Earth heritage

The geological and landscape conservation magazine

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Earth Heritage goes on-line only – see page 2

Changes and challenges – a new era for *Earth Heritage*

The publication of *Earth science conservation in Great Britain – A strategy* in 1990 was – and still is – a massive landmark for geoconservation. For the first time it set out a coherent and comprehensive vision for geodiversity and geoconservation work in Britain. It has gone on to serve as the framework underpinning all our efforts for two decades and more. The timespan alone is testament to the Strategy's sound evaluation of key issues at the very outset and its enduring relevance.

Earth Heritage 35 celebrates the Strategy by giving a flavour of what has been achieved since the document's 1990 launch, how aspirations and practice have evolved and, most importantly, what key challenges lie ahead to ensure that geoconservation delivers maximum benefits for society.

There can be no doubt that the vast assessment programme called the Geological Conservation Review has formed a critical 'backbone' for geoconservation in the statutory sector. With nearly 4,000 nationally significant research and scientific sites (currently making up some 2,100 Sites of Special Scientific Interest across Britain) and a 45-strong series of definitive books, the GCR is a true world-class programme. The challenge is to maintain these sites for society's benefit and for science.

The scale of achievement on Local Geological Sites (in my mind, indelibly RIGS – Regionally Important Geodiversity Sites!) is also nothing less than phenomenal… from virtually none to over 3,500 in 20 years! This is almost entirely down to the enthusiasm, knowledge and commitment of geoconservation's voluntary sector, whose efforts the Strategy identified and harnessed to work alongside the country's statutory bodies in a major way. There are now more than 55 voluntary groups active across the UK. The geo-volunteer and cross-agency/partnership approach will be central to seeing this magnificent site series fully used for everyone in society.

Geoparks represent the value of thinking internationally. Who would have thought 20 years ago that we would have eight European Geoparks in the UK? Although this is a massive accolade, maintaining their status will require constant work and clear demonstrations that the Geoparks are bringing the social, educational, economic and geodiversity benefits for which the programme was set up.

With such huge achievement behind us, such massive experience and such large numbers of us involved, we should now be able to plant geodiversity and geoconservation at the same level as biodiversity in the minds of the public and politicians! TV programmes like the excellent *Coast* and *Men of Rock* demonstrate the relevance of geodiversity and geoconservation in memorable fashion.

In a society increasingly driven by economics, there is growing pressure to put a value on the 'services' that the natural environment provides to society. Now is the time to show how crucial geodiversity is to every strand of our existence – from providing primary geological resources to regulating climate; from underpinning biodiversity and landscape to providing an outdoor laboratory! We must use the Geodiversity Action Plan process at all levels to engage with others and, increasingly it seems to me, we need to speak as much with one voice and present a common agenda – much as the esteemed Strategy did in 1990!

Many of these hot topics will be discussed at the forthcoming *Geoconservation for Science and Society: an Agenda for the 21st Century* conference on 9-10th September 2011 (*see page 27*). Book now to have your say!

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Managing Editor

Cover photo

Visitors enjoying the winter landscape on the flanks of Pen y Fan, in the eastern reaches of the Fforest Fawr Geopark. *See page 19*. *Photo by Gareth Owen*

Earth heritage

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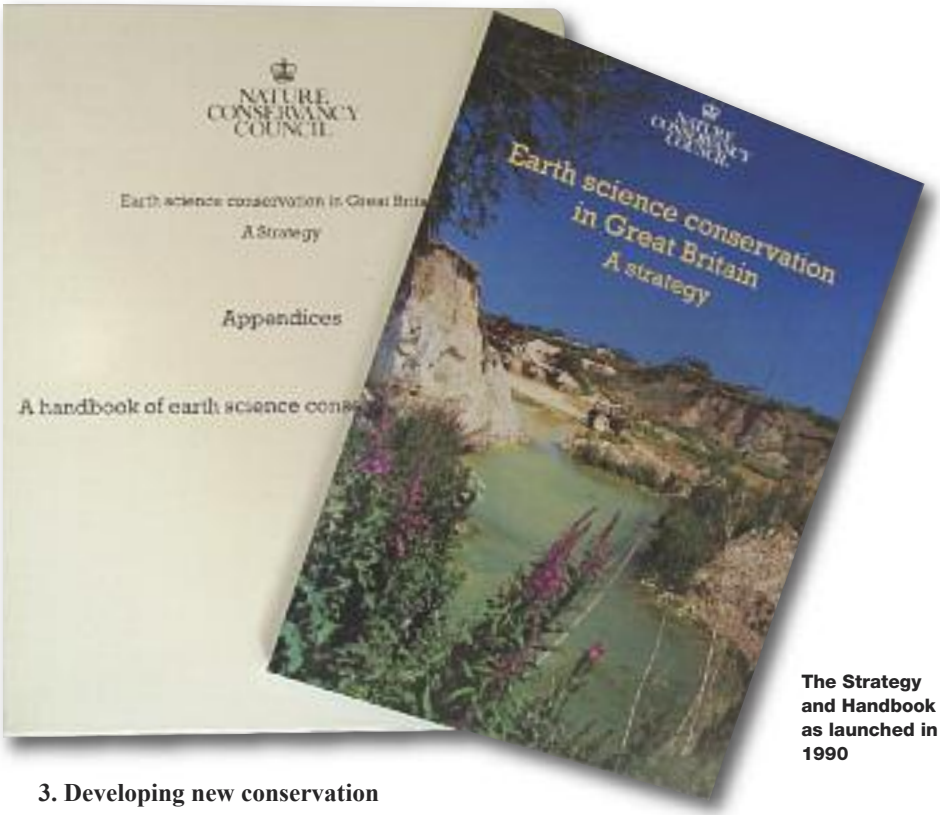
Strategy stands test of time

Colin Prosser
Natural England

On 5 December 1990, a landmark for geoconservation in Great Britain was reached with the launch of the first and, to date, the only Great Britain-wide geoconservation strategy.

Earth science conservation in Great Britain – A strategy and the appendices that accompanied it, *A handbook of earth science conservation techniques*, provided a rationale for geoconservation, identified six strategic themes where action was required and highlighted the approaches to conservation, management and interpretation that were available to help deliver the strategy.



The Strategy and Handbook as launched in 1990

Whilst the published documents were the physical manifestation of the strategy, its real strength arose from the partnerships and inclusive process that generated it. Although driven forward by the Nature Conservancy Council (NCC), it was a shared strategy and the wide range of partners involved in developing it, and committing to help deliver it, included geological conservationists, academics, museums, wildlife bodies, landowners, mineral companies and local authorities. The strategy's themes provided a clear direction and framework that helped to maintain common goals and joined-up delivery across Great Britain, even when the NCC was split into three country conservation agencies and the Joint Nature Conservation Committee in April 1991.

The strategic themes that have helped shape geoconservation over the last 20 years are:

1. **Maintaining the network of Sites of Special Scientific Interest (SSSI)**
2. **Expanding the RIGS (local sites) network**
3. **Developing new conservation techniques**
4. **Improving site documentation and the conservation of samples**
5. **Increasing public awareness**
6. **Developing international links**

It is not intended that this article, or this special edition of *Earth Heritage*, should be a definitive review of the delivery of the strategy, but it is fair to say that major progress has been made against all six themes over the last 20 years. The articles and photographs on the following pages illustrate some of the achievements.

We now have a very robust series of geological and geomorphological SSSI, greater in number and better managed than 20 years ago and with many examples of the successful deflection of potentially damaging impacts on sites through the development of innovative conservation solutions and the successful defence of sites at public inquiry.

The network of RIGS / local sites has expanded over the last 20 years from virtually nothing, to many thousands, and alongside this we have seen the establishment of GeoConservationUK, the Geology Trusts and many local geoconservation groups which together have made a major contribution to geoconservation and education.
New conservation techniques, especially around coastal protection options, specimen rescue and recording of rock faces through bedding plane moulding, have emerged, and a great deal of work has been done both on SSSI and local sites (*e.g.* RIGS in Wales) to improve site documentation.

There is still a long way to go in increasing public awareness but the work of European Geoparks, World Heritage Sites, local geological conservation groups and events such as the Scottish Geology Festival have meant that many more people have been exposed to, or become involved in, geology and geoconservation, aided quite often by grants such as those available through the Aggregates Levy Sustainability Fund.

Continued on page 4

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GCR:

Sites of Special Scientific Interest (SSSI) provide the backbone of geoconservation in Great Britain. The sites themselves were originally identified through the systematic and scientifically rigorous Geological Conservation Review (GCR), the vast assessment programme conducted by geologists working in and with NCC and the national conservation agencies.

Supported by robust conservation legislation and protected through a range of planning measures, SSSI are extremely effective in conserving our nationally and internationally important geological and geomorphological sites. The last 20 years have seen the number of geological/ geomorphological SSSI across Great Britain reach approximately 2,100.

In addition, most SSSI now have management plans and many have benefited from management work, enabled, for example, by the Face Lift site enhancement programme. The last 20 years have also seen many geological SSSI threatened by coastal protection schemes, landfill and development. Many of these threats have been deflected through negotiated compromises with developers, or through public inquiries – all widely reported in *Earth Heritage*. Our SSSI series is the envy of many geoconservationists overseas. However, it is the GCR which provides the scientific underpinning of every geological SSSI and the credibility of each will continue to depend on the scientific credibility of the GCR in the years ahead.

– Colin Prosser, Natural England

Neil Ellis with a stack of GCR volumes. Since the photo in 2003, nine further volumes have been added to the stack. ***Photo by JNCC***

20 years of strategic progress

From page 3

International links have grown too, with a number of international conferences taking place on subjects such as geological World Heritage Sites, Global and European Geoparks, geosite selection and geotourism. ProGEO and the new Springer journal *Geoheritage*, can only help to establish geoconservation and share good practice through offering a means to contribute to, and learn from, geoconservation worldwide.

In addition to delivery against the strategic themes, many unanticipated opportunities and challenges have arisen over the last 20 years, and have resulted in new thinking and activity. These have included opportunities to demonstrate the wider values and benefits of geodiversity through ecosystem services, to inform adaptation to climate change and to develop more integrated approaches to the management of biodiversity and geodiversity. The same period has also seen the development and wide acceptance of both the term, and the concept, of 'geodiversity' and the rise and establishment of the network of Global and European Geoparks. Working with these new opportunities and threats is likely to be a key part of 'mainstream' geoconservation for many years to come.

As geoconservation developed over the last 20 years, the 1990 strategy was steadily replaced by new national and organisational strategies produced in England, Scotland and Wales to help re-focus work within the devolved administrations. Whilst it can be hoped that Professor Chris Wilson, Eric Robinson, the late Chris Stevens and the late Sir John Knill, who all spoke at the launch of the strategy in 1990, would be very satisfied with the progress made, it is certain that geoconservation will face many more opportunities and challenges in the future, particularly in the current climate of economic austerity and social change. The Coalition Government will hope that local groups and local action will play an enhanced role in delivering conservation in their communities but a framework in which to set this local activity will be required. As such, geodiversity action planning is likely to play a major role in the future of geoconservation. Whilst the 1990 Strategy is now part of geoconservation history, the foundations that it provided, alongside the new opportunities and challenges that exist today, will form the basis of the UK GAP, national GAPs or frameworks and LGAPs. Together these can provide a framework to take geoconservation forwards to meet the challenges of the next 20 years.
A conference scheduled for later this year will consider this subject. *See page 27.* ■

Further reading

Nature Conservancy Council. 1990. *Earth science conservation in Great Britain – a strategy,* and appendices, *A handbook of earth science conservation techniques*. Peterborough.
Burek, C., Campbell, S. & Larwood, J. 2007. *Moving towards a National GAP.* Earth Heritage 28.
Chris Stevens 1991. *The 'Strategy' launched at Westminster.* Earth Science Conservation, 29.

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A world-leading achievement

Neil Ellis
Joint Nature Conservation Committee

When the Geological Conservation Review (GCR) project was formally launched in 1977 by the Nature Conservancy Council, it was viewed as a major undertaking that would take many years and involve a large number of geologists and geomorphologists. However, the scale of the work and the impact it has had on geoconservation have been more far-reaching than could ever have been anticipated at the outset. The GCR has made a massive contribution to geoconservation in so many ways.

Often mistaken as only a series of volumes detailing the scientific credentials of Britain's best geological sites, in fact the GCR rationale, criteria and methods justify the selection of sites destined to become geo-SSSIs conserved under British law. The project was a world-first in the assessment of the whole Earth heritage of a country from first principles and has been used as an invaluable model abroad as a way to evaluate the national importance of sites.

After evaluation of what is estimated as over 20,000 potential sites, and following widespread consultation with geologists and geomorphologists across Great Britain, almost 3,000 sites were selected for around 100 site selection categories for the GCR by 1990.

As part of the site-selection process, a considerable archive of information about sites was amassed and a major publication exercise detailing all the confirmed GCR sites was devised early on in the work programme. To date, 36 of an intended 45 books in the GCR Series have been published (*see the table on the right*).

Although budgetary constraints mean that JNCC will no longer be able to publish the remaining volumes, the good news is that the GCR Series will be completed through the *Proceedings of the Geologists' Association*, meaning that the series will provide an encyclopaedic coverage of British geoconservation that will be an essential reference for the future.

In addition to the published books, some volumes have been converted to a freely available on-line resource at **www.thegcr.org.uk**, and volumes published by the

Continued on page 6

THE GCR SERIES

An Introduction to the Geological Conservation Review (1)

PRECAMBRIAN AND STRUCTURAL GEOLOGY

Caledonian Structures in Britain **CH @ (3)**
Lewisian, Torridonian and Moine rocks of Scotland **(34)**
Dalradian Rocks of Scotland (in prep.)
Precambrian Rocks of England and Wales **(20)**
Variscan to Alpine Structures in Britain (in prep.)

IGNEOUS PETROLOGY AND MINERALOGY

Caledonian Igneous Rocks of Britain **@ (17)**
Igneous Rocks of South-West England **CH (5)**
Carboniferous and Permian Igneous Rocks of Great Britain **@ (27)**
British Tertiary Volcanic Province **CH @ (4)**
Mineralization of England and Wales **(36)**
Mineralogy of Scotland (in prep.)

PALAEOZOIC STRATIGRAPHY

British Cambrian to Ordovician Stratigraphy **(18)**
British Silurian Stratigraphy **@ (19)**
Old Red Sandstone Rocks of Great Britain **@ (31)**
British Marine Devonian Stratigraphy (in prep.)
British Lower Carboniferous Stratigraphy **(29)**
British Upper Carboniferous Stratigraphy **CH (11)**
Marine Permian of England **CH @ (9)**

MESOZOIC–CAINOZOIC STRATIGRAPHY

Permian and Triassic Red Beds and the Penarth Group of Great Britain **@ (24)**
British Lower Jurassic Stratigraphy **@ (30)**
British Middle Jurassic Stratigraphy **@ (26)**
British Upper Jurassic Stratigraphy **@ (21)**
British Marine Lower Cretaceous Stratigraphy (in prep.)
Jurassic–Cretaceous Boundary rocks in England (in prep.)
British Upper Cretaceous Stratigraphy **@ (23)**
British Tertiary Stratigraphy **@ (16)**

PALAEONTOLOGY

Fossil Reptiles of Great Britain **CH @ (10)**
Palaeozoic Palaeobotany of Great Britain **CH @ (8)**
Mesozoic and Tertiary Palaeobotany of Great Britain **@ (23)**
Fossil Fishes of Great Britain **@ (16)**
Fossil Arthropods of Great Britain **(35)**
Mesozoic and Tertiary Fossil Mammals and Birds of Great Britain **(32)**
Pleistocene Vertebrate Palaeontology of Great Britain (in prep.)

GEOMORPHOLOGY

Karst and Caves of Great Britain **CH @ (12)**
Fluvial Geomorphology of Great Britain **CH @ (13)**
Mass Movements in Britain **@ (33)**
Coastal Geomorphology of Great Britain **@ (28)**

QUATERNARY GEOLOGY AND GEOMORPHOLOGY

Quaternary of Wales* **(2)**
Quaternary of Scotland **CH @ (6)**
Quaternary of the Thames **CH (7)**
Quaternary of South-West England **CH (14)**
Quaternary of East Anglia and Midlands (in prep.)
Quaternary of Northern England **(25)**
Quaternary of Southern England (in prep.)

Published titles are in ***BOLD*** with the volume number in brackets
@ indicates titles available digitally at www.theGCR.org.uk
* Published by NCC
CH Published as a Chapman and Hall imprint
Other ***BOLD*** titles published by JNCC

Titles in *Light Italic* are planned to be published by the Geologists' Association. Future digital editions of this magazine will keep you posted of progress!

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Regionally Important Geological/ Geomorphological Sites (RIGS) emerged in the late 1980s and with them came the establishment of a network of local geoconservation groups. More than 20 years on there are now over 55 groups active across the UK, reflecting the rise of the 'geoconservation volunteer'. Today there are at least 3,500 Local Geological Sites across England, Wales and Scotland, offering visitors a vast selection of geological trails and interpretation. In addition, an impressive array of events and activities runs throughout the year, much of it driven by these groups and volunteers.

The existence of this network has led to new ways of working. For instance, Local Geodiversity Action Plans (LGAPs) – now numbering at least 40 – provide a framework both for geoconservation and for developing new partnerships and connections. Volunteer initiatives and Local Geological Sites remain critical to the future of geoconservation.

– **Jonathan Larwood**, Natural England

Gaining the **big** of Local Geologic

Since 1990 there has been a steady growth in the number of Local Geological Sites (then known as RIGS). In 1993 there were 1,388 Local Geological Sites notified to local authorities throughout England and by 1998 this had risen to over 2,000 for England, Scotland and Wales. In 2006 a comprehensive survey of Local Geoconservation Groups in England boosted this number to 2,577. This survey raised concerns that there was no centrally held, or consistent, data on these sites; there was a range of boundary formats (from paper records to GIS) and no consistent data about their condition.

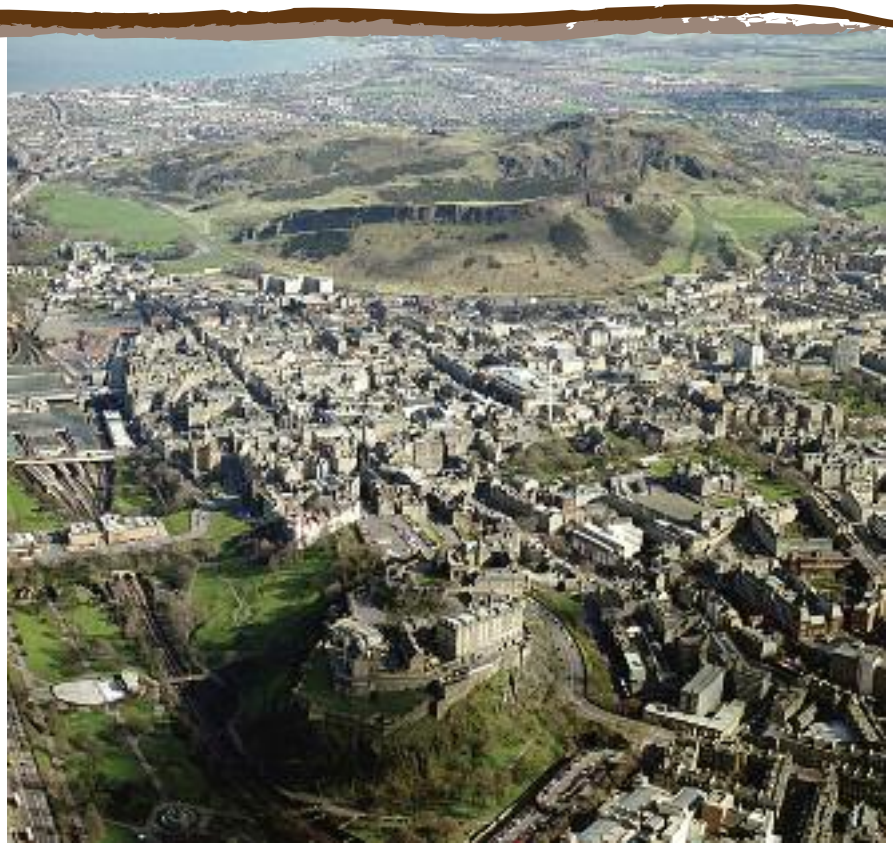
In response, since 2008 Natural England has been assembling a Local Geological Site dataset that is now building to provide some useful facts and figures. Funded by Natural England, this

From page 5

Geologists' Association will be published on-line as they become available. *British Marine Devonian Stratigraphy* will be published in the middle of 2011 and *Quaternary of East Anglia and the Midlands* early in 2012. It is planned that the other remaining titles will be published in a steady stream after that.

The information contained in the books and on the Web – and the firm ethos of the GCR principles – have already proved invaluable in summarising the geological history of Britain. They have also been used in SSSI notification, site management and monitoring work, and particularly in justifying the conservation value of sites (*e.g.* at public inquiries, as well as in enquiries from the general public). The information has also formed the basis of Local Geodiversity Action Plans (LGAPs) and Geopark proposals, and provided the foundation of the scientific case for the Jurassic Coast World Heritage Site (which is basically a mosaic of over 60 GCR sites).

In the future, the country conservation agencies – and many others – will continue to use the GCR data in their work, and will also use the GCR's principles to evaluate sites that are proposed for inclusion in the GCR. Designation will therefore continue to be a hallmark for quality in British geoconservation for years to come. ■



The Arthur's Seat Volcano GCR site, Edinburgh, is a classic example of geological features which have influenced landscape, security, urban development, communications and culture over many centuries. In the foreground, Castle Rock is a plug of basalt, representing the feeder pipe of a small volcano that erupted during Early Carboniferous time. During the last ice age, deep grooves were gouged in the softer sedimentary rocks on either side. These became marshes but are now occupied by the railway and the Grassmarket. Behind Castle Rock the soft rocks were protected from the ice and capped with glacial debris to form the long 'tail' stretching away from the camera that is followed by the High Street of the 'Old Town'. In the background are the sill of Salisbury Craigs and the volcanic neck and lavas of Arthur's Seat that dominate Holyrood Park, a unique mountain landscape in a city centre.

Photo by British Geological Survey © NERC. All rights reserved. IPR/131-82C

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picture
al Sites

Jonathan Larwood
Natural England

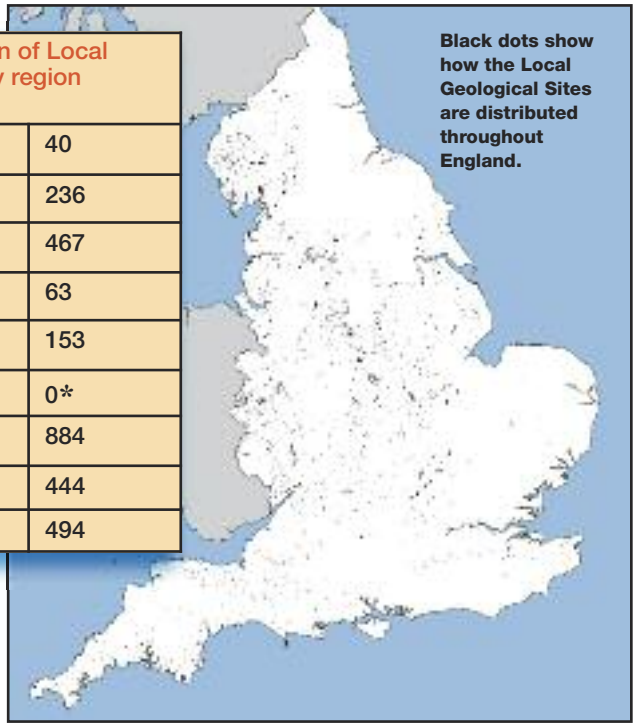
substantial task has been co-ordinated by GeoConservationUK (formerly UKRIGS) and The Geology Trusts with local geoconservation groups from across England providing input on three fronts:

- **Firstly, site boundaries that Natural England has then digitised to a common format.**
- **Secondly, a range of associated attributes including group contact details, simple geological information, selection criteria, site type and access.**
- **Lastly, information on site condition following the standard approach to monitoring that was developed for Local Geological Sites (see www.geoconservationuk.co.uk).**

As of December 2010, 3,065 Local Geological Sites are represented in the database and condition data are available for almost 50%. Here are some of the facts and figures we're starting to see:

Table 1: Distribution of Local Geological Sites by region (Dec 2010):	
North East	40
Yorks & Humber	236
East Midlands	467
East of England	63
South East	153
London	0*
South West	884
West Midlands	444
North West	494

*Local Geological Sites are currently being proposed in London



Black dots show how the Local Geological Sites are distributed throughout England.

Table 2 (*right*) reveals that, unsurprisingly, the highest proportion of Local Geological Sites in England is disused quarries (29%) and inland outcrops (24%).

Lancashire, however, shows a different picture with 24% of sites being FM and disused quarries being on a par with IS and EW at 13% each.

Table 2: Site type	National	N. West	Lancs
EA – active quarries and pits	129	2	0
ED – disused quarries and pits	800	44	17
EC – coastal cliffs and foreshore	138	9	4
EW – river/stream sections	155	23	16
EO – inland outcrops	655	64	6
EU – exposure underground	35	4	2
EB – extensive buried interest	35	14	13
ER – road, rail, canal cuttings	183	19	3
IS – static geomorphology	178	31	18
IA – active geomorphology	123	25	10
IC – caves	23	6	1
IK – karst	12	1	1
FM – finite mineral, fossil or other	134	32	32
FD – mine dumps	63	2	2
FU – finite underground	44	4	3
FB – finite buried interest	15	4	2

Not only does this indicate how important different site types are in different areas, it also starts to indicate prevalent management issues.

Table 3: Local Geological Site condition based on 1,459 surveyed sites (as of Dec 2010)	
Good*	639
Good declining	212
Good improving*	34
Good steady*	283
Poor steady	71
Poor improving*	4
Poor declining	161
Poor declining or lost	41
Poor	5
Lost	9

*Positive conservation management (NI 197)

Table 3 data (*left*) are now starting to show some challenges. For example, whilst 66% of Local Geological Sites are in positive conservation management, 34% are not.

When we start to cross-reference information of those sites which are either good declining or poor declining, 50% are disused quarries.

So what are the benefits of knowing all this?

We now have consistent simple information on Local Geological Sites in England, all held in one place. The digitised boundaries can be cross-referenced with other digital information and the monitoring data, for the first time, give a bigger picture of the condition of Local Geological Sites and are the only data outside SSSI that give an indication of the overall condition of geodiversity in England.

This will allow better targeting and justification for the use of increasingly limited resources for geoconservation and provide baseline data for reporting progress against the UK Geodiversity Action Plan (UKGAP). Gathering these data has only been possible through co-operation across local geoconservation groups.

As a consequence, we can present coherent information about Local Geological Sites across England for the first time. This will raise their profile and status, at the same time highlighting the role that local groups play in conserving these sites. ■

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Geovolunteers

The unpaid force that fuels Britain's geoconservation programme

Cynthia Burek
University of Chester

The role of the volunteer within geoconservation, the so called 'Geovolunteers', has been significant but often unrecognised. During the last 20 years the number of volunteers involved with geoconservation activities has risen enormously. Perhaps this is due to the retirement of the geology 'baby boomers' with time on their hands, but that may be a bit cynical. But there is no doubt that the advent of the RIGS (Regionally Important Geodiversity Sites) initiative 20 years ago opened the door to geovolunteers. These people, who give their time without expectation of reward, have been invaluable to geological conservation, achieving much, sometimes with little funding. In particular, they have been instrumental in developing a network of local geological sites.

The advent of the Aggregates Levy Sustainability Fund in 2002 (sadly due to be discontinued in March 2011, at least in England) provided a further significant boost, allowing geological voluntary organisations a first opportunity to apply for project funds.

It is important to recognise the work done by volunteers at the local level and stress the difference between RIGS and Sites of Special Scientific Interest (SSSI). The latter are designated only by statutory organisations for exceptional scientific or research value while RIGS are non-statutory and recognised only within the planning system. They also permit broader criteria for designation, including educational worth, historical value and aesthetic appeal as well as scientific merit. The RIGS scheme was developed as the non-statutory, voluntary arm of the *Earth Science conservation in Great Britain – a strategy* (1990), devised by the former

The creation of the Hamps and Manifold Geotrail was in large part down to the enthusiasm and effort of volunteers. *Photo by Staffordshire Sentinel*

Nature Conservancy Council (NCC) for the conservation and management of RIGS. After four years, the Welsh RIGS 'army' had advanced sufficiently to form the Association of Welsh RIGS Groups (AWRG). This went on successfully to convene annual conferences across Wales. At the same time, the RIGS movement also grew apace in England and Scotland.

Eventually it was recognised that RIGS groups needed guidance and a national voice, so in 1999 the Association of United Kingdom RIGS groups, 'UKRIGS', became the national organisation, with the encouragement and support of the national statutory conservation agencies (English Nature, Countryside Council for Wales and Scottish Natural Heritage) and the Royal Society for Nature Conservation (RSNC). It was rebadged in 2009 as GeoConservationUK. Membership of GeoConservationUK has now risen to 51 groups (37 England, 5 Wales, 9 Scotland) and many of these are county based. Most have active membership ranging from a handful of dedicated volunteers to sub-groups of large geological societies with members numbering hundreds. Each RIGS group has its own identity and strengths.

While not all RIGS group members are volunteers, paid jobs are severely limited and many people undertake active geoconservation for minimal expenses. In 2007, active members of geoconservation groups numbered about 800.

Over the years, *Earth Heritage* has carried news of a phenomenal amount of voluntary work. Whether it is giving talks, running walks, clearing sites, producing leaflets and other publicity materials, running conferences, putting on exhibitions or appearing on TV and radio, it has been documented across the whole country, from the Scottish Highlands to The Lizard.

The number of RIGS designations, over 3,000, now numbers more than geological SSSI. In 1995 it was 1,700. There are 578

Deserved recognition

When Margaret Wood (right) received a Distinguished Service Award medal from the Geological Society of London in 2010, it rewarded the immense amount of effort she had devoted to geoconservation on a voluntary basis, quite outside the permanent and remunerated posts she has held. She will have been instrumental in helping Wales to be the first country to complete its geological audit in 2011. The vast amount of work required was carried out mostly, but not always, by geovolunteers.

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A guided walk around Rossett graveyard in 2010. *Photo by Cynthia Burek*

alone in Wales (without South Wales) and that area is just about to complete its audit (*see right*). Some groups undertake geoconservation activities outside GeoConservationUK. Here, the Geology Trusts (launched in 2003) stands out as very successful, achieving remarkable work, but again not all its workers are volunteers. Their work is broad, holistic, research project-orientated and has raised awareness of geoconservation across a wide spectrum, especially in the areas around Hereford, Worcester, Gloucester and Wiltshire.

The work of two other national groups is also well worth mentioning. The Geologists' Association, especially through its Curry Fund, is a great promoter of geoconservation. Secondly, the work undertaken by sundry societies across the country, especially the Open University Geological Society with its over 2,200 members, is enormous. While not all this work is geoconservation, they are all geovolunteers.

So the last 20 years have seen an enormous increase in geovolunteering. Their work underpins the geoconservation movement and should be recognised and applauded. Their effort is especially important as we move through this period of austerity. All I can say is 'Keep up the good work'. Tomorrow's generations will thank you! ■

Further reading

Burek, C.V. & Prosser, C. (*eds*), *The History of Geoconservation*. Geological Society of London, Special Publications 300.

Marren, P. (2002), *Nature Conservation: A review of the Conservation of wildlife in Britain 1950-2001*. New Naturalists Series 91, Harper Collins, London.

A **Welsh first** on local site surveys

Wales will shortly become the first country in the world to complete a nationwide coverage of Regionally Important Geodiversity Sites (RIGS), providing a comprehensive coverage of locally selected geological conservation sites from Anglesey to Chepsow. Identified as special places for geology, geomorphology and soils outwith the national network of SSSI, RIGS are registered by local authorities, so helping protect them for future generations to enjoy.

The identification and recording of RIGS sites has a long history in Wales. The first RIGS group, Powys, was set up in 1990. This was followed by the creation of four more RIGS groups over the next four years, culminating in the formation of the Association of Welsh RIGS Groups, AWRG, in 1994.

Notable early successes were many, including: winning planning authorities' recognition for RIGS; a series of annual conferences; research projects on limestone pavements (funded by CCW); published booklets and trails (funded by the Geologists' Association Curry Fund, Tarmac and local authorities); lectures; field trips; and, of course, the identification and reporting of new RIGS.

This latter activity increased considerably with the involvement of the Aggregates Levy Sustainability Fund (ALSF) for Wales from 2003 onwards. This was spearheaded by a joint application by the two northern RIGS groups to undertake a more extensive and systematic audit of potential RIGS. This provided the template for reporting across the whole of Wales. Two more RIGS groups were successful with bids, and work continued apace.

On completion of the audits in 2008, in excess of 550 RIGS sites had been identified and written up by the four RIGS Groups (Gwynedd and Môn, North East Wales RIGS (NEWRIGS), Central Wales (which had evolved from Mid Wales and Powys Groups) and South-West Wales (which had evolved from the Pembrokeshire Group). This is entirely thanks to the hard work and commitment of the volunteers involved.

Only South Wales remained without an audit, and this was duly commenced in 2008 by the South Wales RIGS Project. A large group of volunteers is currently working under the guidance of the British Geological Survey to complete this audit, again funded by the ALSF for Wales. Due for completion in April 2011, this project will add a few hundred further sites to the Welsh RIGS register.

The final step will be to compile a systematic, catalogued compendium of all the Welsh RIGS identified and recorded so far. Subsequently it will be presented in GIS digital form.

As well as being an excellent testament to the hard work and dedication of all those involved in its collation, this will form a powerful tool for planning authorities, providing them with the evidence base necessary to include RIGS in their decision making. The challenge for the future will be ensuring that this database remains live and relevant; that new sites continue to be identified and recorded, and that current ones are monitored and well maintained. We owe it to the next generation to make this process sustainable and successful.

– **CYNTHIA BUREK**, University of Chester
– **GARETH OWEN**,
Countryside Council for Wales

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The big secret in getting things done has always been to enlist the consent and co-operation of all involved, and then to use methods that are cost-effective. That has required wide thinking, a keen eye for techniques that can be applied with the minimum of fuss, and the ability to get all parties working together, sometimes for multiple conservation objectives.

Quarry geodiversity and biodiversity conservation

Win win

Carol Smith & Cynthia Burek
University of Chester

The aggregates industry's growing contribution to the UK's biodiversity targets is helped by the location of many RIGS (Regionally Important Geodiversity Sites) in active quarries and further complemented by the advent of Company Local Geodiversity Action Plans (cLGAPs). The RIGS not only provide excellent examples of local geodiversity, but can also offer a haven for wildlife, particularly birds.

A study at the University of Chester questioned managers of active hard rock and soft rock quarries in North West England, North East Wales and the Midlands about breeding birds in their quarries. In the past 20 years quarries have come to provide birds with an important extension to the natural habitat in areas devoid of nesting cliffs and banks. The steep cliffs of hard rock quarries typically attract birds of prey such as peregrine falcons and the sand walls and sand and spoil heaps of soft rock quarries draw burrowing birds such as sand martins. The Wildlife and Countryside Act 1981 (as amended 1985) requires that quarry managers do not disturb or disrupt breeding birds through quarrying operations.

Nesting birds

All 24 quarries surveyed had nesting birds, so they were a feature of the quarry for at least half the year, with some quarries hosting birds of prey year-round. The loss of original breeding habitats such as riverbanks and steep coastal sand walls has made sand martins increasingly dependent on the aggregates industry. And sand martin breeding success in Britain will help the species withstand serious population loss caused by prolonged drought in its sub-Saharan wintering grounds.

The study found managers of hard rock and soft rock quarries had similar perspectives on breeding birds, although the greater challenges posed by burrowing birds made some soft rock quarry managers slightly more ambivalent about them.

Disused faces in a Lafarge quarry. Peregrines (below) nest on the higher levels. *Photos by Carol Smith and US Fish and Wildlife Service*

Sand martins (above) nest in soft cliff faces, and artificial nesting burrows are being tried at Rutland Water. *Photos by Andreas Trepte and Environment Agency*

Birds of prey were found to be fairly tolerant of humans and noise in quarries and the added security from human persecution afforded by a working quarry benefited the birds. Birds of prey usually roost or nest on inactive quarry faces, so good planning by quarry managers could readily accommodate nesting birds. By contrast, burrowing birds tend to change nest site year on year and use active faces, including sand and spoil heaps. This requires quarry managers either to re-profile sand faces before the birds' arrival in spring or use netting to encourage or discourage birds nesting in active parts of the site. A recent innovation is artificial nesting walls for the birds.

Company Biodiversity Action Plans (cBAPs) and site BAPs have been in place longer than Company Geodiversity Action Plans (cGAPs) and site GAPs in quarrying. Geodiversity provides opportunities for mineral operators to demonstrate quarrying's benefits to the environment and economy, with considerable cost savings to be had by dealing holistically with geodiversity and biodiversity.

In protecting and managing RIGS for their geodiversity interest, quarry managers create relatively peaceful and undisturbed areas which can prove attractive to breeding birds and other wildlife. Our survey revealed that all quarry managers could see the PR benefits of conserving both geodiversity and biodiversity. They felt that such actions increased their good standing with the local community and their peers in the quarrying industry. The ongoing development of cGAPs will help to bring a stronger focus to geodiversity issues in quarries to match the strong focus already existing on biodiversity issues. ■

Further information

Thompson, A., Poole, J., Carroll, L., Harris, K., & Cox, P. (2006). *Geodiversity Action Plans for Aggregate Companies: A Guide to Good Practice.* East Grinstead: Capita Symonds Ltd.

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New ‘supporting cast’ for conservation

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Mould and cast replication of specimens has long been used for display and teaching. Now, though, the conservation technique is being applied at larger scale for ‘site’ replication, as demonstrated through projects in Charnwood, Leicestershire and Wren’s Nest National Nature Reserve, Dudley and the Scottish arthropod trackway (*Earth Heritage 34*).

The technique of replicating a site has now been well and truly field tested at a range of scales, conditions and geology, including Precambrian exposures in Charnwood, underground sections in Wren’s Nest NNR and on the coast in Scotland. Mould and casting should not be viewed as an alternative to conserving sections *in situ*. It can, however, augment conservation, education and research.

CONSERVATION – a mould and cast can provide a perfect three-dimensional replica of a bedding plane and the features on it. Where there is concern over damage or the possibility of temporary or permanent loss, a mould provides an excellent record.

EDUCATION – the casts, particularly when backed with foam, are light in weight, reasonably robust and easy to handle. They can be used to develop displays and allow people to see detail and fossils they wouldn’t otherwise be able to access.

RESEARCH – the ability to control lighting and examine surfaces which are normally difficult to access provides significant opportunity for new research, particularly when supported by site documentation, photography and LIDAR survey.

Charnwood Forest

Charnwood has long been known for its Precambrian fossils, found on steeply inclined bedding planes in locations ranging from natural crags to disused quarries. Concern over the potential effects of weathering, damage from people scrambling and climbing and occasional illegal collecting led to the proposal to create moulds (and casts) of key localities. Working together, GeoEd, Natural England and the BGS tested techniques on a small scale (2m^2) and then a more adventurous 24m^2. Finally, we tackled a bedding plane that resulted in a 150m^2 mould. This is probably the largest moulded area of its kind in the world and more than twice the size of a recent mould taken of the Mistaken Point Precambrian fauna in Canada.

Each section at Charnwood was photographed and, where feasible, scanned using Light Detection and Radar (LIDAR) equipment. This provided a significant amount of additional data. Individual moulds and casts (a maximum of 1m^2 allowing for easy storage at the BGS, Keyworth), can be re-assembled, examined and photographed indoors with controlled lighting. As a consequence, our record of Precambrian biota has increased several-fold and there is a new impetus to research on these classic *Charnia* sites.

Wren’s Nest NNR

The Wren’s Nest NNR is underlain by caverns, some of which are in danger of collapse. Prior to temporary infilling of some of the threatened caverns with sand, there was an opportunity to access the voids and inspect faces unseen for decades. Using the techniques developed in Charnwood, GeoEd, working under the guidance of Dudley Metropolitan Borough Council, produced moulds of Wenlock Limestone within the cavern. Despite new challenges – difficult access and damp – successful moulds were made of large blocks weighing several tons. The subsequent casts revealed a spectacular Wenlock reef death assemblage which (hopefully temporarily) would otherwise not have been available for use and analysis.

Above, Dave Williams, GeoEd, inside the Wren’s Nest NNR removing silicone rubber mould. *Photo by Graham Worton*
Below, detail of Wenlock Limestone cast from Wren’s Nest NNR. *Photo by Jonathan Larwood*

How it’s done

Silicone rubber (with modern setting catalysts) can be painted onto bedding planes, will cure quickly and can then be peeled off, forming a perfect mould. The mould can then be used to make casts which can be reassembled to create perfect replicas of entire bedding plane surfaces. Surfaces must be clean, so dirt and lichen must be removed with a high-pressure hose, scrubbing brushes and an appropriate herbicide. Fissures and cracks need to be temporarily filled (coloured Plasticine) and, when the surface is dry (this is essential), silicone rubber can be applied. If a thicker, more robust mould is needed, then multiple layers can be built up. Once the mould is fully cured, plaster casts can be made. If portability is a factor, the imprint need not be solid plaster; the imprint surface can be laid down and backed with foam to save weight.

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Trackways partnership triumph

In June 2010, the dinosaur trackway site at Ardley Quarry in Oxfordshire was confirmed as a Site of Special Scientific Interest. This was the culmination of several years' discussion, planning and co-operation between Natural England, the quarry operators Smith and Sons (Bletchington) Ltd, the landfill operator Viridor and Oxford University Museum of Natural History.

Although individual fossil footprints and small portions of trackways are known from the Jurassic and Cretaceous of Britain (*e.g.* Yorkshire Coast, Portland), extensive multiple trackways like Ardley's are globally rare. So when a schoolteacher from Birmingham made the discovery on the floor of Ardley Quarry in Oxfordshire in 1997, Phil Powell of the Oxford University Museum of Natural History investigated. Over 40 theropod and sauropod trackways were identified and preserved in a single bed on the quarry floor.

Apart from the sheer rarity of such features, these trackways have yielded evidence about the origins of titanosaurs; about the mechanics of limb movement in theropods; and on how sauropod herds and theropod packs moved. The number, length, and extent of the trackways, and the information they provide, make this site internationally significant – on a par with some of the larger trackway sites in the Americas. The trackways were formed as a herd of sauropods (possibly followed by a pair of theropods) travelled across lagoons and mudflats on the margins of the London Platform during the Middle Jurassic. Once again, this demonstrates the importance of mineral extraction in advancing our knowledge of many aspects of geology.

Without the active support and enthusiasm of Smith and Sons and Viridor, much of the research achieved to date would have been impossible. The operators provided access on many occasions for educational visits and have worked closely with Natural England on options for the long-term conservation of the trackways.

At first sight, the long-term prognosis for the Ardley trackways appeared poor. Much of Ardley Quarry has permission for landfill, so any trackways exposed could ultimately be buried in waste. Furthermore, once exposed on the quarry floor, the trackways are susceptible to weathering and can be degraded quite rapidly. This can be hastened by heavy machinery moving around the quarry floor. Spurred by these difficulties, co-operation between all involved at Ardley has yielded some very positive outcomes. For instance, Viridor has recently financed the removal of a trackway from the landfill area for partial display and preservation at the Oxfordshire Museum at Woodstock.

It was clear from the trend of the trackways that they might extend into Ardley North quarry as well as southwards. In August 2004 permission was given to Smith and Sons for a large extension to the south of the quarry, but with the condition to protect the trackways that no

Measuring up the trackway.
Photo by Ardley Quarry

excavation should take place below the White Limestone horizon. Thereafter, this area will be restored to agriculture. Here was a real chance to discover and conserve any trackways that might exist beyond the landfill area! Both Smith and Sons and Viridor were receptive to the principle of SSSI designation, with Smith and Sons particularly eager to secure the future of yet-undiscovered trackways.

But how best to manage the interest features? It was agreed during a series of meetings that the presence or absence of trackways would be assessed through excavating trenches as new areas of the quarry were worked. Any

Digging deep for answers to moraine questions

Gareth Owen
Countryside Council for Wales
Adrian Humpage
British Geological Survey

The glacial history of the Usk Valley should become a little clearer through a project to investigate Llanfihangel Moraine SSSI.

The site, extending over 140 hectares of farmland near Llanvihangel-Crucorney, Abergavenny, was identified by the Geological Conservation Review as "the finest example in South Wales of a terminal moraine formed at the extremity of the ice-cap during the final (Devensian) phase of glaciation." The moraine is asymmetrical in cross-section; the gentle southern slope blends into the wide river valley to the south, whereas the dramatic, steep, arcuate-shaped northern slope forms an imposing barrier at the mouth of the Vale of Ewyas. It is thought the moraine caused the Afon Honndu (which flows south down the Vale of Ewyas) to change course and flow back north, leaving the small misfit River Gavenny occupying the large valley to the south.

Scientific consensus in the 1980s was that this steep northern scarp was an ice-contact slope, and that the moraine was formed by a glacier advancing down the Vale of Ewyas from the north. However, research over the last couple of decades has raised questions:

- Was the moraine formed at the extremity of the Devensian Usk ice-sheet advancing from the south instead?
- Is the dramatic arcuate northern slope a fluvial feature, formed by the Afon Honddu in post-glacial times?
- What can the composition of the moraine tell us about its history?
- What are the moraine's key elements? and
- How should they be managed?

To try to find answers, the British Geological Survey has initiated an investigation project. Jointly funded by the BGS and the Countryside

Sinking one of the series of boreholes.
Photo by Gareth Owen / CCW

Council for Wales, work has progressed apace since it started in summer 2010: a series of boreholes has been drilled to form a transect across the moraine, with the aim of providing a detailed cross-section of the sediment type. In tandem, a programme of fieldwork has been started to inform a detailed geomorphological map. The techniques will provide a detailed picture of the composition and morphology of the moraine, and shed light upon its origins.

In addition to providing sound evidence upon which to base future management, the work is in line with the landscape-scale approach to conservation favoured in the National Environment Framework: understanding the soils and drift deposits of the area provides a better insight into the ecosystems and agriculture it supports. It also provides detailed

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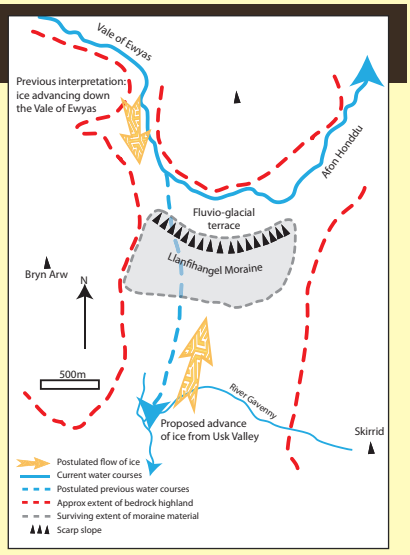
Dave Evans
Natural England

discoveries would be recorded and then re-buried beneath the overlying clay, so identifying the broad distribution of the trackways and leaving them largely undisturbed.

Planned trenches to explore the northern part of the quarry were made impossible by the wet summers in 2007 and 2008, and the work drew a blank in 2009. However, in summer 2010, Phil Powell found trackways on the west of the area, showing that they did extend beyond the original site. These have been recorded and re-buried, as will any further trackways found through this method. They will lie undisturbed until it is possible to conserve them in a manner that makes them visible, accessible and weatherproof.

Meanwhile, it may be worth considering research through non-invasive surveying, perhaps using a technique like Ground Penetrating Radar, which has been piloted on a number of trackway sites in North America. There is plenty of time for such work. The southern extension known as Dewars Farm is only just starting to be developed and the clay unit above the trackways bed will be progressively exposed over years to come. The Dewars Farm extension is a working site, and permission to access it may be obtained from Smith and Sons. However it will be some time before the lowermost beds become accessible. ■



information on the landscape response to historic climate change during global warming, glacier melt and sea-level rise – an obvious analogue to today's changing world. The work is scheduled for completion in 2011. ■

Further reading

Campbell, S. and Bowen, D.Q., 1989. *Geological Conservation Review, Quaternary of Wales*. NCC.

The documentation of sites and the conservation of samples/specimens are fundamental to the study of geology (and many other natural sciences). While site recording has been with us for as long as there has been interest in geology, techniques have been, and are, subject to revision. The 1990 Strategy placed a strong emphasis on the need to improve documentation and the conservation of samples and the intervening years have seen strides in those directions.

– Dave Evans, Natural England

Improvements on the record

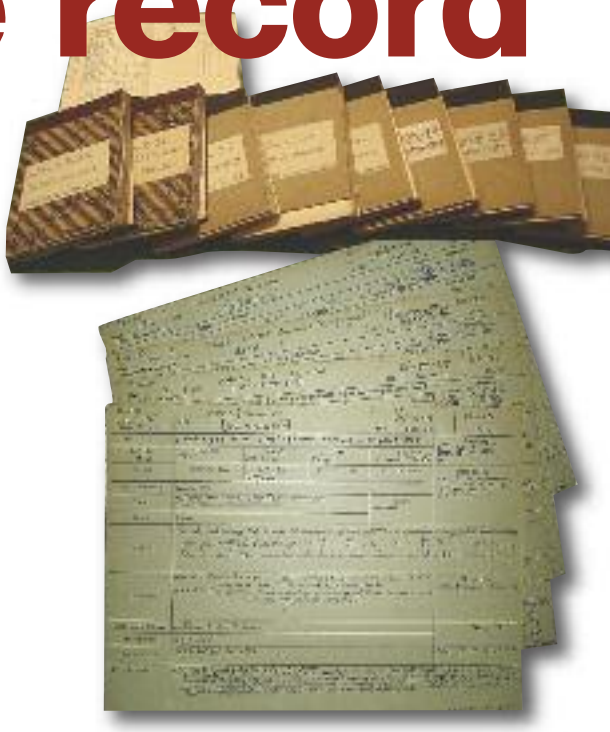
Documentation serves several key purposes. In recording the geologically interesting features of a site, it forms the evidence-base for site selection. It also records the elements to be protected from unsympathetic development or other damaging activities. In the worst case, documentation and the conservation of samples may be the only way of retaining a record of a site, and may provide the only basis for future research. Indeed, many museum collections contain unique assemblages from sites that have long since disappeared.

Documentation forms the basis for site management, so it needs to be relatively simple and clear because the management itself can often fall to owners or managers with little knowledge or understanding of the site's special scientific features. Clear documentation also facilitates imaginative interpretation for the public.

Finally, complete documentation may come to form a valuable historical document, not just to aid understanding of a site's science, but also because the site may also contain important elements of an area's social and economic history (Wren's Nest National Nature Reserve in the West Midlands provides a case in point).

While the 1990 Strategy acknowledged the importance of conserving samples, its greatest emphasis was on the need to improve site documentation.

Developments of fossil and mineral collecting policies and codes have doubtless helped moderate the manner and scale of sample



Original notes and index cards from the 1950s written by W.A. Macfadyen, the first geologist employed by the Nature Conservancy. Recording has come on a bit since they were done half a century ago, but it was a vitally important start. ***Photo by Colin Prosser / Natural England***

Dave Evans
Natural England

collecting from sites, and much good practice in sample conservation has been developed within the museum community. These constitute substantial steps toward fulfilling Strategy objectives, but gaps remain, in part because of difficulties developing a consistent approach to site recording and documentation.

Prior to the 1990 Strategy, site documentation existed broadly in three forms:

- management documentation, mostly in the form of Nature Conservancy Council site files that originated from

continued on page 14

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From page 13

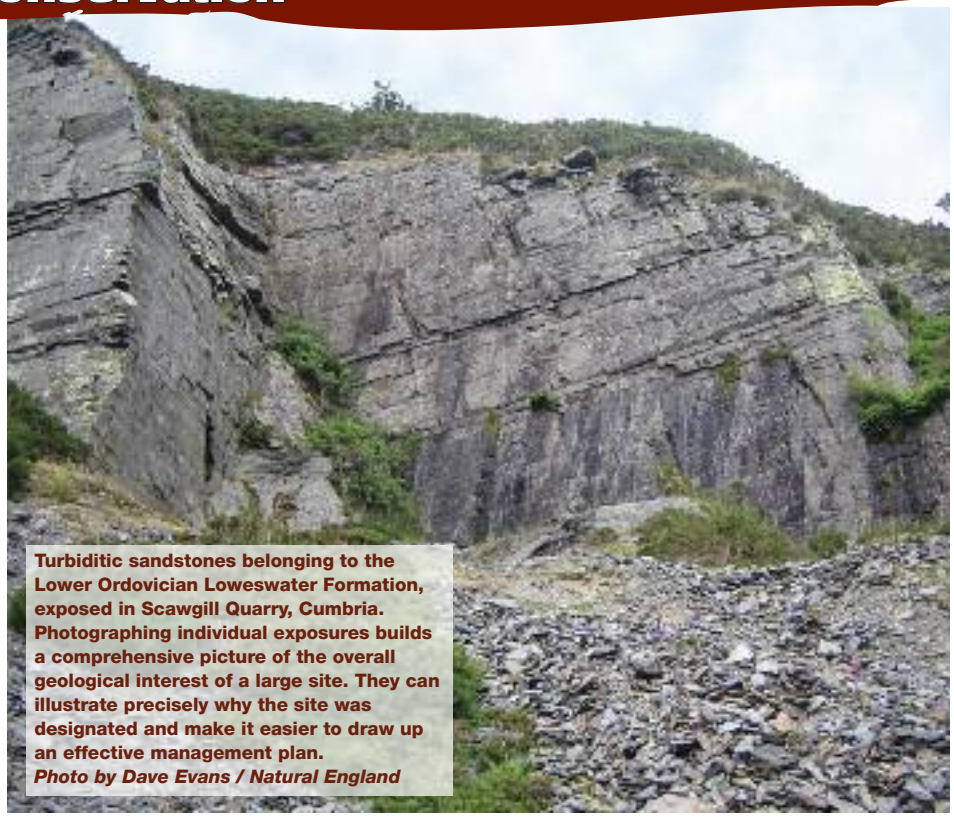
Macfadyen's site index card system (which build into a record of site management and condition);

- local sites documentation such as the National Scheme for Geological Site Documentation (NSGSD), set up in 1977 and based in local records centres and museums; and
- the scientific documentation of sites, of which the *Geological Highlights of the West Country* by W. A. Macfadyen provides an example. This was a forerunner of the Geological Conservation Review (GCR) volumes. The first of these just pre-dated the publication of the Strategy.

The Strategy focussed on all three of these areas. So what has been achieved?

It is to be hoped that scientific documentation of all GCR sites (*page 4*) will be completed before long. For me, these GCR volumes are vital for day-to-day work as they offer the only comprehensive scientific documentation of a site, provide justification for the GCR networks, and provide a guide to further documentation. They also help identify specific features to be managed and set customised conservation objectives for each SSSI.

More broadly, some of the volumes may become classic works – one can draw parallels between the Upper Cretaceous GCR volume (Mortimore, Wood and Gallois) and the work of Jukes-Browne and Hill at the beginning of the 20th Century. One of the major drives of the Strategy was the development of Site Management Briefs (SMBs), designed for use by the country agencies' geologists and conservation officers. The first of these were produced as the Great Britain Nature Conservation Report Series to a standard set by the Joint Nature Conservation Committee. Their extensive photographic documentation of the sites was invaluable, but there was relatively little advice on site management.



Turbiditic sandstones belonging to the Lower Ordovician Loweswater Formation, exposed in Scawgill Quarry, Cumbria. Photographing individual exposures builds a comprehensive picture of the overall geological interest of a large site. They can illustrate precisely why the site was designated and make it easier to draw up an effective management plan.
Photo by Dave Evans / Natural England

By 1992 the country agencies were producing briefs to their own needs and standards, leading to somewhat different documents in each country. For instance, Scottish Natural Heritage produced comprehensive documents, and English Nature (as then) produced documents aimed at helping site managers and so reducing the day-to-day casework for geologists.

As such, these documents were a step change from previous resources. However, they could be dense and word-heavy, making them challenging for non-specialist readers to absorb, and their overall context was hampered by the lack of the appropriate GCR volumes.

Today, technological advances – Geographic Information Systems (GIS), digital photography and video and good graphics software – herald great improvements for site management documentation (*see issue 34, Visualising the future*). Precise prescriptions, as well as 'visions' for a site, can be set out and the site management brief becomes an interactive document that can be readily updated as work progresses.

This is particularly fortuitous in the light of present economic pressures and the possible need to adjust conservation objectives.

However, in the face of these new methods, it is vital to hold on to the decades of painstaking paper documentation. These records will remain indispensible in understanding sites and the nuances of their management. ■

Challenge of local site paperwork

Local Site Documentation was driven largely by the recognition that if local features were not evaluated, many potentially important sites and specimens could easily be lost permanently. In addition, temporary excavations for laying water mains or other services made it possible to record geological features and even significant fossil assemblages that were normally hidden.

The bulk of this documentation was carried out by local geological groups, including RIGS Groups and the Geology Trusts, financed through grants from the Heritage Lottery Fund, Aggregates Levy Sustainability Fund and the country agencies.

The work has taken a variety of forms, ranging from site assessment and site management documents to literature archives, database site inventories and other resources (*e.g.* the Educational Register of Geological Sites available from Devon County Council). Despite the plethora of local site documentation, the variation in standards and criteria from one area to another presents difficulties in gaining an objective overview of the local sites resource. These difficulties are compounded by sensitivities over availability and use of some data. However, with the development of a national database of Local Geological Sites, this situation is changing for the better, as Jonathan Larwood explains on page 6.

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Conservation systems:

Take it or leave it?

Mick Stanley

In the age of scientific and antiquarian investigation during the 18th and 19th centuries, countless philosophical societies were formed with collections of artefacts, cased natural history specimens, rocks, minerals and fossils at their heart. Collection for investigation and preservation of the human and natural world was the norm and this activity accelerated as more scientists and archaeologists were trained, and many more amateurs were galvanised into a collecting frenzy. Geodiversity collections were made and deposited in museums across the world, especially in Europe and North America.

Protecting

By the end of the 19th Century there was also a movement to protect specific sites with the first at Salisbury Crags in Edinburgh and the Cheesewring in Cornwall. However on 12 January 1895, Octavia Hill, Robert Hunter and Canon Rawnsley founded The National Trust for Places of Historic Interest and Natural Beauty in England and Wales. The NT was "to set aside the best and most beautiful parts of Britain for the public and posterity". But other countries had already started protection: in 1836 the volcanic landscape of Siebengebirge (Seven Mountains), near Bonn, Germany, was designated as the first geological nature reserve. Yosemite Valley in California became protected in 1864, closely followed by the world's first national park at Yellowstone.

In the open air, rock outcrops and visible minerals and fossils are vulnerable to natural weathering and prone to being vandalised unless they are physically protected. But protection is not preservation, which is defined as maintaining something in its original or existing state. *Earth Heritage* over the past decade has reported on the few experiments to preserve geodiversity. The only geological examples of *in situ* preservation are the Fossil Grove in Glasgow, totally covered in 1887, and Rifle Butts Quarry section near Goodmanham, East Yorkshire, partly covered in 1994. *In situ* archaeological monuments are far more common, for example Stonehenge and the many other standing stones and crosses from antiquity. But only one standing stone, Sueno's Stone, located near Forres in Scotland, has a controlled environment as it sits in a glass enclosure. The penalty is the loss of accessibility and ambience.

The Sueno Stone enclosure (left) affects access and ambience. The Rifle Butts shelter (below) was an expensive protection for a unique condensed sequence (inset). Museums like Madrid's (far left) represent the best way of conserving most specimens. *Photos by Paul Allison, Patty McAlpin, Gordon Hatton, Mick Stanley*

Why are there so few attempts at *in situ* preservation of geodiversity? Is it due to the high costs of suitable structures that could also limit access? It is certainly not due to the lack of significant and spectacular specimens.

Preserving

There are countless examples of human artefacts preserved in museums. A prime example is the Parthenon Marbles, purchased by Parliament for the nation from the 8th Earl of Elgin and brought to London in 1806 and preserved in a controlled environment for the past 200 years. Elgin's act of removal preserved the Marbles from damage that later conflicts in the Balkans and the degradation of the atmosphere would certainly have inflicted.

Clearly it is significantly cheaper to preserve (select, record, collect, research, store and display) thousands of rocks, minerals and fossils in a museum storage system than it is to try to preserve them *in situ*. In addition there is the question of whether the many protective structures needed for the *in situ* method would be aesthetically acceptable.

Museums and heritage sites preserve millions of rocks, minerals and fossils and have done so for hundreds of years. The museums reduce the natural degradation by controlling the environment of the specimens, and ensuring that they are available for study, entertainment, enjoyment and education.

The costs involved with *in situ* preservation are incomparably greater, but occasionally the cost can be justified. The farm building covering the Rifle Butts section cost several thousand pounds and only justified construction as it was protecting a small, limited and unique condensed sequence that is a designated SSSI. Every year, and for many years up to 1994 when the structure was built, members of Hull Geological Society cleaned the low face by removing debris. All involved agreed that the exposure would soon disappear forever if the Society continued to remove the debris created by frost heave. The structure was a pragmatic solution to a particular small and limited exposure. And on-site conservation is likely to remain a rarity. ■

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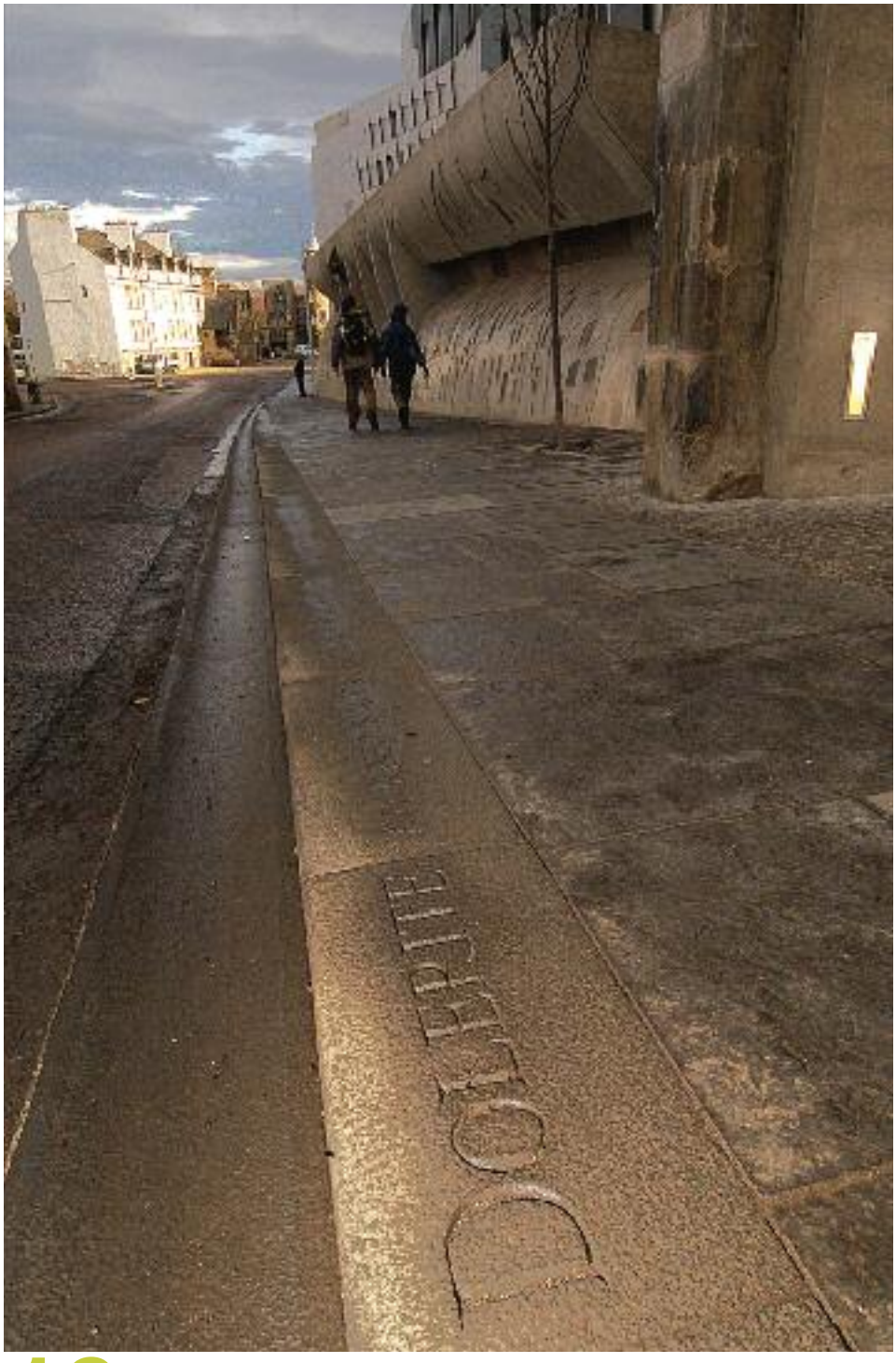
In 20 years, the development of geodiversity interpretation in the UK has been extraordinary. Many sites and areas of geological and geomorphological interest now have some form of interpretation or information to tempt visitors with vastly varying levels of knowledge of our subject. The challenge has always been to produce material that at once hooks those with a casual interest and at the same time informs those with a deeper knowledge of geodiversity.

In Scotland, leaflets, trail guides, rock-routes, panels and highly readable and colourfully illustrated guide books have become increasingly common.

The development of centres such as Knockan Crag, north of Ullapool, offer people a full-on taste of the country's spectacular geology through state of the art interpretation and through less traditional means, including sculpture.

In Wales, vibrant, informative visitor centres focus on geodiversity in a growing number of places, as exemplified by the Waterfalls Centre at Pontneddfechan. Events such as the Fforest Fawr Geopark Festival, the Prestatyn and Clwydian Range Walking Festival and the Anglesey Walking Festival all provide the opportunity to explore the country's geology where it's at its best – in the field. A wealth of self-guided walk leaflets, building-stone trails, guidebooks and children's activity



Time

With the plethora of interpretative materials and initiatives available, but reduced resources becoming a reality, now is a good time to take stock and set the foundation for forthcoming geodiversity interpretative work.

Across Scotland, geodiversity interpretation is undertaken by a variety of organisations including local geoconservation groups, the geoparks, Scottish Natural Heritage, the National Trust for Scotland, local authorities and many others. Public education remits, the development of niche tourism, or simply an enthusiasm to share a good Earth story with others have been major drivers to date. *Earth Heritage* has over the years included news of many interpretative projects; however, there is little in the way of readily available information concerning the evaluation of the effectiveness of such work.

Evaluation is a key aspect of interpretation, no matter the scale and vehicle used. The aims and objectives of every interpretative

Left: 'Named' kerbing outside the Scottish Parliament on the Royal Mile, Edinburgh. This item of geological interpretation was designed to link geodiversity and the built environment in the minds of passers-by. But has it worked as intended? It will be a challenge to evaluate that, but it may be a worthwhile exercise. ***Photo by Dougie Barnett / Scottish Natural Heritage***

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booklets have become increasingly augmented by digital media: EarthCaching trails, downloadable audio trails and podcasts are growing in popularity, bringing the geology and geoheritage of the Welsh landscape to life.

In England, innovations have included 'ChalkEast', a series of projects and initiatives aiming to explore how chalk links people and communities to the landscape in eastern England, 'Rockworks', an interpretation and education project in the North Pennines European Geopark and the creation of a long-distance walking route and accompanying geological interest guide through the Abberley and Malvern Hills.

The internet has provided a new avenue of communication and an increasingly accepted method of presenting, disseminating and sharing geodiversity interpretation in recent years.

However, in the electronic age, guided walks and public awareness events, such as the scores of occasions encompassed by the national Scottish Geology Festival, continue to provide invaluable face-to-face contact and practical experiences.

The challenge going forward is to keep building public awareness of geodiversity on tighter budgets and scarcer resources.

to take stock

Colin MacFadyen
Scottish Natural Heritage

project should be revisited to determine if it has worked. Must-ask questions include: is the project still appropriate and functioning the way intended? If it is a success, how does it achieve that and how may that be applied elsewhere? Are there any weak points and if so how can it be enhanced and augmented? The paucity of evaluation data is unfortunate since they would provide invaluable background information for redeveloping interpretative products. It would be useful guidance on what works and what does not work for others in the geodiversity interpretation community planning fresh projects.

The process of taking stock may include securing what has already been achieved. It is a fact that once cherished and hard won items of interpretation are developed, they are often left to their own devices, with neither plans nor funds to enable follow-up care and maintenance. Leaflets go out of print, panels and way-marked trails become degraded and, eventually, even the best state of the art interpretation may be lost.

All interpretation, whether ground-breaking and successful in its approach or found to be lacking in some aspect, should be archived to provide a permanent record of what has been achieved. There is a strong case to be made for the setting up of a national archive of leaflets and information from panels, to secure it for future reference.

Looking to the future, it is likely that the drivers for geodiversity interpretation will remain much as they are today.

However, a scarcity of resources means that in the next few years, new approaches may have to be adopted. This may include greater collaboration. Collaborative interpretation involving other subject areas may provide a means of getting geodiversity messages over. It's a tactic that has already been utilised to good effect in some projects.

Linkages everywhere

Rather than being viewed as a dilution of geodiversity, this particular approach may be serendipitous: it offers scope for securing the public's interest in geodiversity through linkages with other natural and cultural heritage interests. Linkages are possible practically everywhere – biodiversity, industrial archaeology, the built heritage, all of which offer scope for introducing important messages about the geodiversity and the services it provides. Even without the current economic constraints, this is a very important area for development, representing a major route ahead for geodiversity interpretation.

Collaboration is also required among geodiversity interpreters, to enable joint working and the sharing of lessons gleaned from the evaluation of existing projects. This could lead to improvements in interpretative provision generally. Sharing experience and the compilation of best practice can be achieved, for example, by means of articles in *Earth Heritage*, and perhaps at specially convened interpretation forums. In Scotland, an interpretation working group may function within the emerging Scottish Geodiversity Forum.

As regards developments in interpretation, anecdotal evidence suggests that Scotland, which once was a leader in the field, now has much to learn from other countries. Interpreters should be on the look out for improved methodology and techniques, for example through use of electronic means, and seek ways of adapting them where appropriate. However, this should be with the proviso that before importing new ideas, their value and success should be demonstrated through evaluation!

One thing is for sure: all interpretative information for particular sites and areas has to be made more widely available via the internet. It has been a long-held aspiration in Scotland to gather information on all interpreted locations on a website such as **www.scottishgeology.com**.

Continued on page 18

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Building up a head of steam over lime

A demonstration lime-burning event at Whitlingham Country Park, Norfolk, touched on numerous natural and cultural heritage issues, providing an exemplary way of cross-cutting through themes.

Notions of geology and rock extraction, traditional building processes, local employment and geological conservation were there for all to think about.

The event was organised by the Geological Society of Norfolk, the Whitlingham Charitable Trust and the Natural Building Company to build the kiln; local historians Geoffrey Kelly and Robin Whitmore brought history alive with a programme of walks and talks about the industry at Norwich and Whitlingham, including the history of the local landscape.

The project was funded by Natural England and the Geologists' Association in association with Chalk East.

Download a factsheet on lime burning from www.geoeast.org.uk/geoimap/norfpdf/lime_burning_factsheet.pdf

***Above*, Matt Muldoon (The Natural Building Company) oversees a visitor's attempts at lime plastering.**
***Left*, Matt and Dirk Bouwens (EARTHA) watching steam rise from the slaking process.**
Photos by Tim Holt-Wilson

● The Norfolk Geodiversity Partnership has just published *Norfolk's Earth Heritage – valuing our geodiversity*. Written by Tim Holt-Wilson, it is a concise introduction to the county's key geodiversity features and why the resource is important for society. Copies are availalbe for £12 + £2 p&p by contacting Jenny Gladstone, email jennygladstone@aol.com

From page 17

Ultimately, using the selective power of an online database, these interpreted locations could form the basis of an information network that may be themed at various levels. For instance, geotourists could select information on particular areas of the geodiversity, such as Palaeogene volcanoes, glaciation, modern dynamic processes, geology and the built heritage, and links with biodiversity. Huge advances have been made in geodiversity interpretation over the last 20 years. However, in this challenging economic climate, there has never been a better time to take stock, evaluate, archive and start planning the way ahead.

Future projects should be based on best-practice principles and draw upon proven and improved methodology and techniques, seeking collaboration where possible.

In doing so, geodiversity interpretation will continue to move forward and convey important messages about why the geodiversity matters and – perhaps more importantly to the interpreter – instil a sense of wonder in others. ■

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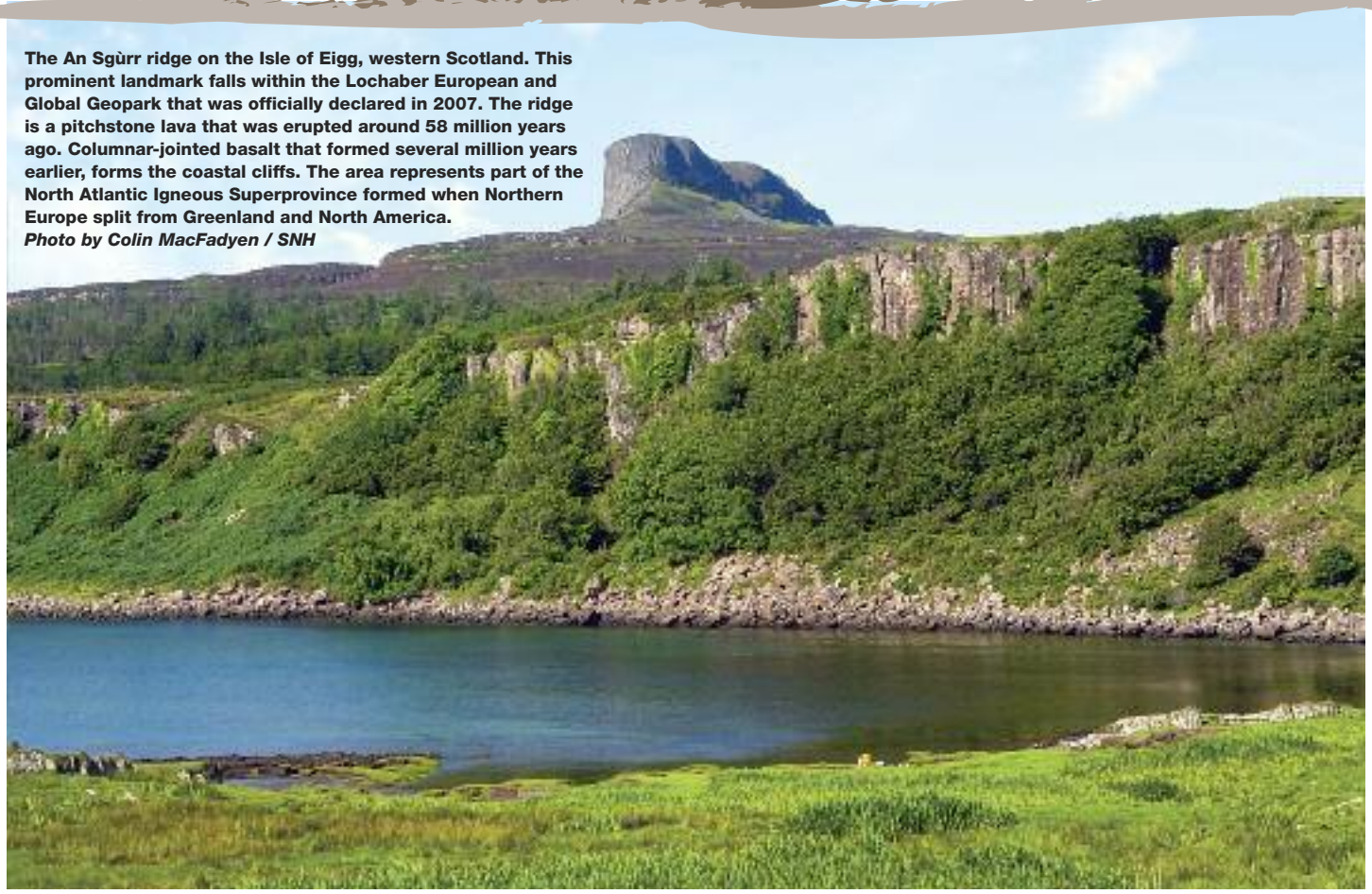

The An Sgùrr ridge on the Isle of Eigg, western Scotland. This prominent landmark falls within the Lochaber European and Global Geopark that was officially declared in 2007. The ridge is a pitchstone lava that was erupted around 58 million years ago. Columnar-jointed basalt that formed several million years earlier, forms the coastal cliffs. The area represents part of the North Atlantic Igneous Superprovince formed when Northern Europe split from Greenland and North America.
Photo by Colin MacFadyen / SNH

In 1993 the Malvern International Conference on Geological and Landscape Conservation brought together geoconservationists from across the world. At the time it was the most significant geoconservation event ever to have been hosted in the UK.

Some significant events have shaped the international (and local) profile of UK geodiversity in recent years. Firstly, the inscription of the Jurassic Coast as a UNESCO World Heritage Site in 2001 (alongside the Giant's Causeway WHS) placed UK geodiversity and geoconservation on a global platform. Secondly, the establishment of the European and Global Geopark network not only raised the profile and value of selected areas internationally but changed the way geodiversity is valued locally. There are presently eight European Geoparks in the UK (two in England, three in Scotland, two in Wales and one in Northern Ireland).

Perhaps the longest-serving sharing of geoconservation knowledge and experience, from a local to international level, has been through this magazine. With its origins in 1968, it has been published in its present format since 1994 and has a global circulation list.

– Jonathan Larwood, Natural England

Cross-border network spreads

good practice

Fforest Fawr Geopark is one part of an international movement geared to bring an understanding of geodiversity to the public.

Alan Bowring
Fforest Fawr Geopark

When Fforest Fawr Geopark hosts the 27th European Geoparks Network meeting in March 2011, nearly 90 delegates from 18 countries across Europe should attend. They will represent some 42 Geoparks stretching from Arouca in Portugal to Magma in Norway, Marble Arch Caves in Ireland to Psiloritis in Greece.

The movement has grown from an initial four geoparks just 10 years ago, when the Network's founders set out aims to bring an understanding of geology to a wider audience and to bring economic benefits to the communities involved. Indeed, one of the criteria for Network membership was that the development of a Geopark should have the potential to bring tangible benefits to local people; making money from the landscape but in ways that ensure the special qualities, features and character of the place are protected and, where possible, enhanced.

Continued on page 20

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Urban geopark on tourism

When UNESCO* announced the English Riviera Global Geopark as the world's first urban Global Geopark in 2007 for its geological, historical and cultural heritage, it brought international recognition to the Torbay area of South Devon.

The view from the top of the Berry Head National Nature Reserve, gateway site for the Geopark.
Photos by English Riviera Global Geopark

Melanie Border

English Riviera Global Geopark

As with all Global Geoparks, the English Riviera is not simply about geoconservation. The status is a strategic driver for community benefits, quality tourism, and sustainable economic regeneration. It offers us an opportunity to use our geology, landscape, heritage and culture to promote a sense of belonging and pride amongst residents, particularly young people.

With wide support from the tourism sector, the Geopark is now securely placed within the area's new tourism strategy. Seen as a new hook to reverse the gradual decline in visitor numbers and spending, the designation will be used to increase the value of tourism to the regional economy, and to re-position the English Riviera as a leading UK destination.

So what's actually been happening?

Working to bring the Geopark's stories of the last 400 million years to life has been essential. With that in mind, this year, the Geopark has been working with the local community and creative sector to produce a short film (see www.englishrivieargeoaprk.org.uk) which combines animation and live action. The characters developed for the film reappear in the beautifully illustrated new *Official Guide to the English Riviera Global Geopark*. Both the film and guide highlight how the Bay's outstanding geological heritage has influenced the area's remarkably diverse marine and terrestrial biodiversity, and shaped its history, from the earliest cave dwellers of Kents Cavern through to the tourism industry of today. The book is available on line at www.amazon.co.uk.

Of course, events take place all year round but the greatest success of the Geopark Festival 2010 was Geoquest, which was awarded the Inspire mark by the Cultural Olympiad. Geoquest saw three artists (the Geo-trio) take the Geopark into the heart of the community. Dressed in exclusively

from page 20

Working together

The Network places an emphasis on Geoparks collaborating to mutual benefit. Individual Geoparks have established links with one another, a process which starts in some cases with an existing member of the Network mentoring a prospective member. A recent development has been the establishment of thematic groups intended to encourage discussion and co-operative working between those Geoparks which share common stories. For example, Fforest Fawr Geopark is engaging with seven or eight others to explore aspects of their mining and quarrying heritage and with a different group to consider the legacy left by the ice age. Some of this latter group are very much in the thick of it as they have active, albeit shrinking, glaciers within their bounds.

Alan Bowring, Geopark Development Officer interprets the landscape of Cribarth to a group of walkers during the Fforest Fawr Geopark Festival.
Photo by BBNPA

Public understanding

Each Geopark reaches out to its public, whether resident or visiting, in ways appropriate to its own circumstances. In addition, the Geoparks undertake a co-ordinated promotion at the end of May/start of June each year, when they all celebrate European Geoparks Fortnight. Like others, Fforest Fawr Geopark marks the occasion with its own Geopark Festival - a mix of walks, talks and exhibitions focussing on aspects of its heritage. At the heart of all this activity is the area's geodiversity which goes on to underpin its biodiversity and provides a foundation for its cultural diversity.

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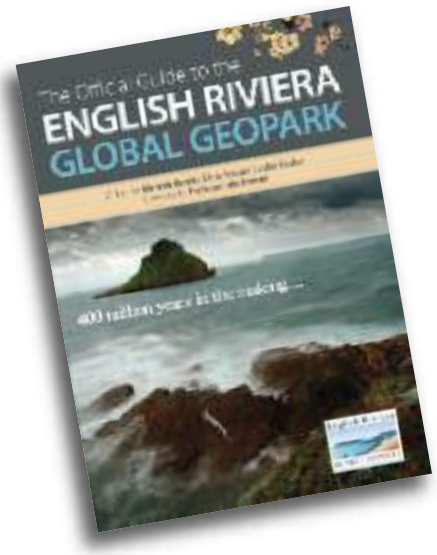
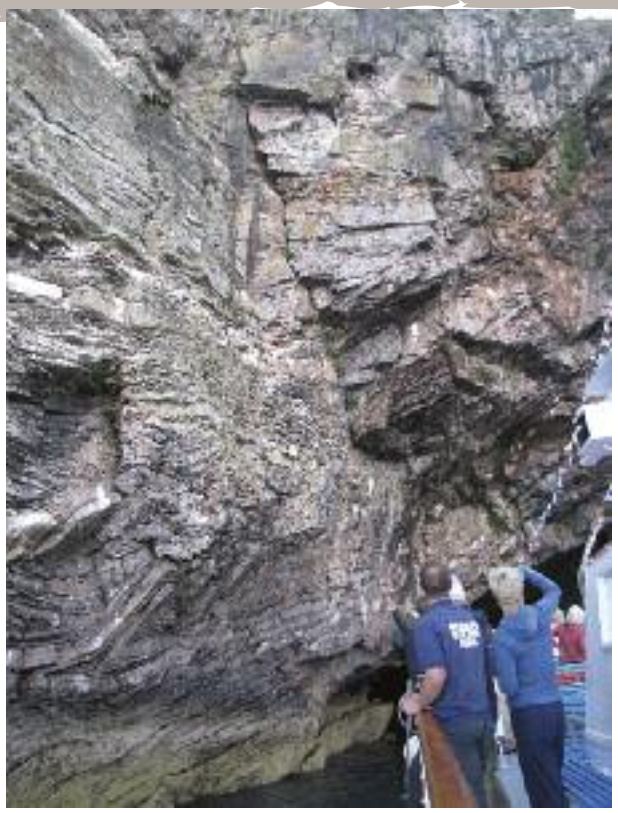


The official guide helps give the Geopark cohesion

One of the Geotrio from a 2010 event, dressed in his coat of stones, explains a point to a fascinated youngster.



A Geopark boat cruise brings visitors up close to the Berry Head Devonian limestone cliff face.

designed stoney costumes, the Geo-trio embarked on a journey of exploration through the Geopark over the course of one week. On their amazing journey, by day they followed the arc of the bay and interacted with numerous community groups from nursery children through to a day-care centre for the elderly, researching, creating and telling stories and performing songs about the land and the communities as they passed. By night they brought those stories to life in a series of free walks followed by evening performances at key English Riviera Geopark sites. Songs that developed as part of the journey were recorded. Basic rock song, for instance, is just great as an introductory tool to engage younger children with the concept that there are three types of rock.

Meanwhile, the excellent new Geopark Gateway Site, visitor centre and café at Berry Head, Brixham, has opened. Managed by key Geopark partner Torbay Coast and Countryside Trust, the development at the site was part of a 3-year £1.8m programme designed to rejuvenate completely Berry Head's heritage and the way people experience it, with state of the art interpretation.

So, what next for the English Riviera Global Geopark? On the horizon is a new guided walks book and an amazing Geopark themed play area for Paignton seafront following the success of Paignton Community Partnership's bid to the Big Lottery Fund.

All in all a busy few years, but ultimately every Geopark success has come as a result of partnership working and the commitment and combined strength of public, private, and voluntary sector. ■

*UNESCO – United Nations Educational, Scientific and Cultural Organisation

Connections have been made and continue to be made between the geology and geomorphology of Fforest Fawr and wider issues of public interest. By way of example, this Geopark contains within its Palaeozoic rock sequence a record of past glaciations, just as its Quaternary deposits reflect a later period of substantial environmental change. Examination of these records helps to inform discussion on what climate change may hold for us. The Geopark recently held the first of what is intended to be an annual series of research seminars. A key focus was the local record of glacier expansion and recession in what was a marginal area. While the seminar was aimed at academics, the outcomes will be presented in layman's language for wider consumption. ■

National Park warden Wyn Morgan introduces a group of Geopark walkers to the old limekilns at Henllys Vale. *Photo by BBNPA*

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New approaches – geod

Although *Earth Science Conservation in Great Britain – a Strategy* reflected the priorities as they stood in 1990, it was inevitable that new and unanticipated challenges would have to be addressed. An example is the need to understand and adapt to the impacts of climate change. For geoconservation, coastal and river protection schemes designed to counter climate change effects like erosion and flooding pose threats to geological exposures and the functioning of geomorphological processes. At the same time, the geological record revealed at protected sites presents us with the opportunity to pinpoint past environmental change and its consequences. This knowledge can be invaluable in helping to develop the adaptation strategies needed today.

In the economically driven society in which we live, attempts are now being made to put a value on the 'services' that the natural environment provides to society. In order to reflect this value accurately, we need to ensure that the services provided by our geodiversity are recognised when making decisions about the importance of the natural environment. Recent political, economic, social and environmental changes mean that it is now timely to review the vast opportunities and challenges facing geoconservation in the future and the Annual Geologists' Association Conference in 2011 will do just this.

– Colin Prosser,
Natural England

Blaze Beck in the Lorton Fells of the NW Lake District, near one of the areas where Natural England is piloting the Ecosystem Approach. Here, geodiversity provides a foundation for habitats of national/international importance, water resources and valuable assets for tourism, recreation and inspiration.
Photo by Dave Evans, Natural England

John Gordon
Scottish Natural Heritage
Eleanor Brown
Natural England

Approaches to conservation in the last 60 years have evolved from an initial focus on the protection of key features in SSSI. Although this has remained important, conservation has since developed to include broader area-based approaches, such as National Character Areas and Natural Heritage Futures Zones. The concept of an 'Ecosystem Approach' has now become a key driver, with a shift in focus to the management and conservation of ecosystem 'goods' and 'services'. Here we outline some opportunities and challenges for geodiversity and geoconservation.

The definition of an ecosystem includes the living and non-living elements of an interdependent system (Campbell *et al.*, 2009). Consequently, an Ecosystem Approach is intended to be a more holistic way of looking after the natural environment. It is defined under the Convention on Biological Diversity (CBD) as "…a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way." National commitments to the CBD mean all signatory states are required to develop and apply this approach. The Millennium Ecosystem Assessment (2005) [MEA] reported on the international state of ecosystems and the goods and services they provide for society. These are typically grouped into four main categories.

The table on the right shows that geodiversity either provides or influences a wide range of ecosystem services. For example, it is a fundamental component of supporting services and also contributes to the other three categories. In some cases, the benefit is direct, whilst in others it is achieved through the influence that geological, hydrogeological or geomorphological factors (including soils) have on biodiversity and landscapes. Understanding geodiversity is essential in the sustainable management of the land, rivers and the coast, particularly in the context of climate change and mitigating natural hazards (see *Earth Heritage 30, 2008*). It is also very much an integral part of cultural services as it contributes to sustainable economic development through local community

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iversity and ecosystem services

involvement in tourism and generating opportunities for outdoor recreation and enjoyment of the natural world. Geodiversity also underpins the aesthetic value of landscapes and has influenced many aspects of our cultural heritage (see *Earth Heritage 32, 2009*).

Essential goods and services

In addition, geodiversity supplies essential goods and services for society that are not considered ecosystem services, such as minerals, aggregates and fossil fuels. The MEA viewed these as non-renewable resources, whereas Gray (in press) describes them as 'geosystem services'. The MEA also acknowledged a lack of analysis of long-term trends in ecosystems and service delivery; clearly evidence from recent palaeoenvironmental archives can address this gap.

Adopting an ecosystems approach in policy- and decision-making (for example in land use planning) means recognising and taking into account the value of the many different services that an ecosystem can provide by looking at the whole natural environment. This ensures that a balance between social, economic and environmental factors is maintained, or even improved.

The Ecosystem Approach is being adopted in the UK and is becoming an increasingly important policy and funding driver for conservation. The Ecosystem Approach is a great opportunity for demonstrating the wider values and benefits of geodiversity. It also provides a potentially powerful framework for developing much better integration of geodiversity and biodiversity.

We now need to evaluate the contribution of geodiversity in the management and delivery of ecosystem services and to use the ecosystem approach to enhance the delivery of benefits for society. Geoconservation already delivers many ecosystem services, but we need to communicate this much more effectively.

There is a strong case to be made for much better integration of geodiversity into the Ecosystem Approach and the assessment of ecosystem services, as set out in the UK National Ecosystem Assessment (NEA) due in early 2011. These are key challenges for the geoconservation and the geoscience communities, both at a national and a local level. ■

Further reading

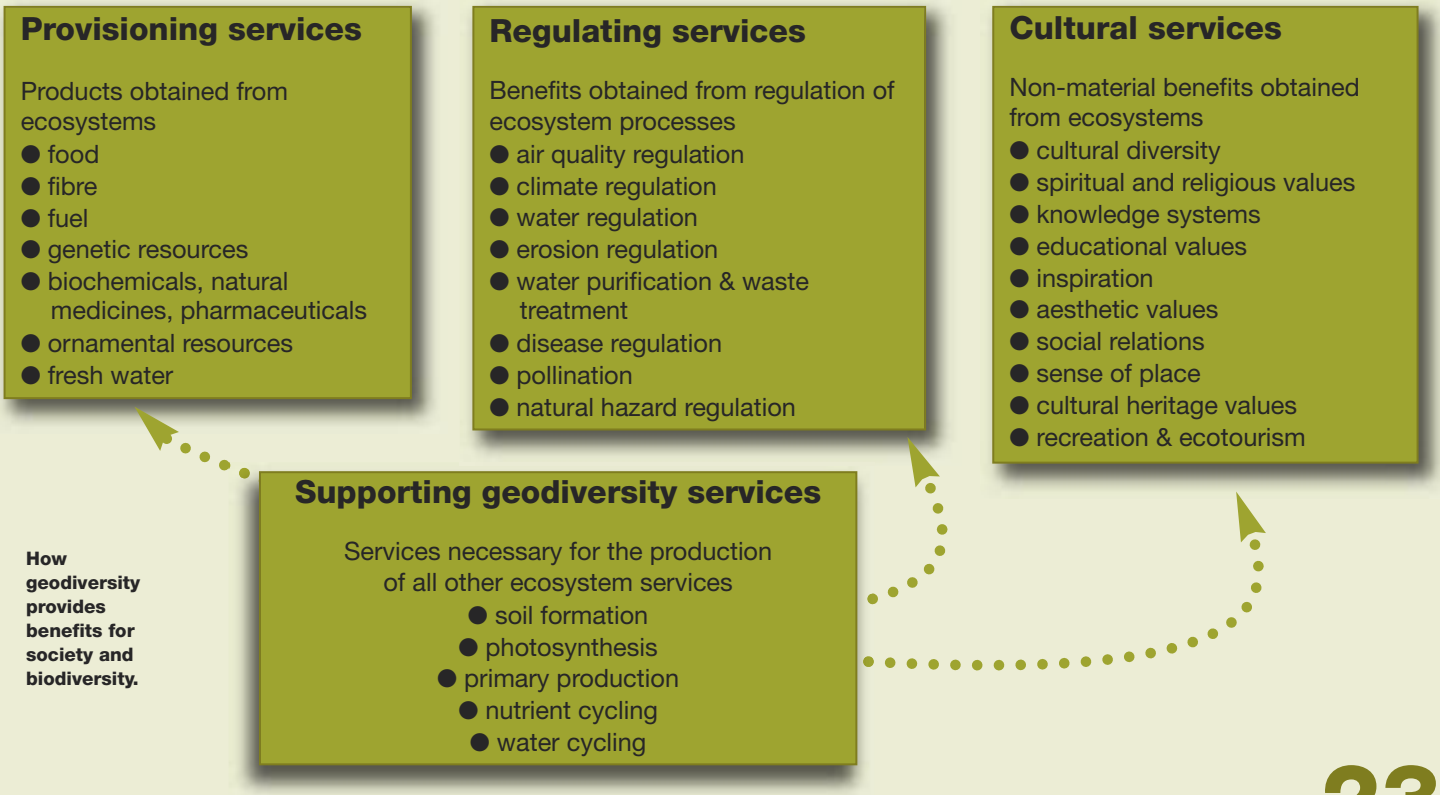
Campbell, N.A., Reece, J.B., Taylor, M.R., Simon, E.J. & Dickey, J.L. (2009) *Biology: Concepts and Connections*. 6th Edition. Benjamin Cummings.

Gray, J.M. (in press) Other nature: geodiversity and geosystem services. *Environmental Conservation*.

Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC.

Applying an ecosystem approach – what it means for geodiversity

Natural England is working to pilot the Ecosystem Approach in three upland areas. These projects are in their early stages, and aim to work in partnership with others to demonstrate how investment and improvement in the natural environment can result in benefits for people and society. The pilots will help to identify innovative ways of delivering increased service provision to society through addressing issues such as water quality, carbon storage, flooding etc. in an integrated way. Natural England's geological specialists have been involved in setting out how to incorporate geodiversity.



How geodiversity provides benefits for society and biodiversity.

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Saving the peat that supports so much

Waun Fignen Felen is an area of blanket peat bog on the plateau of Mynydd Du in the Brecon Beacons National Park. It is unusual in that the peat covers a post-glacial basin within the plateau, underlain by reedmarsh deposits indicative of a former lacustrine environment.

The peat is up to 4m thick in the centre of the basin but has suffered from large-scale wasting over the past 70 years. In the last few years, the bog has been the subject of conservation work to attempt to halt this erosion. Waun Fignen Felen lies within Mynydd Du SSSI, and drains into a series of sink holes that feed the underlying Dan-yr-Ogof cave system, itself a National Nature Reserve.

Waun Fignen Felen provides **supporting services** as the substrate upon which a fragile wet upland ecosystem depends. Regulating services include climate regulation afforded by the large volumes of carbon locked up within the peat, and flood buffering that the peat can have at peak flows and during heavy rainfall. It also regulates the sediment input to the caves. The bog fulfils **provisioning services** as grazing land for hill-sheep farming and a habitat for upland species including game. The **cultural services** it provides are many: a number of Mesolithic stone artefacts have been found within the peat, making it a valuable archaeological site; the peat is a palaeoclimate record in a part of Wales with relatively little rain-fed peat; groundbreaking palaeoclimate reconstruction research has been undertaken on the site (Smith and Cloutman, 1988); and the site is a distinctive and spectacular landscape feature adjacent to a popular hill-walking route. The tourism and recreational caving destination of Dan-yr-Ogof Caves is also affected by events on Waun Fignen Felen.

Damming work being undertaken by Brecon Beacons National Park Authority to prevent further peat erosion is vital in ensuring that the bog is able to fulfil all of its services effectively. Stabilisation work has concentrated on spreading heather bales over the flatter areas of bare peat and a combination of heather bales, wool bales and timbers has been used to impede the flow of peat-laden water in gullies. The techniques have increased vegetated areas considerably and dramatically reduced the amount of peat being washed into the cave system. If left unchecked, the continued wasting of peat would lead to a large loss of grazing land and upland habitat, a huge release of carbon into the atmosphere and a significant scar on an area of outstanding scenic wilderness. In-depth understanding of physical processes and sympathetic management at a landscape scale are vital to the future integrity of this geomorphological gem.

– Gareth Owen
Countryside Council for Wales

A view of the bog area.

Some of the stabilisation works that have been done to date.

Photos by Gareth Owen, CCW

Conditions in the underlying Dan-yr-Ogof caves complex are affected by the overlying peat bogs.
Photo by Brendan Marris

Further reading

A. G. Smith and E. W. Cloutman, 1988. *Reconstruction of Holocene Vegetation History in Three Dimensions at Waun-Fignen-Felen, an Upland Site in South Wales*. Phil. Trans. R. Soc. Lond. B, 322, 159-219

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At Ynyslas, a little Spit goes a long way...

Ynyslas Spit forms an integral part of Dyfi SSSI on the coast of mid-Wales. This coastal barrier is approximately 6km long, attached at its southern end to sea cliffs below Upper Borth.

The spit has formed on a shingle ridge or storm beach, 6m high by 80m wide, and forms a stable substrate for an active dune complex at its northern end. The latter is flanked by extensive areas of inter-tidal sand and saltmarsh, and farther to the east by peats of Cors Fochno (Borth Bog). Chronological data indicate that the spit formed *c.* 6,500 years ago, approximately 1km seaward of its present position, since when it has grown northwards and migrated eastwards.

Ynyslas Spit provides a wide range of services. **Regulating services** include the provision of flood and erosion protection to adjacent coastal land and associated infrastructure (which includes roads, railway, housing, businesses and shipping) and provision of shelter for continued growth of Cors Fochno, the 4th largest lowland raised bog in the UK and an extremely large carbon store (extending over at least 700 ha). **Supporting services** include the provision of internationally important habitats (*e.g.* dune, estuary, saltmarsh, raised bog) and a substrate for internationally and nationally important biodiversity features.

Amongst **provisioning services**, the landform provides for livestock farming on over 1,000 ha of agricultural land located in its protective lee and shelters the important fishing and shipping in the navigable Dyfi Estuary. The numerous **cultural services** provided by the spit include education and coastal research (which, in turn, provide data that can be used to inform climate change models) and recreation and tourism (with over 240,000 visitors to Dyfi SSSI in 2009), whilst the landform provides a unique and visually striking landscape feature.
The continued provision of these various services is reliant upon sympathetic long-term management of Ynyslas Spit and, in particular, upon the sustained movement of sediment northwards along the landform.

Despite the presence of an extensive groyne field, northward flow of sediment continues, probably by over-topping of the groynes. However, the construction of offshore reefs or a northward extension of the groyne system could severely interrupt sediment flow and cause erosion and even possible breaching of the landform, leading to widespread flooding of adjacent low-lying coastal land and subsequent loss of the millions of pounds worth of land, infrastructure and ecosystems it supports.

– Gareth Owen & Bob Mathews
Countryside Council for Wales

Ynyslas Spit from the air. ***Photo by GeoPerspectives; COWI AS***

Right, the Spit in perspective from the south. ***Photo by Bob Mathews/CCW***

Climate change:
Learning from our geological past

Eleanor Brown
Natural England
John Gordon
Scottish Natural Heritage

As geologists we know a lot about how our natural environment has changed over time. We investigate the impact of past climate change, plate tectonics and meteor strikes on Earth, and reconstruct how our Earth system has changed over time. We study how species evolve and we can work out how landscapes have changed, from millions of years ago to relatively recently. Here we set out how we can use this wealth of information to help address the main environmental challenge facing us today – climate change.

Climate change is nothing new. It has been with us throughout geological time, and our recent geological period, the Quaternary Ice Age, has been characterised by rapid shifts

Continued on page 26

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Morrich More on the Dornoch Firth is important for its geodiversity and biodiversity. The 32km² coastal strandplain comprises a series of beach ridges that have accumulated over the last c.7000 years under conditions of initially abundant sand supply and falling relative sea-level. Over the last few thousand years, sediment supply has been reduced, and over the last decade there has been a shift from progradation to erosion of the eastern coastal edge, reflecting the onset of rising relative sea-level. Understanding these long- and short-term processes is crucial to inform future management of the site.
Photo by P. & A. Macdonald/SNH

from page 25

in climate. In the UK we have experienced ice sheets as far south as the Thames catchment, and climates warm enough for hippopotamuses to live just outside what is now present-day Ipswich. Studies of Quaternary records can help us to understand the impact of climate change on our environment, and also the effect of human activities such as land-use change.

At a global scale, models of future change can be validated using palaeoenvironmental data. This testing process gives us information on the reliability of the models and the sensitivity of our Earth system to change. Feedbacks and forcing mechanisms can be explored, along with the magnitude and direction of modelled changes. However, this presents a challenge as it requires a high degree of collaboration between Earth scientists and other scientific disciplines to collate data with wide spatial and temporal coverage.

At a national level, information about past changes is fundamental to constrain scenarios for future change. For example in the UK, studies of Holocene relative sea-level change have provided information on isostatic uplift and subsidence, which is a key component of projections of future sea-level rise made in the UK Climate Impacts Programme.

At a local level, palaeoenvironmental archives are also very valuable. For example, at a catchment and coastal zone scale, studies of Holocene river and coastal dynamics can provide very useful information on how these systems respond to both human and climate impacts. By studying long-term trends it is possible to evaluate critical thresholds and understand changes in the magnitude and frequency of different processes (*see Morrich More, above*). This is very helpful when deciding which management approaches will be most effective in dealing with a particular issue such as erosion or flooding.

A core of sediment from Loch Etteridge SSSI in Scotland. Archives such as these provide invaluable data about past climate and environmental change.
Photo by E.J. Brown

Documentary records, for example of temperature, only tend to go back decades or a few centuries at most. Perhaps one of the most powerful techniques is combining palaeoproxy data with historical records. This can provide a useful context for change, for example the frequency of extreme events, and help answer questions such as the degree to which an area is still responding to a past event such as deforestation or a major flood. By studying entire systems over a long period of time, we are more likely to avoid 'surprises' and be able to evaluate potential responses of ecosystems to natural or human-induced pressures. We are increasingly recognising that sites containing archives of recent environmental changes are inevitably some of the most vulnerable to the impacts of climate change and human disturbance, as they are superficial, relatively soft and therefore easily eroded. Lake sediments and peat bogs may also show hydrological changes which harm the fragile remains within them. Coastal sites will be vulnerable to sea-level change while inland, vegetation growth may affect sites important for their stratigraphy. Although the past will not be an exact analogue for the future, nevertheless "where time is required for an experiment there is no substitute for history" (Deevey, 1969). Our recent archives of change are critically important to help us understand the impacts of climate change and to inform adaptive management of the natural environment. Effective conservation of these important sites now presents the geoconservation community with a key challenge going forward. Equally, the geoconservation community is dependent on the geoscience community to interpret the palaeoenvironmental records and provide the science to underpin adaptive management. It will be crucial for the two communities to work ever more closely together. ■

Further reading

QRA website **www.qra.org.uk**
Deevey, E.S. (1969) *Coaxing history to conduct experiments*. Bioscience 19, 40 – 43.
Oldfield, F. (2005) *Environmental Change: key issues and alternative approaches*. Cambridge University Press, Cambridge. 363p

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Forthcoming event:

Book now to explore future for geoconservation

The Geologists' Association is staging a two-day meeting on the theme ***Geoconservation for Science and Society: An Agenda for the 21st Century***. It will be at the University of Worcester on 9-10 September 2011.

Well-managed geological and geomorphological sites are important to science and society, for research, education and recreation. It is 60 years since the first geological Sites of Special Scientific Interest were designated. A strong framework of legislation, policy, practice and participation in geoconservation is now in place. The meeting, supported by Natural England and sponsored by Elsevier and the Quaternary Research Association, celebrates the success of geoconservation over the last 60 years, but focuses on emerging challenges, opportunities and innovations, as well as new ways of working and the partnerships required to ensure that our geological heritage continues to be valued as part of the natural environment. Lectures, debates and a one-day field excursion will explore issues including:

- site-based conservation *v* landscape scale;
- the future of the Geological Conservation Review;
- the role of geodiversity in supporting ecosystems and climate-change adaptation;
- new conservation techniques;
- the increasing role of local groups and communities in geoconservation;
- the importance of raising public awareness;
- international geoconservation; and
- lessons from archaeological conservation.

Field visits to the Wren's Nest National Nature Reserve and sites in Worcestershire will examine geoconservation in action and the role of local groups and communities.

Registration for the one-day conference only: GA and QRA members £25; others £30. Overnight accommodation at University of Worcester - approx £32 B&B. Cost of field-trip to be announced shortly. Please see **www.geologistsassociation.org.uk/Events.html**. Booking is essential so please register your interest with Sarah Stafford in the GA office as soon as possible (020 7434 9298, geol.assoc@btinternet.com).

New publications:

High-standard GCR volumes

One key role of the Joint Nature Conservation Committee is to provide evidence, information and advice so that decisions are made that protect natural resources and systems, and specifically to work on nature conservation issues that affect the UK as a whole and internationally.

One element of that role is the Geological Conservation Review and its associated GCR publications (*see page 4*). *Fossil Arthropods of Great Britain*, Number 35 (15 pages of introduction and 294 pages of text), and *Mineralisation of England and Wales*, Number 36 (20 pages of introduction and 598 pages of text), will be the last volumes to appear under the JNCC banner, although further titles may appear with the help of the Geologists' Association.

Fossil Arthropods and *Mineralisation of England and Wales* maintain the highest standards that we have come to expect from the JNCC series managed throughout by Neil Ellis. The two volumes have extensive introductions to their subject areas and are written by recognised experts with copious amounts of experience. Both are extensively referenced throughout, with well-drawn plans and maps, and excellent descriptions that give a pen picture of the sites and their contexts. The only criticism is the lack of the occasional colour image to enliven the otherwise splendid volumes.

– Mick Stanley

Discussion point:

Where's the geology?

The cover of Defra's discussion document, *An invitation to shape the Nature of England*, carries four images: one of allotments, one of two girls catching insects in a field, one of trees by a pond and one of a coastal fringe.

While the coast photo may hold a vague geomorphological hint, there is not a rock, mineral or fossil in sight. The document's 20-plus word-packed pages omit all geological considerations, apart from a few words on the intrinsic values of soils. The publication overlooks the importance of geodiversity as the literal bedrock of the natural environment, shaping landscape ecosystems and controlling the range and extent of biodiversity.

If we are to deliver a big society in place of big government, then several critical factors need addressing to enlist the support of the Earth science conservation community: Geodiversity is responsible for the wide range of landscapes, habitats, biodiversity, soils, land use and the local distinctiveness of England. Geodiversity is fundamental to the understanding of past, present and future climate change. Geodiversity provides opportunities for scientific discovery, education and training. Geodiversity gives the background for recreation and public enjoyment of the natural environment.

Fortunately the discussion document drew 15,000 responses, many from the Earth science community. Hopefully these will be sufficient to convince Government to see the Nature of England as an integrated whole, where geodiversity plays the most fundamental role of all in supporting biodiversity and landscape, in underpinning 'ecosystem services' and in informing strategies for adaptation to climate change.

– Mick Stanley

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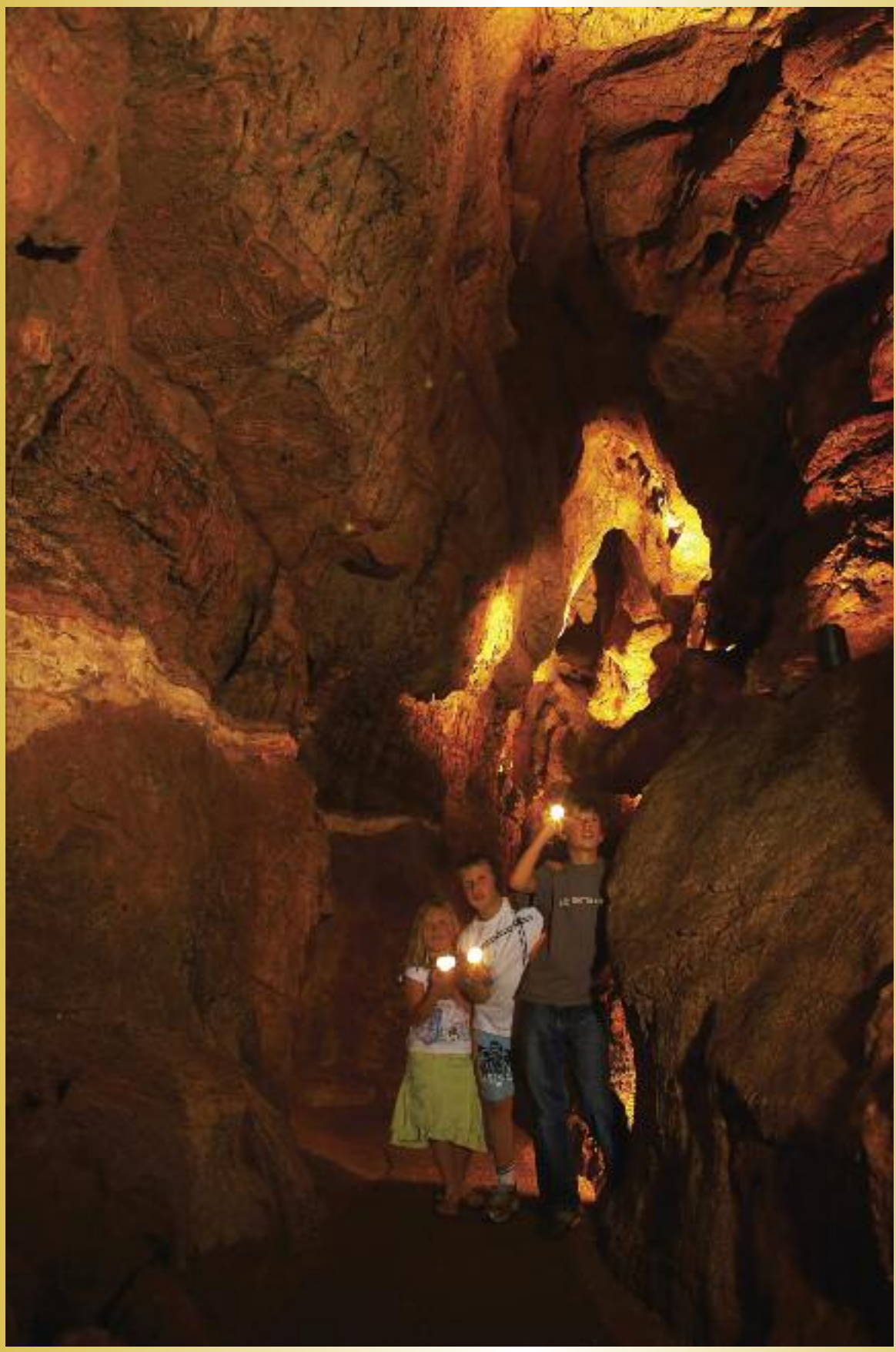

Children explore the wonders of Long Arcade in Kents Cavern, a 400 million-year-old Devonian limestone cave complex. It was once a home for ancient humans and is now an award-winning visitor attraction in Torquay.

The Cavern is one of three gateway visitor centres for the English Riviera Global Geopark (see page 20). From it, visitors can explore the geopark by embarking on a geologically themed self-led circular walk along parts of the South West Coastal Path.

Photo by Kents Cavern

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