Special Landscape Areas, giving geological and geomorphological information a key role alongside more traditional resources such as visual landscape assessments. LANDMAP is

being used in Pembrokeshire to promote geological and geomorphological areas for tourism. LANDMAP's uses are varied and continue to expand.

For further information or a copy of the Geological Landscape methodology, please contact: Jill Bullen, tel: 01970 821107; e-mail: j.bullen@ccw.gov.uk ■



Gait Barrows NNR is a classic example of a stunning limestone pavement with largely undissected clints and deep, narrow grikes.

Limestone pavements:

Seeing the whole picture

With the introduction by Defra of local sites guidance to classify sites holistically, limestone pavements offer an excellent example of geodiversity underpinning biodiversity.

The interaction between geodiversity and biodiversity is key to any classification and limestone pavements are recommended to the Earth Science community as an



Dense runnels on the steeply dipping pavement at The Rakes, Hutton Roof.

Sue Willis, Cynthia Burek, Roy Alexander
University of Chester

example of good practice when dealing with geoconservation issues.

We need to re-examine the long-running issue of damage and abuse of limestone pavement sites and assess whether using a robust classification will lead to improved management. This research is sponsored by the Yorkshire Dales National Park, which has a vast area of limestone pavements, and is being undertaken at the University of Chester. It was decided to look also at the Welsh pavement areas, where much recent work has taken place. It is on these that the RIGS movement has played an important role in nominating conservation status. In England the pavements are protected by Limestone Pavement Orders (LPOs); in Wales by RIGS designation. What follows is the present state of play.

Valuable landform

Limestone pavements are widely recognised as being important, geologically diverse landforms which are often equally rich biologically. As such they are protected under the European Habitats and Species Directive (92/43/EEC) and recognised at an international level as being of great importance. A limestone pavement is a fine example of where geodiversity underpins

biodiversity, but the classification of pavements has not yet developed beyond specific single-discipline (i.e. geological, geomorphological, archaeological, pedological and botanical) terms such as ‘deep grike/shallow grike’ or ‘open/wooded’ or ‘maritime/inland’. This narrow categorisation means that some other points of interest can be ignored; for instance, the zoological component is very much overlooked in existing schemes.

Existing descriptions address either geodiversity or biodiversity and do not explain why pavements with the same geology can be noticeably different – adjacent pavements may have substantially dissimilar floral assemblages, for example. To date there has been no in-depth consideration of how the non-biotic elements of the landform affect this rare ecosystem.

Geodiversity of limestone pavement

A limestone pavement is affected by variations in all the elements of geodiversity, including its lithology, stratigraphy, structure, mineralisation, palaeontology, weathering, pedology and geomorphology. Examples of varying



Rock 'cushions' at Cam High Road, Coverdale, and, below, crinoid ossicles form the surface of this clint.



lithologies include the massive, smooth, barely dissected clints and deep, narrow grikes seen on the thickly bedded limestones such as those at Gait Barrows, Morecambe Bay. This contrasts with Cam High Road, Coverdale, part of the Yoredale series of very thinly bedded limestones. These pavements demonstrate shallow, wide grikes which often form a distinctive pavement resembling 'limestone cushions' in the grassland.

The pavement is greatly influenced by folding and faulting in the bedrock and a particularly good example of this can be



Complex structural elements have resulted in this amphitheatre-like pavement at The Clouds.

All photographs by Sue Willis

seen at The Clouds, Kirkby Stephen, which was well described by Goldie (1996). One of the pavements here forms a stunning pavement amphitheatre.

Pavement dip and direction are also key structural variants influencing the development of solution features, particularly runnels, which look like channels or grooves in the clint surface. At Hutton Roof, The Rakes limestone pavement dips at up to 25°, resulting in distinctive solutional patterns.

Some pavements are rich in fossils, offering a real insight into the palaeoenvironment of limestone deposition in clear, warm, shallow seas. Brachiopods, corals and crinoids are the characteristic organisms which may be preserved *in situ*.

Biodiversity

Substrate undoubtedly affects the plant and animal life of the landform but other factors also play an important role in dictating the biodiversity on limestone pavement. Under investigation are physical and animal/human variables including altitude, climate, maritime influence, grazing regime and human impact such as trampling. This research hopes to build on the original work on limestone pavement flora carried out by the ecologists Ward and Evans (1975).

Holistic research

The extents to which geodiversity and biodiversity dictate the nature of the limestone pavement are being examined in this study. Nearly 50 limestone pavements across North-west England and North

Maritime influence can clearly be seen at Moelfre on Anglesey, where clumps of pink sea thrift nestle in the grikes on the cliff top.

Wales have been systematically and holistically researched. This represents approximately one tenth of the 565 limestone pavements in this geographic area.

Factors including the depth and width of grikes, size of clints and frequency of runnels have been recorded alongside data such as plant species, molluscs found and litter seen. Using multivariate statistical analysis, patterns will be investigated to assess which factors have the most significant influences on the pavement.

The project aims to produce a holistic classification scheme which can be used by non-specialists worldwide. This classification will then be used to examine best practice in management strategies for the different types of limestone pavements and management guidelines related to the classifications will be compiled. This will be a valuable tool to conservation agencies in conserving this rare and magical habitat for future generations. It will also provide British evidence for submission to Natura 2000. ■

Further reading

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Ward, S. D. & Evans, D. F. (1975). *A botanical survey and conservation assessment of British limestone pavements*. Bangor: Institute of Terrestrial Ecology.

Burek, C. V. & Conway, J. (2000). *The relationship between Carboniferous Limestone insoluble residues and soils on limestone pavements in North Wales*. In *Cave & Karst Science* 27, (2), 53-59.

There is more about limestone pavements in *Earth Heritage* issues 10, 12, 16.

Marble Arch Caves Global Geopark: Earth Science without borders!



Entrance to Pollnagollum Coolarka.

The Geopark concept originated in the late 1990s (*Earth Heritage 18*) and the 'geoparks' movement has been the fastest-growing aspect of Earth Science conservation in the 21st Century. The European Geoparks Network (EGN) was established in 2000 with the aims of protecting geodiversity; promoting geological heritage to the public; and of supporting sustainable economic development in geopark territories through the development of Earth Science-based tourism.

20

John Gunn

Limestone Research Group,
University of Birmingham

In 2004, following the rapid growth of interest in European Geoparks, UNESCO (the United Nations Educational, Scientific and Cultural Organization) decided to turn geoparks into a worldwide initiative. A Global UNESCO Network of Geoparks was established with a co-ordination office at the Ministry of Land and Natural Resources in Beijing, China (*Earth Heritage 30*). The existing members of the European Geoparks network (17 at the time) and eight Chinese geoparks were the first members of the global network. It now includes all 33 European geoparks, 20 Chinese geoparks, and one each from Brazil, Iran, Malaysia and Australia.

For Marble Arch and County Fermanagh, achieving Global Geopark status was a major success that provided excellent publicity and opened doors to substantial funding, including around £1 million from the European Union in 2004 to support park management and the development of high-quality sustainable tourism.

One year later the caves achieved another milestone when the millionth visitor was welcomed and the numbers visiting the wider Geopark also steadily increased. In 2006 the public voted Marble Arch Caves Global Geopark the best tourist attraction in Northern Ireland, an accolade which helped to give Earth Science tourism a high profile in Ireland. The same year, at the invitation of UNESCO, the Marble Arch Geopark hosted the 2nd UNESCO International Conference on Geoparks in Belfast, which attracted over 500 delegates from all over the world.

Despite these significant achievements, the Geopark remained the smallest in the

continued on page 22



Cuilcagh Mountain from Garvagh Lough.



Brian Parry besides a large sandstone caprock on a limestone pedestal.

Richard Watson at Shannon Pot, the traditional source of Ireland's longest river.



Photos by Richard Watson and John Gunn

Cross-border geological connections

Extending the Geopark into Cavan also makes a great deal of sense from an Earth Science perspective as the geology and geomorphology do not stop at the political boundary (although readers of the GSNI 1:50k maps might be forgiven for thinking this is the case since the maps are blank south of the border!). There are strong similarities between the rocks and landforms on both sides of Cuilcagh Mountain and, being a karst area, there are also real 'underground' connections. A notable example is Shannon Pot in County Cavan, the traditional source of the longest river in Ireland and longer than any British river. Water tracing has shown that in addition to more local sources (including Pollnaowen which drains a large lake, Garvagh Lough) several stream sinks in County Fermanagh, including one over 10km away, drain to the Pot. Following on from the water tracing, Shannon Cave was discovered, initially from Pollahune, an entrance in County Cavan. This later collapsed and a new entrance was engineered from Polltullyard in County Fermanagh, although most of the cave lies beneath County Cavan!

Megaliths and pedestals

Although the downstream passages in Shannon Cave are up to 30m high, the entrance is very much more constricted and will be seen by few visitors. In contrast, the nearby Burren Forest is proving popular with tourists and is likely to attract many more visitors when details of its geoarchaeological interest become more widely known. The forest contains both megaliths and a dense concentration of pedestal rocks (sandstone erratic caprock on limestone pedestal). The rocks are of interest in their own right, but a study in the summer of 2008 has shown that many of the pedestals, and some of the caprocks, have been modified by early human settlers. The evidence includes both lithic and metallic percussion marks and chock-stones. It has been suggested that early settlers, probably already familiar with megaliths, may have thought of the pedestals as gifts from the gods and used them for their own purposes.

Drumlins and moraines

Farther south, the Geopark extends to the lowlands and wetlands of Lough

Oughter in the centre of County Cavan, an area of undulating drumlins and some of the largest ribbed moraines in the world, reaching up to 16km in length. Many of the moraines have become 'drumlinised' – drumlins have formed on top of the moraines.

Peat pipes

The extensive areas of blanket bog on both sides of the border are internationally important natural habitats that contain networks of pipes cut into the peat by flowing water. The pipes are analogous to the solution conduits that form in limestones. Some have grown large enough to be explored for several metres by humans – the criteria for a cave. Collapse of peat into the pipes has formed dolines and the entire landform assemblage is best referred to as pseudokarst. Bog flows and peat slides are characteristic landforms in several areas of upland blanket bog but they are particularly well developed in the Marble Arch Geopark. They have been the subjects of extensive research by Dr Alan Dykes and there are more published papers on the Cuilcagh peat mass movements than on any other peatland area!



Right: The cliffs of Magho from the shores of Lough Erne, and left, unusual weathering features on a sandstone escarpment in Lough Navar Forest.



Earth Science without borders from page 20

network at only 1,600 hectares. Fermanagh District Council leased part of the area from the Northern Ireland Forest Service and in 2007 the Geopark was expanded when the Forest Service agreed to lease further land in west Fermanagh. A series of National Nature Reserves owned by the Northern Ireland Environment Agency was also incorporated. The European Geopark Network re-assesses each Geopark every four years and geoparks that fail to promote actively both Earth Science conservation and sustainable development can be excluded from the Network. The application to expand the Marble Arch Caves Global Geopark was considered at the same time as the first re-assessment and both were formally approved in September 2007, increasing the park's size over 10 times to 18,000 ha.

The expansion brought in some of Fermanagh's finest landscapes, such as the Cliffs of Magho which overlook Lower Lough Erne and the Belmore escarpment which includes Knockmore Cliff. This iconic landscape feature can be seen from many parts of the geopark, although at present it is not accessible to the public. In addition there is a series of new Earth Science features, including land around one of only two turlough sites in the UK and a series of spectacular sandstone scarps in Lough Navar Forest. One of the scarps has unusual weathering features that appear similar to 'tafoni', although no detailed research has yet been undertaken to determine their origins.

At the same time as discussions with the Forestry Service, neighbouring Cavan County Council suggested extending the Geopark across the international border into the Republic of Ireland. After considerable dialogue a proposal was submitted to EGN in April 2008 and, following assessment, approved in September 2008. The cross-border geopark retains the name Marble Arch Caves Global Geopark

and is currently the only Geopark in the entire UNESCO network that extends across an international border.

The political significance of the cross-border Geopark may be lost on many readers of *Earth Heritage* but will be readily apparent to anyone who knows the history of the Irish Troubles. My first visits to the area took place in 1979 and 1980 as a post-doctoral fellow at Trinity College Dublin and I still remember the comment by a senior academic after I presented a paper at the Institute of British Geographers in 1980: "You must be very brave to work in that area". Thankfully I never experienced any of the violence at first hand, but over the succeeding 20 years I spent many hours waiting to cross the border at the heavily fortified British Army Swanlinbar checkpoint of which there is now no trace, thanks to the great strides made in bringing peace to Northern Ireland.

Now that peace has been restored to this superb area it is hoped that there will be



Calf House dolmen, the remains of a single-chambered prehistoric grave.

many more visits from people interested in Earth Science and, to quote from the application dossier submitted to the European Geopark Network, it is hoped that the enlarged Marble Arch Geopark will "provide a platform to create further social, economic, cultural and environmental benefits, which will be of strategic importance in the Irish Border Region. This international approach to developing the Marble Arch Caves Global Geopark is a model of best practice for other regions of the world where countries share common borders. Given the recent history of conflict in Ireland, the cross-border expansion of the Geopark will be widely regarded as a symbol of hope for peace by people in other countries where conflict still exists." ■

Care over access

Unlike most other European countries, the public has no right to walk on private land in either Northern Ireland or the Republic of Ireland due to public access and trespass laws. To avoid possible friction with private landowners and resentment from disappointed visitors, Fermanagh and Cavan County Councils decided to confine Geopark boundaries to areas with guaranteed public access.

Most of the Fermanagh sites are within larger areas of Public Access Land,

including the Cuilcagh Mountain Park (which formed the core of the original Geopark) and substantial areas owned by the Forestry Service. The largest Geopark site in Cavan, the Burren, is owned by Coillte, the state forestry service, and access agreements have been established to allow the public to visit the other Geopark sites. Within the Fermanagh core area there is an extensive network of walking trails including 17 from the popular '25 Walks in Fermanagh' booklet by Noel Parker and Eamon Keaveney.

Delving into Anglesey's key sites

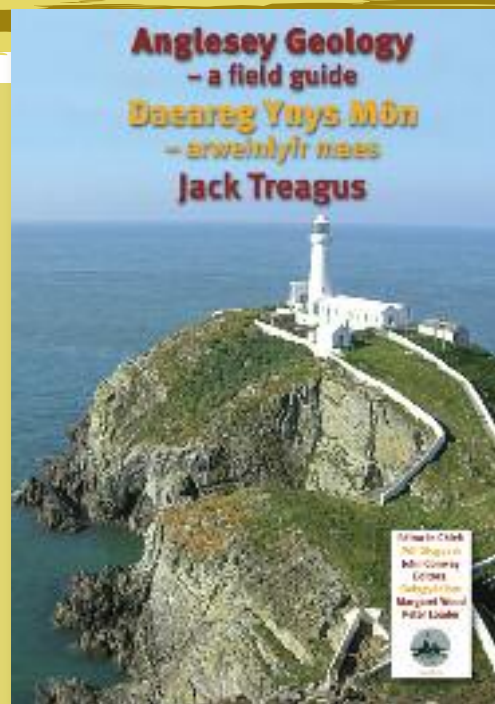
Anglesey Geology – a field guide. Jack Treagus. GeoMôn, Anglesey. 2008. 168 pages. A5. £9.95. ISBN 0-9546966-2-X.

This new book delivers a wealth of detail about many of Anglesey's stunning geological sites. It is a key educational guide for readers seeking an in-depth exploration of some of the island's most prominent features.

Peter Loader, Chief Examiner A-level Geology for WJEC and geology master at St Bede's College, Manchester, says: "For those of us who teach and learn from the rocks of Anglesey, this is an invaluable book that will help a wider audience open a window into the history of the Earth and provide a manual by which to test the plate tectonic model."

Designed as a field guide in A5 spiral-bound format with laminate covers, its author Jack Treagus accompanies his text with a plentiful array of colour photographs to illustrate many of the points he makes about the 14 locations studied. Sites include the Mona Complex strongholds of Llanddwyn Island, Rhoscolyn and South Stack, the Ordovician, Silurian and mineral delights of Parys Mountain, the Devonian exposures of Lligwy Bay and the Carboniferous rocks of Red Wharf Bay.

The 168-page English/Welsh guide has been edited by John Conway, Margaret Wood and Peter Loader and produced through GeoMôn, Anglesey. It is available through book shops or direct from Dr Margaret Wood, Coleg, Llansadwrn,



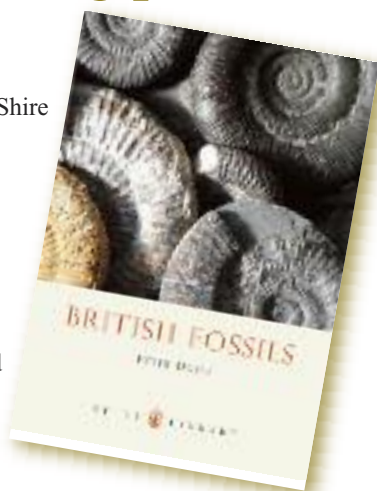
Menai Bridge, Anglesey LL59 5SN, tel: 01248 810287 or via the website www.geomon.org.uk. Its £9.95 price includes delivery.

A super starting point on fossils

British Fossils. Peter Doyle. Shire Books. 64 pages. A5. £5.99. ISBN 978-0-7478-0686-8

This handy, full-colour A5 book is a friendly, accessible starter for anyone wanting to learn about the vast array of fossils in Britain, Ireland and occasionally farther afield. After taking readers through fossil creation, palaeontologist Peter Doyle explains the variety of fossils and then launches into a richly illustrated visual guide to the most common fossil types in Britain.

Importantly for geological conservation, the book's closing chapter debates responsible fossil collecting and the relevance of codes of conduct. "Fossil-collecting codes and guidelines have been published by the conservation agencies, by museums and clubs, and by responsible fossil-collecting websites. These guides ensure that the hobby... has a long-term future and that significant finds are saved for scientific study in museums and universities," he writes. For good measure, he provides readers with an eight-point fossil-collecting code to ensure they have a ready-made set of guidelines to ensure their pastime is both enjoyable and sustainable. *British Fossils* is available through retail book outlets.



Colliding continents and a vanishing ocean

Southwest Scotland: A landscape fashioned by geology. Andrew McMillan and Phil Stone. Scottish Natural Heritage (SNH). £4.95. ISBN 978 1 85397 520 2

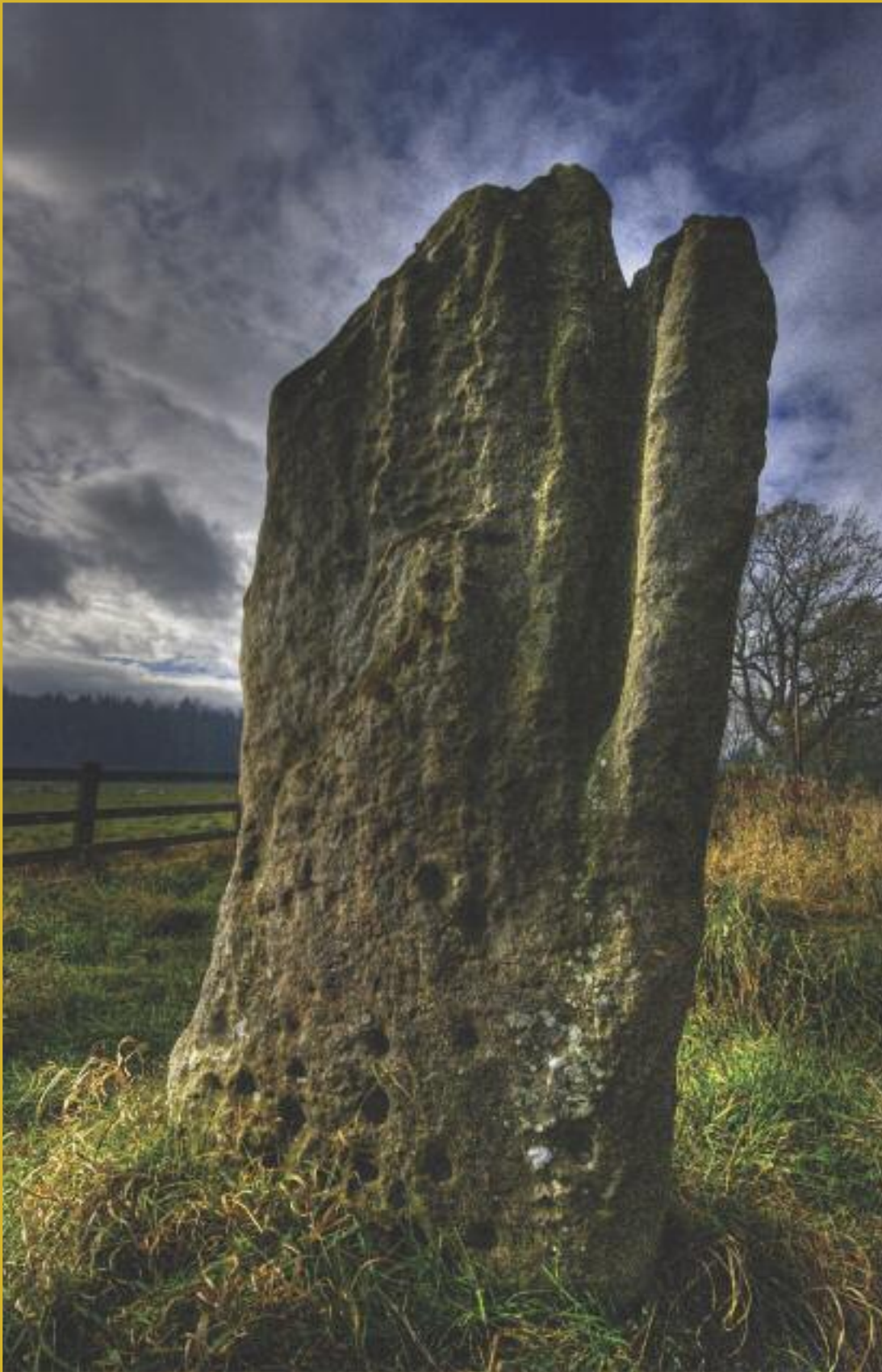
This publication is the latest in the polished 'landscape fashioned by geology' series.

From south Ayrshire and the Firth of Clyde across Dumfries and Galloway to the Solway Firth and north-eastwards into Lanarkshire, a variety of attractive landscapes reflects the contrasts in the underlying rocks. The area's peaceful, rural tranquillity belies its 500-million-year history of volcanic eruptions, continents in collision, and immense changes in climate.

Vestiges of a long-vanished ocean are preserved at Ballantrae and the rolling hills of the southern Uplands are constructed from the piled-up sediment scraped from an ancient sea floor. Younger rocks show that the Solway shoreline was once tropical, whilst huge sand dunes of an arid desert now underlie Dumfries. Today's landscape has been created by aeons of uplift, weathering and erosion. Most recently, over the last two million years, the scenery of Southwest Scotland was moulded by massive ice sheets which finally melted away about 11,000 years ago. *Southwest Scotland* is available direct from SNH (www.snh.org.uk/pubs/).



Earth Heritage magazine is published twice a year to promote geological and landscape conservation.



Matfen Standing Stone, Northumberland, is a dramatic monolith also known as 'The Stob Stone'. The stone itself is naturally fluted and there are 60 engraved 'cups' of rock art on three of its sides, enhancing its mystery and majesty and signalling the fascination that large stones of this sort held for early rock artists. The stone at Matfen may have been moved from its original position, but no-one can really tell – the truth is lost in time.

How best to conserve the geological and rock-art interests of the many hundreds of examples of standing and engraved stones that can still be found throughout Britain? See page 12.

Photo by Brian Kerr
www.briankerrphotography.co.uk

