Palaeolithic archaeology
- a geological overlap

Andrew Lawson, Wessex Archaeology

The discovery, in 1994, ofBritain's earliest human remains has focused attention on the potential of our Quaternary geological deposits to preserve archaeological evidence of international importance. The robust human tibia recovered at Boxgrove in West Sussex, during controlled archaeological excavation, has made a major contribution to the debate on the spread of the first people into Europe and northern latitudes (Roberts et al., 1994).

Boxgrove, however, is only one of thousands of sites in Britain where archaeological finds of this period have been made (Roe, 1968). Lower Palaeolithic artefacts are frequently found in river gravels, having been washed from their original sites by floods and meltwaters. Interesting though their discovery may be, they are, however, unlikely to give us evidence of the way in which the first occupants of Britain lived or precisely when. But at Boxgrove, unlike many other locations, stone tools and associated animal bones lie where they fell and have not been disturbed by subsequent glacial or fluvial action. This type of site is the most valuable for placing people in the changing Pleistocene landscape - archaeological evidence remains in situ, closely related to palaeoenvironmental indicators, and buried without disturbance by sediments whose origin can be accurately deduced.

Correlation, with radiometric dates, between the fauna associated with Lower Palaeolithic implements (especially certain species of small mammals which are indicative of environmental change) and other European faunas is essential in determining when Britain and Europe were first occupied (Gamble & Stringer, 1993; Wymer, 1982). Since that event, the major climatic variations of the Middle and Late Pleistocene, with consequent cycles of glaciation and amelioration, have effected the degree of occupation of our land and the preservation of the evidence of earlier visits.

If we are to understand better the relationship between early people and their environments, and the mechanism by which archaeological evidence was incorporated into the geological record, the deposits which potentially hold appropriate sites must be distinguished from those of lesser value. With threats to Quaternary deposits from commercial working of mineral aggregates, from major road and rail schemes, and from burial beneath urban expansion, the best sites will warrant protection, if necessary through the use of statutory powers.
The English Rivers Palaeolithic Survey

In England, English Heritage is responsible for preserving important archaeological remains and, in respect of Lower Palaeolithic sites, has taken an important initiative by commissioning a project known as the English Rivers Palaeolithic Survey to review all discoveries of this period. Armied with a complete national overview, it will be possible to take strategic decisions on the protection of certain sites and the desirability of investigating others. This conservation role is also shared with others who can control land use change, including government agencies such as English Nature, local authorities and landowners (Owen-John, 1995). Indeed, it is likely that the best means of preserving Palaeolithic sites is through the conscientious implementation of well formulated local authority policies which follow the advice of the Department of the Environment’s Planning Policy Guidance: Planning and Archaeology of 1990 (Gamble & Wymer, 1994).

The project has been commissioned from Wessex Archaeology in Salisbury and is led by Dr John Wymer, with academic advice being given by Professor Clive Gamble of Southampton University and the periodic meetings of a panel of experts.

Following an initial study of southern England, the project is now well into its stride. In total, it will take six years to complete and, by March 1997, a consistent national picture will have been created. For the purposes of the survey, England has been divided into 12 regions broadly based on the drainage pattern of the major rivers, the sizes of the regions also reflecting the density of known sites. The six regions south of the Severn Estuary and the Thames were studied between 1990 and 1993. The middle and lower Thames (Region 7) and the Severn drainage (Region 10) were studied in 1994/5, the Great Ouse basin (Region 9) and the North of England (Region 12) are currently (1995) being studied, leaving East Anglia (Region 8) and the Trent drainage (Region 11) to be studied by 1997.

In each area, three principal studies are made. First, a database is created of all known discoveries of Lower Palaeolithic artefacts - each entry recording provenance, date and circumstances of discovery, source of information, location and quantification. These records sometimes require verification through visits to find spots or to museums, and through discussions with other researchers and collectors. Second, the distribution of Quaternary deposits is plotted, in which every assistance has been offered by the British Geological Survey. Third, a record of material extraction is compiled; many discoveries have been made during extraction, but extraction has also been responsible for the consumption of many relevant deposits. From these studies, a major report on each region is produced. Each contains a description of the geology and the history of discovery, a gazetteer of all sites within the region and, crucially, an interpretation and assessment of the resource. The main text is backed with appendices on mineral extraction and information sources, as well as explanatory diagrams. A major component of each report is a separate atlas of maps charting the extent of geological deposits and the sites of archaeological discoveries. Although this approach may seem fundamental, it has never been achieved on a national scale before and serves to place British studies at the forefront of European standards of documentation for the period.

The reports, each of which comprise two regions, are parts of a longer-term strategy. However, because of the pressures from modern development on archaeological sites, copies are sent on completion to relevant county council archaeologists for use in development control. Although, due to cost, only a limited quantity of reports have been published, they are available for public consultation, both through county councils and a number of national institutions. At the end of the project, it is intended to collate them into a single publication in a format suitable for wider dissemination.

The study of Lower Palaeolithic sites marks the congruence of archaeology and geology. Although specialist studies may diverge, there is a common aim in the better understanding of the Quaternary. Similarly, there are common goals in the conservation and protection of important sites. The English Rivers Palaeolithic Survey will provide the cornerstone for selective conservation strategies, whether protection of best implemented through archaeological or geological statutes. It also provides an incomparable database for the study of Lower Palaeolithic sites, either regionally or individually. The inclusion of in situ Lower Palaeolithic remains in Quaternary deposits is such a rare event that all such occurrences should be regarded as of national or international importance. Quaternary sediments may well contain physical structures which give evidence of their creation and modification. But in some of these sediments, the evidence for people who played an influential part in the contemporary ecosystem is an important scientific feature most deserving of recognition and protection.

References


Conservation Canadian style

- what price legislation?

A group of environmental geology students from the University of Toronto visiting the Don Valley Brickyard. Ordovician sediments are in the foreground and the interglacial deposits are well exposed in the distant wall of the excavation. (Photo by Nick Pearce)

Downtown Metropolitan Toronto, a sprawling maze of concrete and 14 lane interstates, may not seem a likely location for one of the most important sites in deciphering the last interglacial in North America. The Don Valley Brickyard, less than three miles from the Canadian National Tower, contains one of the best known Pleistocene sequences in the world, and this, along with the focus of continued conservation efforts for the last 10 years, has made this site a focal point of geological conservation policy. This is in marked contrast to British wildlife, and once a geological feature is designated as being a Site of Special Scientific Interest (SSSI), the law provides for its protection. The combined efforts of the Friends of Don Valley in ensuring that this important Canadian site is now safe may, however, be a lesson to all of us involved in conservation in Britain.

The Don Valley Brickyard produced most of Toronto's bricks until 1984, when the then owners, Brampton Brick, closed the site due to economic difficulties. The buildings of the brickyard now form an impressive industrial archaeological feature. The brickyard was also the only place in Canada where bricks were glazed with a colourful finish, and these live swimming pools, public buildings and hospitals across the country. In over 100 years of brick production, some 25 metres of Pleistocene deposits were cleared from the Upper Ordovician strata, which were extracted for firing into high quality bricks. These strata, part of the Georgian Bay Formation, were dug from a pit which reached almost 150 metres in depth. With the continued removal of the superficial deposits to recover more of the underlying strata, an unequalled Ice Age record was gradually exposed, interpreted, and finally lost. The importance of the Pleistocene deposits was recognised at around the turn of the century by A P Coleman who, in 1912, received funding from the British Association for the Advancement of Science to excavate the site. Now that brick production has ceased, a series of low (20-25 metre) sandbars surrounding the infilled pit are all that remain.

Glacial and interglacial sediments are present in the Don Valley Brickyard. These date from the end of the penultimate glaciation (The York Till from the Illinoian glaciation), some 120,000 years ago, through the interglacial Don Formation, up to a thin veneer of Iroquois Sands left behind after the last glaciation, about 12,000 years ago. Unfortunately, much of the record from around 50,000 years ago was removed from the Don Valley area by the most recent glaciation, although the Scarborough Bluffs on the northern shore of Lake Ontario show the upper part of this succession, particularly deposits dating from about 20,000-15,000 years ago. Complete sequences of interglacial sediments are rare in continental areas-they are, by their very nature, at the mercy of erosion from the next glaciation - and the Don Valley Brickyard and Scarborough Bluffs county provide an invaluable research resource for this period.

The York Till, the last vestige of the Illinoian glaciation and the oldest of the Pleistocene sediments in the Don Valley Brickyard, is presently poorly exposed due to slumping of unconsolidated deposits from above. This 1 metre thick bouldery diamict probably represents a wave-washed till.

The York Till is overlain by the interglacial Don Beds. The basal 2 metres of this unit were deposited at the margin of a lake, affected occasionally by storms. These deposits give way upwards to a thick (20 metre) sequence of deeper-water sands and muds, which contain abundant fossils. The muds contain leaves, peat, flattened wood fragments and the occasional log, while the sands contain fragments of up to 55 different species of temperate mollusc. Palaeoenvironmental reconstructions, based on mollusc, ostracod, diatom and caddisfly faunas, indicate a shallow lake affected by a nearby river; a gradual increase in planktonic species, coupled with fining-upward sediments, suggest a gradual deepening of the lake. The occasional large, isolated clast within the sediments was probably ice-rafted.

Fossils from the lower Don Beds indicate temperatures about 2° Celsius higher than at present, similar to central Pennsylvania. In addition to pike and catfish fossils, some mammalian megafauna, including bison, mammoth, mastodon, deer and giant beaver (the size of a small brown bear), have been discovered.

The laminated clays of the 8 metre thick Scarborough Formation overlie the Don Beds and are interpreted as a deep water (pellet formation) sediment deposited when temperatures were about 2 to 5° Celsius below present levels. These deposits are overlain unconformably in places by the Pottery Road Gravels, which occupy a large channel cut during a period of low lake water. These channel deposits are, in turn, overlain by the Sunnybrook Diamict, interpreted as a subaqueous debris flow of poorly sorted glacio-lacustrine sediments, which became unstable and slumped downslope.

The highest conformable unit in the succession is the Lower Thorncliffe Formation, consisting of about 8 metres of silty clay rhytmites, which are probably ‘varves’. These were deposited in deep water and produced by annual variations in sedimentation in a prodelta environment. Ice-rafted ‘clots’ of material, and evidence of storms and slumping, are also apparent. Mean annual temperatures close to 0° Celsius are indicated. The total species count (in excess of 500) far exceeds any other site in North America, and the pollen record is unequalled in quality at similar-aged sites in the continent, underlining the scientific importance of this site.

The upper (younger) parts of the succession in the Don Valley area have been eroded by processes within a large lake, Lake Iroquois, which formed as it dammed the St Lawrence Valley. The lake persisted...
The Scarborough Bluffs, up to 100 metres high in places, expose the upper part of
the interglacial sediments in the Toronto area. A recent marine development can be
seen at the end of the valley. (Photo by Nick Perrot)

to the end of the last glaciation, and
left a thin, unconfonnable veneer of
sand (the Iroquois Sand) over the
upper part of this interglacial
succession is, however, well exposed
in the Scarborough Bluffs, which
occasionally reaching 100 metres in
height, along the northern shore of
Lake Ontario.

History of conservation
Brampton Brick closed the Don Valley Brickyard in 1984 and invited
Metro Toronto to buy the site for $4
million. The cost was thought too
high and the City decided not to
proceed, and the site was
immediately purchased by Tor
Valley, a development company.
Despite their knowledge of the sale,
the Ontario Geological Survey did
not alert scientists or the public to
the potential threat to this important
site. This lack of action was a direct
result of conservation being
excluded from their remit (there is
no legal obligation to conserve
geological sites).

T"Volcanic Park"
- a proposed RIGS igneous geology trail in North Wales

Jonathan Wilkins, Gwynedd RIGS Group and Stewart Campbell, Countryside Council for Wales

The dinosaur phenomenon is well known. The perenial
popularity of dinosaur models, books and other
products has been enhanced
recently by the Jurassic Park' craze.
Diligent research over many years has shown
what the creators may have
looked like and how they lived. Other
geological features and processes,
however, are equally capable of
enoughing those with non-geological
backgrounds. High on the list are
the spectacular effects of modern volcanic
activity and earthquakes, and the

the Scarborough Bluffs also has
problems regarding conservation.
These unconsolidated deposits on
the shore of Lake Ontario are readily
eroded by wave action, and are
gradually being lost to protection
works and development. Again, no
legislation is available to ensure their

The site's widely known
golden interest was championed
by Professors John Westgate and
Nick Eyles from the Scarborough
Campus of the University of
Toronto, who argued that its
international significance would be
lost if development proceeded.
Efforts to save the site were focused
through the Friends of Don Valley,
which included natural historians,
biologists, rate payers, potters,
bankers and politicians, all of whom
had interests in seeing the Don
Valley preserved.

After several years of hard
campaigning, the Ontario Provincial
Government finally agreed to
purchase the site to preserve its
scientific and archaeological interest.
No legislation would allow for the site to
be preserved.
The developers asked
for an independent group to assess
the situation as, if their plans were
halted, they stood to lose
considerable revenue. Hearing after
hearing followed during the late
1980s, at which scientific and
archaeological evidence was
presented. Eventually it was ruled
that the Ontario Provincial
Government should be allowed to
purchase the site from Tor Valley
but at a cost of $20 million -
five times the 1984 price. Clearly, had
conservation been part of the
RIGS Group's first major
interpretation project, and its potential
and problems are explored here.

Conwy Mountain (Mynydd y Dref)
dominates Conwy Bay. Its rugged and
attractive scenery is a product of
Orдовician volcanoes, major earth
movements and Pleistocene glaciers,
yet it has no official geological
designation. However, the area
around Aire Wern and the Snowdon Pass (partly
included in the proposed trail) fall
within a biological Site of Special
Scientific Interest (SSSI), important for
its 'dry heath and magnificent spreads
of heather and gorse. Most of the area
concerned is administered as common
land by Aberconwy Borough Council,
and the entire site lies within
Snowdonia National Park and is
subject to its planning regulations.

The volcanic history of North Wales
is extremely complicated. Two major
phases of volcanic activity took place in
the Orдовician - at the end of
Tremadoc times and during the
Carboniferous. The latter phase produced
the intrusions, lavas and tuffs which
now crop out in central and northern
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also contained much gas and steam - this combination of properties ensured violent eruptions. Some recrystallisation of the fine-grained rhyolites occurred during the Caledonian Orogeny, when earth movements resulted in low-grade regional metamorphism and caused extensive folding and faulting - the effects of the latter make interpreting the rocks on Conwy Mountain particularly challenging. The present-day landscape owes much to the erosive effects of Pleistocene ice. Hard rhyolite and tuff resisted erosion and now form upstanding areas, with younger and softer sedimentary rocks, which were exploited by ice and meltwater forming lower relief. A series of east-west valleys, lacking contemporary streams, may well have been cut by meltwater flowing under great pressure at the base of an ice sheet. The rhyolites and tuffs give rise to thin acidic soils, colonised mainly by gorse, heather and bracken. In its western section, where the proposed trail overlaps the SSSI, a substantial area of heath, dominated by bell heather and ling, clothes the slopes. Western gorse is also widespread here and a variety of rocky outcrops, scree slopes and small pools add biological diversity. The SSSI is also important for its rare moths and dragonflies.

Developing the trail

Gwynedd RGS Group has no members who are able to devote themselves full-time to developing a geological trail on Conwy Mountain. Fortunately, much of the necessary groundwork has been done by a postgraduate student, Geraint Green, from Wolverhampton University. He has looked, in particular, at the practical aspects of developing the trail, such as safety, access and funding. The principal tasks identified are as follows:

1. To survey, record and categorise rock exposures and other relevant geological and geomorphological features.
2. To propose and discuss a geological and geomorphological interpretation for the area.
3. To consult with archaeological and natural history specialists to ensure that other salient non-geological highlights can be incorporated in the trail and that other interests are not damaged by it.
4. To propose routes for a variety of 'graded' self-guided and accompanied walks.
5. To propose and agree access arrangements with landowners and other interested parties.
6. To find suitable sponsorship.
7. To design and install appropriate waymarkers.
8. To publish guides, worksheets and other teaching aids.

Trail highlights

In devising a geology trail for Conwy Mountain, the overriding consideration is to provide a series of localities which demonstrate the full range of igneous rock types and the most significant Pleistocene landforms and landscape features. The following geological 'stops' demonstrate some of the most interesting features and views, and will be considered for inclusion in the trail (see map).

The proposed trail will start at a conveniently situated car park, from where there are excellent views of the spectacular Sychnant Pass. The absence of running water in the valley may indicate that it was fashioned by meltwater in the Pleistocene - perhaps during the last major glaciation, some 18,000 years ago. The slopes of Alt Wen also display some of the finest outcrops in North Wales.

Locality 1: a high rocky bluff. The rock here is red-brown, brecciated, intensely iron-stained along fractures and permeated by quartz veins. Close inspection shows weakly developed flow-banding. The outcrop is interpreted as an extrusive rhylite (lava) which has undergone subsequent faulting and mineralisation.

From here, the trail crosses a dry valley, which may have been a glacial meltwater channel. The path then climbs over gorse- and heather-covered slopes (part of the SSSI), from where there are excellent views across Conwy Bay to the Great Orme.

Locality 2: a fine example of intrusive rhyolite. The rock here is grey, shows contorted flow-banding and often contains rectangular holes formed by the selective weathering of alkali-feldspar phenocrysts.

Locality 3: flow-banded rhyolite, dark grey in colour and with columnar joints perpendicular to the flow-banding. Microscopic examination of these rocks has revealed that the flow-banding is a manifestation of different grain sizes and that the phenocrysts are aligned in the direction of flow.

Locality 4: abandoned quarries, the various faces of which show excellent cross-sections through extrusive rhyolites. Superb flow-banding is visible, and to the west, the rock becomes tuffaceous upwards and is well-jointed. Debris flows of shale, tuff and tuffaceous fragments are also seen, as well as black, glassy intrusive veins.

Locality 5: an excellent exposure of girty tuff near the crest of Conwy Mountain. A Bronze Age fort, Castell Coet Seion, lies nearby and its rampart was constructed from the local rock.

Locality 6: spectacular examples of nodular tuffs, formed by explosive volcanic activity in a marine setting. Nearby are younger marine sandstones.

There are many additional localities which keen visitors will be able to explore, and there are many possibilities for integrating the geology with natural history and archaeological features. Geological and thematic considerations apart, there are also other important issues to be considered when setting up the trail. Although much thought has been given to the proposed route, and to which features will be included, there are still serious problems to be resolved.

Safety and access

The safety of visitors is paramount, particularly as the site contains several potentially hazardous areas. For example, the abandoned quarries comprise four steep faces, each up to 15 metres high. There are sheer slopes between the quarry levels, while other areas contain derelict buildings, rock wastage and disused haulage inclines. Such rough terrain and potentially hazardous 'drops' prove significant safety problems to

The first rhyolite outcrops of the trail (Locality 1) occur close to the road that runs through the Sychnant Pass. A conveniently situated car park is located to the extreme right. (Photo by Stewart Campbell)

One of the trail's greatest assets is the quality of its surroundings. Here, the colourful heather- and gorse-covered slopes of Conwy Mountain form a backdrop to the abandoned quarries (top right) and the Great Orme (top centre). (Photo by Stewart Campbell)

The Sychnant Pass lies near to the start of the proposed trail. This spectacular dry valley, flanked by impressive screes, may have been partly eroded by glacial meltwaters during the last major glaciation of North Wales. (Photo by Stewart Campbell)

The Sychnant Pass is the point at which the car park is conveniently situated. The road that runs through the Sychnant Pass. A conveniently situated car park, from where there are excellent views of the spectacular Sychnant Pass. (Photo by Stewart Campbell)

The abandoned quarries (Locality 4) contain excellent examples of flow-banded rhyolite, intruded in places by black 'glassy' veins. The steep faces, scree slopes and generally rough terrain, however, pose significant safety problems that must be resolved before the trail can include these localities. (Photo by Stewart Campbell)

The style of volcanic activity responsible for the rock sequence on Conwy Mountain was similar to that seen today at desolate plate margins, where ocean island arcs are formed. Modern examples include the New Zealand - Tonga Arc and the Aleutian Island Arc. The rocks on Conwy Mountain were formed in an extremely violent volcanic setting. The rhyolite lava contained more than 70% silica, consequently was highly viscous and times during the Caradoc. Most of the rocks on Conwy Mountain consist of rhyolite lavas (the extrusive equivalent with viscous acidic lavas. They were forms the Penmaenbach headland. A characteristic flow-banding associated later intruded by rhyolite, which now tuff resisted erosion and now form upstanding areas, with younger and softer sedimentary rocks, which were exploited by ice and meltwater forming lower relief. A series of east-west valleys, lacking contemporary streams, may well have been cut by meltwater flowing under great pressure at the base of an ice sheet. The rhyolites and tuffs give rise to thin acidic soils, colonised mainly by gorse, heather and bracken. In its western section, where the proposed trail overlaps the SSSI, a substantial area of heath, dominated by bell heather and ling, clothes the slopes. Western gorse is also widespread here and a variety of rocky outcrops, scree slopes and small pools add biological diversity. The SSSI is also important for its rare moths and dragonflies.

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The proposed trail will start at a conveniently situated car park, from where there are excellent views of the spectacular Sychnant Pass. The absence of running water in the valley may indicate that it was fashioned by meltwater in the Pleistocene - perhaps during the last major glaciation, some 18,000 years ago. The slopes of Alt Wen also display some of the finest outcrops in North Wales.

Locality 1: a high rocky bluff. The rock here is red-brown, brecciated, intensely iron-stained along fractures and permeated by quartz veins. Close inspection shows weakly developed flow-banding. The outcrop is interpreted as an extrusive rhylite (lava) which has undergone subsequent faulting and mineralisation.

From here, the trail crosses a dry valley, which may have been a glacial meltwater channel. The path then climbs over gorse- and heather-covered slopes (part of the SSSI), from where there are excellent views across Conwy Bay to the Great Orme.

Locality 2: a fine example of intrusive rhyolite. The rock here is grey, shows contorted flow-banding and often contains rectangular holes formed by the selective weathering of alkali-feldspar phenocrysts.

Locality 3: flow-banded rhyolite, dark grey in colour and with columnar joints perpendicular to the flow-banding. Microscopic examination of these rocks has revealed that the flow-banding is a manifestation of different grain sizes and that the phenocrysts are aligned in the direction of flow.

Locality 4: abandoned quarries, the various faces of which show excellent cross-sections through extrusive rhyolites. Superb flow-banding is visible, and to the west, the rock becomes tuffaceous upwards and is well-jointed. Debris flows of shale, tuff and tuffaceous fragments are also seen, as well as black, glassy intrusive veins.

Locality 5: an excellent exposure of girty tuff near the crest of Conwy Mountain. A Bronze Age fort, Castell Coet Seion, lies nearby and its rampart was constructed from the local rock.

Locality 6: spectacular examples of nodular tuffs, formed by explosive volcanic activity in a marine setting. Nearby are younger marine sandstones.

There are many additional localities which keen visitors will be able to explore, and there are many possibilities for integrating the geology with natural history and archaeological features. Geological and thematic considerations apart, there are also other important issues to be considered when setting up the trail. Although much thought has been given to the proposed route, and to which features will be included, there are still serious problems to be resolved.

Safety and access

The safety of visitors is paramount, particularly as the site contains several potentially hazardous areas. For example, the abandoned quarries comprise four steep faces, each up to 15 metres high. There are sheer slopes between the quarry levels, while other areas contain derelict buildings, rock wastage and disused haulage inclines. Such rough terrain and potentially hazardous 'drops' prove significant safety problems to
Very fine exposures of nodular tuff occur at the eastern end of the site (Locality 6). (Photo by Stewart Campbell)

The nodular nature of the tuffs is seen clearly in this close-up. This last stop (Locality 6) on the proposed trail also provides spectacular views of Conwy and its castle. (Photo by Stewart Campbell)

The future
In creating a geological trail on Conwy Mountain, there are many factors to be considered. From a geological perspective, the site has much to recommend it. It is robust and is unlikely to suffer damage from increased usage. There are no fossils vulnerable to over-collection, there is much loose rock material to examine and collect, and the quarry faces are stable, having already stood for some 50 years. Moreover, the various statutory authorities with interests in the area have a generally-declared desire to enhance recreational pursuits and education in the countryside, where appropriate. Naturally, all this accords with the prime purposes for which the RIGS movement and its statutory partner in Wales, the Countryside Council for Wales, exist. It is vital, however, for any developments to fit in with existing requirements, and increased site use must be achieved without damaging sensitive and rare habitats. There are also landscape considerations - waymarkers, boards and footpaths must be blended into the existing scenery and must not be allowed to desecrate it. Footpath erosion may become a problem and remedial measures may have to be considered. Overall, however, it is not envisaged that increased geological use of the area will compete with the existing land uses, which include grazing, conservation and recreation. Conflict is not expected and major advances in the public’s awareness and understanding of geology are to be gained. All of these issues will be subject to scrutiny and discussion at the Association of Welsh RIGS Groups’ forum, to be held in Llandudno on 29-30 September 1995. Conwy Mountain will figure prominently in the forum’s field programme.

Acknowledgements
Ken Addison (St Peter’s College Oxford, Wolverhampton University and Chairman, Gwenyll RIGS Group), Geraint Green (Wolverhampton University) and Riz Hattey and Margaret Wood (Countryside Council for Wales) kindly provided comments and information for this paper; Keith Jones (CCW Maps Section) drew the map.

Ownership and funding
The trail cannot be initiated without the full agreement of the landowners and other interested parties. These include, in particular, Aberconwy Borough Council, Snowdonia National Park Authority and a Commons’ Association, with whom initial consultations are taking place. In the current financial climate, there is little scope for attracting money to a project which may be desirable, but which has little prospect of significant and rapid financial return - although it is hoped that the sales of guides and publications will generate revenue in the long-term. Possibilities for funding include sponsorship, by local industry, of individual signboards and waymarkers, and improvements to safety in the quarried areas might be financed through a derelict land grant.

Popularizing a jewel in the crown of Scottish geology

One of Scotland’s most important geological features, the world famous Rhynie Chert, will soon be on the tourist map of north-east Scotland. An exhibition commissioned by Scottish Natural Heritage officially opened recently at the primary school in the village of Rhynie, a rural community some 45 kilometres north-west of Aberdeen. Using pictures, rock samples and interactive display material, the exhibit reconstructs the fauna and flora of what is the world’s oldest known complete terrestrial ecosystem and provides an insight into its discovery by William Mackie. The Rhynie Chert Site of Special Scientific Interest (SSSI) and National Nature Reserve lies alongside the A941, half a kilometre north-west of the village of Rhynie in Aberdeenshire. The nature of the site is unique among the nation’s network of geological SSSIs. As a common-or-garden grassy field, grazed by cattle and sheep, it belies the major international significance of the 400 million year old rocks beneath. It was during the geological mapping of the Rhynie area in 1912 that Dr William Mackie, a regional medical officer for Elgin and geologist, discovered loose blocks of a very unusual rock type in a field and dry stone walls close to the village. Legend has it that Dr Mackie spotted the first block of chert in a wall as he sat eating his lunch. Geologically, chert was a most peculiar and unique find in the area, made more so by the fact that it contained exceptionally well-preserved plant fossils; consequently it attracted the interest of geologists and palaeontologists nationwide. It was soon realised that the chert blocks discovered in the field had been dug up roughly a century of ploughing and that their source lay at depth below the surface. This was confirmed in 1913 and 1916 through trenching conducted by Mr Tait of the Geological Survey. Unfortunately, the trenches rapidly degraded and the ‘exposures’ of chert were lost. The fossil-bearing blocks of chert, found at the time of the initial discovery and during the subsequent excavations, formed the basis of the classic work on the plant fossils by two renowned Scottish palaeontologists - Dr Ridgway and Professor Lang. Studies of the fossil material by research workers of several different nationalities have continued ever since.

Over the years, the chert has yielded not only some of the world’s earliest land plants, but also the earliest known insect and several microarthropods. The preservation of this early fauna and flora is so perfect that the finest anatomical details, including individual cells, can be seen. In more recent years, information about the environment in which the chert formed has been determined by Dr Nigel Trayw (Aberdeen University) and others, by studying rock cores taken from boreholes through the chert. These studies have suggested that during Lower Old Red Sandstone times, around 400 million years ago, the Rhynie area comprised a river plain and lake district landscape, dotted with geysers and hot springs.

Despite the hostility of this ancient environment, it represented a habitat for some of the earliest known land plants and arthropods, which colonised the marshy areas around the hot springs. This early ecosystem was home to a variety of early vascular plants, including the famous Rhynia and Atrypoites. Associated with the macroflora was a substantial microflora of both algae and fungi. This primitive plant community developed on a sandy substrate akin to soil, and was replenished periodically by sediment-charged stream floods that inundated the area. The animal component of the ecosystem was represented by minute arthropods. Some of these have only been found within the empty spore cases of the plants, suggesting that they either ate the plant spores, or used the empty spore cases for shelter. The microarthropod Protacarus, with a body length of half a millimetre or less, possessed strong (Continued on page 31)
Landscape interpretation for the public in the United States: examples of good practice

Anyone interested in the interpretation of landscape, whether for student or visitor, soon becomes aware of the enviable reputation that the United States has for high-quality on-site landscape interpretation for the public; a public which generally seems very receptive to what is on offer. In the first two articles, I will consider some of the underlying reasons for the supposed pre-eminence of the United States in on-site landscape explanation for the general public. For any conservationist interested in the public interpretation of physical landscapes and geological structures, there is much to be gained from a visit to the United States, where geological and geomorphological landscape interpretation in National, State and Forest Parks is taken very seriously. The basis of recording and reporting back on the many examples of good practice which help the public to understand the history of the rocks and the processes responsible for the appearance of the landscape. My research tour, undertaken in the summer of 1994, included such chronicling, but also had a broader brief. This brief was to examine the variety of ways in which landscape interpretation catered for a public who perceived these landscapes, not principally as areas significant for their earth science heritage, but as environments valued for a whole range of scientific interests, or places of recreation and leisure, or places appreciated for their historical and cultural association and their beauty. If one believes that the success of future conservation measures depends upon interpretative education across a wide spectrum of the public, then the necessity for an awareness of the way landscapes are perceived and used by the public becomes of fundamental importance to conservationists (Keene, 1994).

English Nature's move towards the concept of the Natural Area (Duff, 1994) signalled the need for a conservation strategy which addresses environmental issues on a broader interdisciplinary front than had previously been the norm. In a recent issue of Earth Heritage, John Hopkins draws attention to the surprisingly limited dialogue between geologists, geomorphologists and ecologists, especially about conservation issues (Hopkins, 1994). Both these examples demonstrate the need for joint, interdisciplinary, conservation strategies.

However, beyond 'scientific' cooperation is the need to pay more than lip service to strategies which fully integrate recreational needs and the cultivation of the emotional interaction with landscapes; for example, the Countryside Commission, writing about the long-distance footpath alongside Hadrian's Wall, suggest it should provide "spacious and insightful insight, aesthetic and emotional pleasure, physical exercise, social contact and a giving recreation" (The Observer, 1 August 1993). Such approaches, whilst not directly related to further physical landscape interpretation, can be seen as significantly broadening the experience of place beyond that of formal landform or geological explanation.

Seeking a broad environmental awareness is not new to the environmental scientist, but is too often seen as a diversion from the true role of the 'scientist'. In the area of conservation, this is far from being the case and, indeed, this objective is now passing beyond being a simple conservation strategy to become a broader holistic educational aim within scientific environmental education. The point has long been made that "it is possible to develop the emotional and the intellectual appreciation and understanding of Nature side by side, and to achieve in the individual mind a synthesis of Poetry, in the wide sense of the word, and of Science as the word is commonly used" (Cornish, 1933).

Rather than seeking to establish a linking theme between the 36 sites explored during my 1994 study visit, six specific locations in the United States have been selected, all of which are attractive to geologists and geomorphologists interested in physical landscapes. Attention is drawn to a variety of successful, useful and sometimes distinctive, thought-provoking approaches to landscape experience and education for visitors.

**Lion's Eye Nature Trail, Anna Ruby Falls**

Administration: Chattahoochee National Forest, Chattooga District, Burton Road, Highway 197, Clarksville, GA 30523.

The Anna Ruby Falls, a spectacular slide of water tumbling from the Blue Ridge at an esouthern tip of the Appalachians, is reason enough to visit this site. However, at the beginning of a longer forest trail to the falls is the Lion's Eye Nature Trail. This trail provides a self-guided tour to a short, surfaced loop through some woodland and down to a stream. It has wheelchair access and can be followed by any walker. Signs draw attention to terms of the trail's location, such as the short, woodland, streamside walk, it might be considered unexceptional. But what makes this trail sign significantly different is that it is designed to be undertaken by the blind. A smooth, continuous handrail gives reassurance of passage. Breaks in the handrail signal near small Braille plaques. Close by might be 'listening bench' - a running water - birdsong - the wind in the trees. 'Touch and feel boxes' contrast dead litter with living tree bark. You are invited to dip your fingers in the stream, ice-cold from the mountains, or to slide your fingertips over the smooth cold rub of slickenside. Such experiences are fairly common. Most people associate them with primary school education or with the Earth-consciousness tradition. They are seldom brought out by a more self-conscious adult public. The arresting feature about the Lion's Eye Trail is, though it is not a doubt, a valued focus for blind tourists, here is clearly serving a further function. Sighted children and adults, eyes tightly shut, were using the trail and, in doing so, using senses normally suppressed by the dominance of sight. Those normally too embarrassed to be seen experiencing this style of environmental education, perhaps have their misgivings assuaged by this being a trail for the blind. It would seem that the trail did provide a deeper sense of place for a wide variety of people, engendering an enhanced environmental consciousness and, presumably, subliminal support for conservation as well, one would hope, emotional support for the provision of greater facilities for the disabled.

**Coke Ovens and Red Canyon ‘Lookovers’**

Administration: Colorado National Monument, Fruita, CO 81521.

At one level, National Parks, Forest Parks and National Monuments of the central and western United States have a fundamental advantage in demonstrating the relationship between geology and landscape. The relatively dry climate and resulting lack of dense vegetation make these landscapes of simple, bare structures a teacher's dream. Furthermore, the sheer space and physical drama of these landscapes stimulate an eager curiosity amongst visitors, many of whom are visiting the location specifically because of the spectacular panoramas. Most sites, building on this interest, handle the task of explanation with considerable success, offering a range of explanatory options – simple notice boards, visitor leaflets, a local radio service, ranger talks and guided walks, self-guided trails and the back-up of visitor centres with comprehensive bookshops run by independent charitable associations supported by local communities.

The style and provision of on-site notice boards and their content is a matter of experimentation by English Nature (Page, 1994). Elsewhere, fear has been expressed that, without care, over-enthusiastic interpretation may be responsible for an intrusive presence which deters the way that sites are experienced. The extensive use of on-site notice boards in semi-wilderness areas in the United States may, therefore, be questioned. However, despite initial reservations and a personal resistance to being 'processed', the provision of boards at these overlooks seemed entirely appropriate and helpful, despite the "natural setting" in which many are located (Photo 1). The possible reasons for this are outlined below:

- Many visitors are actively seeking explanation of the scene.
- The signs are thoughtfully designed and serve their function well; that function being to respond to the immediate curiosity of the non-specialist visitor, stimulated by the drama of the landscape to seek some simple, but not trivial, understanding of its origin and evolution.
- The content is clearly and graphically communicated.

At a slightly more advanced level, visitors can refer to detailed, colour-coded booklets which address landscape evolution and which are issued to all, either at the park entrance or at the visitor centre. A third level of interpretation is

![Photo 1. A roadside interpretative panel at the Red Canyon Overlook, Colorado National Monument. (Photo by Peter Keene)](image-url)
Arches National Park, Utah

Administration: Arches National Park, PO Box 907, Moab, UT 84532.

National Parks and Monuments in the United States are almost exclusively "owned" by the nation. Interpretation, conservation, recreational provision and visitor control are, therefore, more easily integrated than in the United Kingdom. Furthermore, the availability of space (there is always another mountain over the hill) has meant that providing universal access to prime sites is not considered a real conservation issue. In general, since the parks are "to be accessible for the enjoyment of the nation", it is accepted that, if a site is of prime visitor interest, then car and recreational vehicle access will be provided both (a) to an overlook where walking might be unnecessary and (b) to a trail head park from which the site can be visited by a short walk on clearly signed, surfaced paths.

Conservation and safety are approached by a policy of what might be called defence in depth. Beyond the short, surfaced walks lie the 'pioneer trails', rough tracks or simply cairn-marked routes needing some agility and, in desert and mountain terrain, some forethought before exploration. To many, a row of boulders signalling the end of the surfaced path is a sufficient deterrent (Photo 3). Penetration beyond the pioneer trails into the backcountry may lead the walker into environmentally sensitive zones or areas of some physical danger. An example within the Arches National Park is the Fiery Furnace, a waterless maze of bare rock fins, where summer day-time temperatures can reach 43°C (110°F Fahrenheit). This zone may only be visited by ranger-led groups or by permit holders (Photo 4). Obtaining a permit here includes watching a video at the visitor centre. This reinforces the safety message, but also emphasises the ecological fragility of the desert, with its delicate, living "cryptobiotic" surface crust.

The implementation of this policy within the parks is, in part, a matter of ranger control, but also the subject of intense "persuasive communication". Despite having a vaguely Orwellian ring about it, this term simply means influencing people by providing reasoned information. Such policies, strictly implemented, work well in the less populated desert or mountain environments, but are coming under increasing pressure in the more densely populated east coast and California.

Particularly sensitive environments may have national "wilderness" status. Such areas, administered separately from the National Parks, normally exclude public access.

The Hazelwood Trail, Sequoia National Park


Rising above the surrounding Giant Forest in Sequoia National Park is the Fiery Furnace, a waterless maze of bare rock fins, where summer day-time temperatures can reach 43°C (110°F Fahrenheit). This zone may only be visited by ranger-led groups or by permit holders (Photo 4). Obtaining a permit here includes watching a video at the visitor centre. This reinforces the safety message, but also emphasises the ecological fragility of the desert, with its delicate, living "cryptobiotic" surface crust.

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The Giant Forest

This short 3/4-mile trail offers a gentle stroll through a garden of majestic giant sequoias.

Park is Moro Rock, a granite monolith. Its steep-sided dome is controlled by sheets of granite exfoliating under pressure release. It is a "rock simple" homestay, crowded with visitors climbing up and down the long coiled steps which, supported by iron railings, cling tenaciously to the side of the dome. On the summit, children scream and jostling adults pose against a backdrop of the Sierra Nevada.

Explanatory panels extol the wonder of mountain building. Another panel reinforces the safety message, but also emphasises the ecological fragility of the desert, with its delicate, living "cryptobiotic" surface crust.

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Explanatory panels extol the wonder of mountain building. Another panel reinforces the safety message, but also emphasises the ecological fragility of the desert, with its delicate, living "cryptobiotic" surface crust.
This is only one small corner of a vast network of trails at the Hazelgrove site, Grand Canyon National Park, under the control of the Forestry Service (Department of Agriculture), who undertook a 20 year development programme. Scientific investigation of the site and the study of the natural recolonisation of the area has been ongoing. The trails were to go hand-in-hand with the development of the infrastructure for educational and recreational use.

A new highway was built to serve a visitor centre at Coldwater Ridge within the zone devastated by the eruption. Like most parks in the United States, a comprehensive range of educational services ensures that needs at a wide variety of levels are met.

As the landscape is recolonised by plants and animals and regeneration takes hold of the landscape, so the emphasis at the visitor centre has shifted away from the simple overpowering vision of the explosion and its devastating effect (Photo 10) to that of the eruption. With the decaying remnant of St Helens in the background, the scene is impressive. The audience, including myself, is not aware until enlightened at the end of the tour, that this landscape, the soil section and the blasted trees seen on the trail, are a reconstruction in a fiberglass. At one level, a fiberglass landscape seems like the beginning of the end, one more step towards visual reality in interpretation - perhaps as a way to one day shift away from the simple overpowering vision of the explosion and its devastating effect (Photo 12) at the time of the eruption. With the decaying remnant of St Helens in the background, the scene is impressive. The audience, including myself, is not aware until enlightened at the end of the tour, that this landscape, the soil section and the blasted trees seen on the trail, are a reconstruction in fiberglass. At one level, a fiberglass landscape seems like the beginning of the end, one more step towards visual reality in interpretation - perhaps as a way to one day shift away from the simple overpowering vision of the explosion and its devastating effect (Photo 12) at the time of the eruption.

References
Evaluating interpretation at Hunstanton

Tom Hose, Buckinghamshire College

The popularity of fossil hunting and pebble collecting can be readily witnessed at many holiday locations throughout Great Britain. Interpretive strategies for these places could help raise the public’s awareness of our rich geological heritage, and have great potential as a tool in conservation education.

English Nature has identified over 50 geological sites in England which show some potential for on-site interpretation. Of these, a scheme for Hunstanton cliffs on the north Norfolk coast is now in place. Here, an angled panel (540 mm x 600 mm, with descriptive text, orientation drawing and photographs of the principal rocks) was erected in 1993. Its size, colour scheme and location produced an unobtrusive, aesthetically pleasing result, expected to be viewed by between 1,000 and 10,000 casual passers-by and interested visitors each year.

Hunstanton cliffs are a geological Site of Special Scientific Interest (SSSI) and clearly show bands of red and white chalk containing abundant fossils, including bivalves, belemnites and trace fossils. Overall, the rocks indicate the deepening of a tropical sea in Cretaceous times, some 97 million years ago.

The visitor survey

An evaluation of the interpretive panel’s effectiveness was undertaken on three successive Sundays in May 1994, over a total of 10 hours. The weather varied from heavily overcast with rain to brilliant sunshine, with an onshore wind of varying strength and coolness. A log was kept of the panel’s attracting and holding powers and of all passing visitors.

An interview survey of 90% of those who viewed the panel was conducted.

Despite some differences between the social grouping and probable ages of interviewed and observed visitors, a general pattern is evident. Half of those interviewed were aged 45-64 years, and a quarter were aged 30-45 years; the remainder were almost equally split between those aged 20-29 years and over 64 years. Two thirds of interviewees were making a repeat visit to Hunstanton and most lived within about two hours drive. Just under half had left school at the legal minimum age, whilst a quarter had been educated up to ‘A’ level standard. A quarter had undertaken some form of tertiary education. Most had never studied geology. Two thirds of those interviewed regularly read a daily newspaper and of these, just over half read a tabloid.

American studies have shown that most interpretive displays in museums and zoos, with their ‘captive audiences’, only manage to attract between 8% and 40% of visitors. Therefore, this panel’s recorded 24% attracting power is quite successful. The maximum holding time recorded was 2.51 minutes, the minimum was 0.05 minutes and the mean was 1.02 minutes.

The ability of visitors to recall panel information was analysed. Just over half could give an accurate age in millions of years, but not the geological system, for the rocks. There was a general inability to identify common British fossils from an illustrated prompt card, except for the bivalve mollusc which was similar to the living forms encrusting rocks on the beach. High recall rates for ‘Chalk’ and ‘Red Chalk’ were not, perhaps, surprising, but the ability of some two thirds to fairly accurately recall the site’s palaeoenvironment was encouraging.

Interpretive implications

The generally high readership of the tabloid press gives clear limits to the vocabulary and style that can be employed in interpretive material. The shortfall in geological knowledge probably lies in a general lack of formal geology tuition in schools; the inclusion of the subject in the National Curriculum is, however, encouraging for the future. Undoubtedly, greater public exposure would help promote the value of geology and the need for geological conservation. Clearly, a greater public interest in the subject which, with appropriate interpretation, can be made memorable.

The Cairngorms

- geomorphological sensitivity and management of a fragile and dynamic mountain landscape

John Gordon, Vanessa Brazier and Andrew Taylor, Scottish Natural Heritage

The sediments preserved in lochs and bogs contain a record of past environmental changes (climate and vegetation) and human impacts in the form of pollutants and land use changes - these aspects are well-known. Similarly, the landform and sediment record provides a less widely-known measure of the magnitude and frequency of geomorphological processes in the past (for example, river channel change, flooding, debris flow activity). This allows current changes (both natural and moderated by human activity) to be placed in a wider perspective.

Geomorphology and land management

From a management viewpoint, many of the landforms are fossil and, if damaged or destroyed, cannot be replaced, since the processes that formed them are no longer active. Others are active, and in some cases the essence of their interest lies in...
enabling the continued existence of the dynamic environment. As well as causing irreparable physical damage, and disruption of natural processes, human activity may incur loss of integrity and fragmentation of the interests.

In relation to wider issues of land management, an understanding of past and present landscape sensitivity provides a basis for assessing the relative impacts of human activities, and natural environmental changes, on the landscape. Of particular relevance today are concerns about slope and soil erosion, river channel variations and habitat changes in response to different types of land management and recreational pressure. Geomorphology has a potentially significant contribution to make to landscape management and impact assessment, not only from the point of view of the intrinsic interest in landforms, but also to the development of a wider strategy for integrated landscape management - embracing aspects such as deer management (for example, control of soil erosion and slope erosion); landscape assessment, inventory, audit and monitoring; footpath study (for example, routing of footpaths); river conservation; and visitor facilities (interpretation).

**Geomorphological sensitivity**

The development of appropriate management guidelines for the geomorphological interest, within a wider management framework for the Cairngorms, depends critically on an understanding of geomorphological sensitivity, which in simple terms is a measure of the ability of a landform to absorb externally imposed change. Such change may arise, for example, from climatic variations or human interference. Relict features may be particularly sensitive where damage or disturbance cannot easily be repaired or re-created by natural processes. The fragility of individual landforms or landform systems will depend on the nature of the impact, but may be assessed using a simple ranking system. This type of approach could be applied to develop a sensitivity zonation for a range of activities, such as afforestation, building development, and sand and gravel extraction.

The response of dynamic systems is more difficult to assess. For example, the effect of bulldozing a gravel bar in a high energy river environment may be short-lived, with the bar reforming after a single flood. Such a response could be described as robust. However, a sensitive response would occur where there is a significant change in the nature of the process environment. This may be dramatic, as in a shift from a braided, multi-channel stream to a single channel, which might arise from changes in sediment supply or discharge control. Sensitive behaviour may also occur in less dramatic ways, but can have significantly wider impacts on habitats; for example, trampling and disturbance of fragile plateau soils may lead to erosion of fine sediment and a permanent reduction in the ability of the soil to support plant cover. Consequently, understanding the sensitivity of geomorphological systems, and how they respond, also requires awareness of the natural variability in the magnitude and frequency of different processes.

**Recent geomorphological activity**

The geomorphological evolution of the Cairngorms did not cease at the end of the Ice Age, 10,000 years ago, although the magnitude and pace of change have slowed. Evidence of landscape change during the Holocene is seen, for example, in flights of river terraces with abandoned channels on their surfaces, in alluvial fan formation, in scree slope development and in debris flow activity.

**Conclusion**

Geomorphology has a potentially significant contribution to make to landscape management and hazard assessment, beyond the intrinsic interest in landforms and soils, that could assist in the development of a wider strategy for integrated landscape management. As part of Scottish Natural Heritage's input to the Cairngorms Project, work is underway, or proposed, to provide the necessary information on the geomorphological sensitivity of the whole landscape through:

- A baseline inventory of the geomorphological resource (including soils), its current condition and how it is changing in response to natural causes and human activity.
- An assessment of the spatial variability in geomorphological sensitivity of different types of physical process environment, from plateau surface to river bed, and how such environments respond to natural change and human impacts.
- An understanding of the interactions between geomorphological processes, soils, land use and habitat changes, particularly in the fragile montane core area.

**References**

Planning Policy Guidance: Nature Conservation (PPG 9) was issued by the Department of the Environment in October 1994. It sets out the Government’s objectives and the legal framework for nature conservation in England, addresses the treatment of nature conservation in development control, and sets out development control criteria for Sites of Special Scientific Interest and sites with additional national and international designations. The PPG identifies a formal hierarchy of sites from the internationally important - Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) (which will collectively form the Natura 2000 series) and Ramsar sites, through sites of national importance - National Nature Reserves (NNRs) and Sites of Special Scientific Interest (SSSIs), to regional and local sites - Local Nature Reserves (LNRs), Sites of Importance for Nature Conservation (SINCs) or equivalently and Regionally Important Geology/geomorphological Sites (RIGS). The Department clearly indicates that it expects development plan policies and development control criteria to respect the relative importance of these different levels of designation.

Much of the content of PPG 9 emanates from the European Community (EC) Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (the Habitats Directive). To that end, it might not seem to be of immediate relevance to geological conservation and, indeed, PPG 9’s opening paragraph largely addresses wildlife and the conservation of biodiversity. Clearly, however, many of the habitats on which wildlife relies are geologically significant and many existing SPAs established under the EC Birds Directive are also geological SSSIs. There are, therefore, implications for PPG 9 for the protection of these and other geological SSSIs. Furthermore, RIGS are recognised as important contributors to the whole nature conservation resource.

Rocks, landforms and PPG 9

Implications of new planning policy guidance for geological conservation

Graham Culley, English Nature

PPG 9 properly recognises that nature conservation is not simply confined to designated sites. Paragraph 15 says that "statutory and non-statutory sites, together with countryside features which provide wildlife corridors, links or stepping stones from one habitat to another, all have important roles to play in ensuring the maintenance of the current range and diversity of our flora, fauna, geological and landform features and the survival of important species".

Some concern has already been expressed that too strict an adherence to this approach is unrealistic in that it does not allow for flexibility to reflect local circumstances. The concept of sustainability requires the protection of what is increasingly being called "Critical Environmental Capital" - those parts of the environment which should be regarded as irreplaceable. It is being argued in some quarters that that definition must include sites which come close to SSSI standard but have not been designated as such, but which are still an important component of an area’s Critical Environmental Capital. The PPG emphasises that local designations should only be applied to sites of substantive nature conservation value. It seems reasonable that if local sites have been identified according to strict criteria, and preferably following wide consultations, that they should be regarded as a necessary constraint on development.

Development control

So what guidance does PPG 9 offer about development control criteria for the various types of sites? Because of the key importance of all SSSIs, development proposals in or likely to affect them must be subject to "special scrutiny". This seems to imply that a planning authority must go beyond the normal "have regard to material considerations" and give special consideration to the presence of an SSSI. Note also that the use of the word "likely to affect" seems to apply a precautionary principle - in other words, there is no burden of proof that a site would definitely affect the site.

For sites meeting Geological Conservation Review (GCR) criteria, as well as Nature Conservation Review (NCR) sites and NNRS, a planning authority must pay particular regard to their national importance, thus adding another important material consideration.

For those geological SSSIs which are, coincidentally, ‘European’ sites - SPAs, SACs or Sites of Community Importance (candidate SACs since they have been agreed between the Government and the European Commission, but have not yet been designated), any development proposal must be subject to "the most rigorous examination". In practice, it is likely that any such proposal will be subject to a full environmental assessment.

For RIGS and other non-statutory sites, the position is not so clear. I have already mentioned that the PPG sets RIGS as an important supplement to geological SSSIs and as an important educational resource. It does not, however, suggest any special protection for them; whilst RIGS clearly fill the requirement of local sites to be of "substantive nature conservation value", they are also subject to the requirement on local authorities to have regard to the "relative significance of international, national, local and informal designations".

Finally and, perhaps in some ways, of greatest significance for many geological sites, the PPG sets out development control requirements in respect of minerals developments, where an application in or likely to affect any SSSI must be subject to the most rigorous examination. This is a clear recognition of the devastating effects that can be caused by intensive mineral working. The PPG goes on to explain that, where permission is given, conditions on the winning, working, restoration and aftercare of the site will be required. On the other hand, there is recognition also that mineral extraction may reveal important geological features.

Development planning

It may seem somewhat illogical to consider forward planning after development control, but it is in fact the development control requirements of PPG 9 that provide the most satisfactory wording for development planning. Taking into account all of the foregoing, I have drafted the set of policies shown in the accompanying box. These do not pretend to be the last word since, as noted earlier, there may need to be flexibility to reflect local circumstances. They are, however, a good starting point and one which is already being accepted by some Department of the Environment Regional Offices as correctly interpreting PPG 9.

International sites

"Proposals for development in or likely to affect Sites of Special Scientific Interest (SSSIs) will be subject to special scrutiny. Where such development may have a significant adverse effect (directly or indirectly) on the SSSIs, it will not be permitted unless the reasons for the development clearly outweigh the value of the site itself and the national policy to safeguard the intrinsic nature conservation value of the national network of such sites. Where the site concerned hosts a priority natural habitat type and/or a priority species, development or land use change that is permitted unless the authority is satisfied that it is necessary for reasons of human health or public safety or for beneficial consequences of primary importance for nature conservation.

Where such development does proceed, the authority will consider the use of conditions or planning obligations to ensure that all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected."

National sites

"Proposals for development in or likely to affect Sites of Special Scientific Interest (SSSIs) will be subject to special scrutiny. Where such development may have a significant adverse effect (directly or indirectly) on the SSSIs, it will not be permitted unless the reasons for the development clearly outweigh the value of the site itself and the national policy to safeguard the intrinsic nature conservation value of the national network of such sites. Where the site is a National Nature Reserve (NNR) or a site identified under the Nature Conservation Review (NCR) or Geological Conservation Review (GCR), particular regard will be paid to the individual site’s national importance.

Where development is permitted, the authority will consider the use of conditions or planning obligations to ensure the protection and enhancement of the site’s nature conservation interest."

Sites designated locally

"Development and land use change likely to have an adverse effect on a Local Nature Reserve (LNR), a Site of Importance for Nature Conservation (SIONC) or a Regionally Important Geological/geomorphological Site (RIGS), or which would adversely affect the continuity and integrity of listed landscape features, will not be approved unless it can be clearly demonstrated that there are reasonable grounds for the proposal which clearly outweigh the need to safeguard the intrinsic nature conservation value of the site or feature. In all cases where development or land use change is permitted which would damage the nature conservation value of the site or feature, such damage will be kept to a minimum. Where appropriate, the authority will consider the use of conditions and/or planning obligations to provide appropriate compensatory measures."
Scotland's first dinosaur

- the real one!

Michael Taylor, National Museums of Scotland

Earlier this year, Neil Clark of the Hunterian Museum (University of Glasgow) reported Scotland's 'first' undoubted dinosaur bone - the leg bone of a sauropod dinosaur, possibly *Cetiosaurus*, from the Middle Jurassic of Skye (Clark, 1995). It could have been the complete leg bone, if someone had not hacked a large chunk out of the shaft! But what Neil did not know when his article went to press was that the National Museums of Scotland (NMS) had already acquired an even earlier dinosaur bone. This minor confusion, arising from the fact that we did not know about the other's bone, was entirely due to the regrettable need to withhold information concerning sites of major new finds, until they can be checked for vulnerability.

Neil and I at once got together and produced a joint press release about both 'first' dinosaurs, and that went out in January 1995. The resulting coverage was mixed - fair to excellent in the Scottish nationals and the Scottish Press, but almost nil in the London nationals. There is also the question of the 'original' Skye dinosaur - the bone has been found in an ammonite-bearing marine bed. This is not, in itself, too surprising, as this is an inshore deposit and sporadic finds of dinosaurs are known from various British marine Lower Jurassic sites, such as the dinosaur *Dilophosaurus* from the Lyme Regis-Charmouth area of the Dorset coast (Benton & Spencer, 1995). However, dinosaur bones are certainly not that common, and it is rare to find one when few, if any, of the presumably more common marine reptiles have been collected.

There is also the question of the isolated bone's provenance - how did it get there? Perhaps it is a remnant of a carcass washed out to sea from a river, or the victim of a marine predator, caught and dragged into the sea, like the action of modern killer whales beaching themselves to catch sea lions. A third possibility, suggested by memories of watching red deer feeding on intertidal seaweed, is that the dinosaur was washed in the sea in some kind of food, and was either drowned or caught by a predator.

At the NMS, we don't see the Skye ceratosaur as a one-off find to put on display and forget once the formal paper is published, but rather as part of our still fairly low-key, but long-term, programme to improve our understanding and, if possible, the NMS's collections of Scottish Mesozoic vertebrates. Indeed, the NMS have formally identified the Mesozoic vertebrates of Scotland as a major priority in our recently revised acquisitions policy. Since serious collecting began in the early 19th Century, an alarming number of Scottish Mesozoic vertebrate specimens have gone abroad to private collections and museums outside Scotland, to the point where the national collections are not fully representative. However, matters are improving. We are, for example, supporting preparation work on new specimens to aid research, on the basis that we receive the specimens in due course. We also hope to continue funding David Martill to examine various Scottish Jurassic sites for their future vertebrate-bearing potential, as a complement to the newly published Geological Conservation Review volume (Benton & Spencer, 1995).

Of course, and this is true for any site, there is little point in collecting specimens without a home for them to go to and where they will be put to good use. Here at the National Museums of Scotland, we feel we have an excellent combination of national museum facilities for preparation, storage and research, combined with an active exhibition programme and a policy of 'outreach' - lending specimens to local museums all over the country. Communities such as that on Skye have legitimate concerns about the apparent removal of their heritage, and if we are to be a truly national museum we must address these fears. As far as the Skye ceratosaur bone is concerned, it is, at the time of writing (May 1995), on display at the Royal Museum of Scotland in Edinburgh, but we are looking forward to seeing it displayed, maybe with other finds, on Skye itself - complete with bilingual texts. Finally, a happy ending and a moral about the merits of the right kind of publicity - soon after the press release in January, an anonymous parcel containing the missing shaft of the Middle Jurassic bone was delivered to Neil Clark at the Hunterian.

References


Strengthening the RIGS movement

The RIGS (Regionally Important Geological/geomorphological Sites) initiative has been formally operative for over four years in England. Since July 1992, it has been serviced by a National RIGS Officer, based at The Wildlife Trusts national office in Lincoln.

In addition to one-to-one local group support, the Officer is responsible for the national overview and implementation of strategic initiatives to further the RIGS movement. Identification, notification and enhancement of RIGS is in the hands of those involved with the initiative locally.

For RIGS to be sustainable in the long term, opportunities must be grasped to strengthen the movement and integrate it with mainstream nature conservation. To further this, a new system is being set up in England to provide those 'on the ground' with greater control of the movement’s development nationally.

Regional Working Groups

It is proposed that six Regional Working Groups (RWGs) are constituted, based largely on the regional structure of The Wildlife Trusts (Figure 1). Each RWG will consist of five to nine RIGS groups. A Convener will head each RWG. The proposed arrangement is given in Table 1. This framework is flexible and may change according to the requirements of each RIGS group.

The aim of the RWGs will be to:
- Provide a mechanism for sharing information, experience and skills between RIGS groups within each region.
- Guide the strategic direction of the RIGS movement nationally.

The RWGs will operate within the structure illustrated diagrammatically in Figure 2. Each RWG will represent the RIGS groups within their region and feed into a National Forum to formulate national RIGS policy. The National RIGS Officer, together with English Nature’s Voluntary Conservation Partnership, will remain in close contact with the RWGs, enabling:
- A national overview of RIGS to be maintained.
- Networking between groups to be developed.
- Communication of relevant national issues to take place.

National Forum

The input from RWGs into the National Forum will enable a consensus to emerge on the priorities for action shared by many RIGS groups (such as funding, involvement of land owners, the requirement for a model constitution). These may be tackled in a number of ways, including regional seminars, a best practice manual and broadening awareness of RIGS outside the movement.

Scotland and Wales

Such a regional structure will complement the operation of RIGS outside England. Wales now has in place the Association of Welsh RIGS Groups, a comparable arrangement to that proposed here. RIGS in Scotland is developing on an ad hoc basis at present, but progress is being made between Scottish Natural Heritage and Scottish Wildlife Trust to take RIGS forward in a well structured and planned way.

Table 1. Regional Working Groups and RIGS groups within them as of April 1995.

<table>
<thead>
<tr>
<th>Region</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anglian</td>
<td>Bedfordshire, Cambridgeshire, Essex, Herfordshire, Lincolnshire, Norfolk, Northamptonshire, Suffolk</td>
</tr>
<tr>
<td>North East</td>
<td>Cleveland, Durham, Northumberland, Tyne &amp; Wear, North Humberside, North Yorkshire, South Yorkshire, South West Yorkshire</td>
</tr>
<tr>
<td>Midlands</td>
<td>Leicestershire &amp; Rutland, Nottinghamshire, Herefordshire &amp; Worcestershire, Shropshire, Staffordshire, Warwickshire, West Midlands</td>
</tr>
<tr>
<td>North West</td>
<td>Cheshire, Cumbria, Derbyshire, Lancashire, Greater Manchester, Merseyside, Wiltshire</td>
</tr>
<tr>
<td>South East</td>
<td>Berkshire, Devon, Dorset, Gloucestershire, Somerset, Wiltshire</td>
</tr>
<tr>
<td>Wales</td>
<td>Welsh RIGS Groups, Association of Welsh RIGS Groups</td>
</tr>
<tr>
<td>Scotland</td>
<td>Scottish Natural Heritage, Scottish Wildlife Trust</td>
</tr>
<tr>
<td>South West</td>
<td>Cornwall, Devon, Dorset, Gloucestershire, Somerset, Wiltshire, Wexford, West Yorkshire</td>
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<td>North West</td>
<td>Cheshire, Cumbria, Derbyshire, Lancashire, Greater Manchester, Merseyside, Wiltshire</td>
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<td>Cheshire, Cumbria, Derbyshire, Lancashire, Greater Manchester, Merseyside, Wiltshire</td>
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</tbody>
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Figure 1. Proposed RIGS regions (April).
Earth Heritage Conservation

Book review

The second part is a comprehensive introduction to both theoretical and practical geology. It encompasses all scales, from the nature of individual minerals to the formation of mountains, incorporating the history of the development of some basic geological principles. Throughout, comments on conservation (for example, mineral extraction affecting the local landscape; the necessity for freshly broken, unweathered surfaces to study rocks, yet only using a hammer sparingly) are integrated into the text, and the case studies from the previous section are referred to and placed in a wider geological context.

The importance of safety in the field and of obtaining permission for access is stressed throughout the book.

Technically, there are one or two comments which could have been included, particularly when considering the depth of coverage of other issues. In the sections dealing with caves, karst and limestone scenery, there is no mention of limestone pavements and the threat from landscaping projects. Given that the book will be used as a practical manual, this should have been addressed. Likewise, in chapter 9, the 'Scheme for Geological Site Documentation (NSGSD)' is rightly identified as "a key operator in the development of the RGS scheme". However, under "Sources of Earth heritage information", there is no reference to geological data held by wildlife trusts, local authorities, local industry and, indeed, local people.

Layout and text style

Overall, there is no doubt that Earth Heritage Conservation forms a vital and informative contribution to geological and geomorphological, and will be an essential tool for those already involved in wildlife conservation and for geologists and planners with a strong interest in the subject. Although it may be a bit too specialized for the general reader, the informal style of writing and the layout of the book will make it accessible to all. There are, however, a few points that I am unhappy with. Creating the acronym NCA (for new community agency) is a nomenclature error. I also have a few complaints about the way of phrases such as "these are interpreted as having been...", "it is thought that...", "in the absence of..." and "in what is called..." to "to convince ordinary..." give many parts of the text an academic, sometimes patronising, flavour which could easily have been avoided. It is probably unfair to pick out such points in a text in which typographical errors are minimal and which is highly readable, incorporating a liberal sprinkling of humour, poetry and popular analogies to make its case.

Conclusion

The final chapter deals well with the more philosophical aspects of earth heritage conservation in relation to policy and planning. Throughout the book, however, I feel that there is over-optimism in effecting geological conservation through trying to convince people that landforms and geological sites are part of our heritage. The book touches upon how wildlife conservation reaches out to so many - "images of whales or meadows of wild flowers". I feel that this is misleading, and that this vision is unrealistic for the living that forces us to think about wildlife conservation in its own right. The majority of the record and particularly the human and animal and which is highly readable, incorporating a liberal sprinkling of humour, poetry and popular analogies. Overall, I feel that the book is feeding on spores or micro-organisms staff and children at Rhynie Primary School will benefit geographical conservation in action. A useful "How to use this book" preamble suggests which parts would be best read by the reader's prior knowledge and experience. Each chapter (10 in all) is prefaced by a "Study guide" and there are numerous exercises and activities within the text. This "hands-on" approach and encouragement to the reader to think through the ideas presented and formulate independent conclusions. The book attempts to reinforce the practical aspects of earth heritage conservation and, as such, many of the exercises are fieldwork simulations. These are supported using field photographs in the accompanying 12 page colour plate booklet. In addition, the book concludes with a set of field exercises that may be purchased independently to accompany the book. The first part is reasonably short and introduces the reader to earth heritage conservation through a series of case studies, illustrating the geological and conservation facets of example sites. Some basic terminology is introduced, which can contribute to a basic understanding by any reader. Although much of this section is repeated subsequently in the book, it does serve to immediately capture interest and outline some of the varying conflicts and problems associated with geological conservation.

Repetition of some of the information also serves to reinforce the basic principles being studied.

The work is now complete and Blue Circle are to be congratulated on the outcome - an excellent example of conservation in practice.

Interpretation at one of Edinburgh's volcanics

Colin MacFadyen, Scottish Natural Heritage


(Continued from page 13)

The Charter outlines the minimum standards of service that customers and partners can expect from English Nature. It also covers how English Nature intends to implement the six principles in the Government's Citizen's Charter, including its procedure for considering complaints and suggestions for improving services. The service standards and numbers and types of complaints will be monitored carefully, with a view to continually improving the quality of service that English Nature provides.

Copies of the Charter are available free of charge from any of English Nature's field offices or by contacting Publications, Communications and Grants Team, English Nature, Natural Environment Centre, Durham DH1 3LE. Telephone 01733 318256 or fax 01733 897629.

Quaternary Research Association to visit lower Thames sites

Neil Glashier, English Nature

Following the publication of the second edition of the Geological Conservation Review volume Quaternary of the Thames, the Quaternary Research Association (QRA) has announced a short field meeting to visit the lower reaches of the Thames. The meeting will take place between 13 and 16 October 1995 and will visit various Sites of Special Scientific Interest (SSSIs) which includes the famous Swanscombe Skull site. English Nature is assisting the QRA by helping to facilitate site arrangements and clearing access to various localities. An accommodation list will be published by the QRA. English Nature believes that the field meeting will benefit geological conservation through the creation of fresh exposures at several SSSIs and through increasing the awareness of Quaternary scientists of the key sites involved in conserving our geological heritage. Further details about the visit can be obtained from Dr D B Bridgland, University of Durham, Department of Geography, Science Laboratories, South Road, Durham DH1 3LE.

Blue Circle conserves Wealden site

John Patmore, English Nature

Horton Clay Pit, a geological Site of Special Scientific Interest (SSSI) in Weald in West Sussex, is important for Wealden clay deposits which contain fossil faunas from over 40 million years ago. Ammonites are particularly abundant and indicate that the clay was originally deposited on the floor of an ancient sea. Blue Circle Industries, the site owners, were extracting the clay and are now overseeing a landfill operation at the site. English Nature is working with Blue Circle to achieve a conservation solution so that the clay could continue to be examined in situ. Blue Circle have agreed to donate any soil from the land to English Nature to form the chert; this thick silica gel encased and perfectly preserved the tiny plants and animals, often before much decay could take place, with the result that many of the fossils were petrified in an upright (growth) position with their cell structure intact. The Rhynie Chert, formed from algae up to 530 million years ago, has been incorporated into a complete ecosystem, frozen at a point in Earth history when land on Earth was gaining a foothold. Now, to add to the support of staff and children at Rhynie Primary School, this international rare fossil-filled rock formation is to be displayed, depicting the ancient environment at Rhynie and the history of its discovery through rock specimens and interactive panels. It is hoped that the exhibit will increase public awareness and understanding of this remarkable time-capsule, a jewel in the crown of Scotland's fossil-forest and an important record of the population of north-east Scotland and beyond.
Earth Heritage is published for English Nature, Scottish Natural Heritage and the Countryside Council for Wales.