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Earth heritage conservation in England:

A Natural Areas perspective

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Earth heritage conservation in England: A Natural Areas perspective

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PART I

1. INTRODUCTION

"In Britain, the conservation of geological and geomorphological sites is an integral part of nature conservation, and we have a long history of successful site protection ... ... In England, English Nature has recently been reviewing the whole approach to wildlife and geological conservation, and has developed a system which brings these areas much closer together. The new approach recognizes the need to set objectives and targets for wildlife and Earth science conservation, and proposes that this is best done by having a series of objectives which reflect the variety of England's landscape and wildlife. Therefore, the concept of Natural Areas has been developed, which turns this idea into practice" (Duff, 1994).

The close dependency of Natural Areas on underlying geology and geomorphological processes provides a very real opportunity to integrate wildlife and Earth heritage conservation. Although geological and geomorphological sites undoubtedly have their own intrinsic interests and values, they also permit us to see and understand the foundations from which the soils and vegetation of the Natural Areas have sprung, and the operation of the natural processes which continue to shape the land. Links of this kind provide many opportunities to create much closer working relationships between conservationists and land managers.

This report builds upon the initial guidance provided by an earlier paper (Wright, 1993). It is intended to provide a country-wide synthesis of England's Earth heritage within a Natural Areas format which will in turn assist the clarification of Earth heritage conservation priorities and objectives. The data sheets are particularly intended to influence the production of Natural Area Core-profiles and Profiles.

The holistic view EIT is adopting to geological and geomorphological site conservation is indicated in our gradual shift away from an 'Earth science' approach towards an 'Earth heritage' role. By implication, this role views geological and geomorphological sites within the wider picture of nature conservation. From April 1996 onwards we will be fully adopting a Natural Areas approach to our Earth heritage casework and individual geologists within EIT will assume lead contact responsibility for allocated Natural Areas. The contact points for casework and enquiries are listed in Annex 3 of this report.

DUFF, K. *in* O'HALLORAN, D. *et al.* (eds.) 1994: Natural Areas: an holistic approach to conservation based on geology. Geological and Landscape Conservation. Geological Society, London, pp. 121-126.

WRIGHT, R. 1993: Natural Areas - the role of Earth sciences. Earth Science Branch, 36pp.

2. METHODS

2.1 Data sources

A variety of data sources and references were used to compile the profiles. Specific references are listed on each profile but sources which proved to be of particular value are listed below:

a) DUFF, P.McL.D. & SMITH, A.J. (eds) 1992: Geology of England and Wales, The Geological Society, London

b) WHITTOW, J.B. 1992: Geology and scenery in Britain. Chapman and Hall, London

c) British Regional Geology - series of regional handbooks (various authors and dates), British Geological Survey, HMSO.

Upon completion of the individual Natural Area data sheets, each was sent to the appropriate local team lead contact. Comments and corrections received from this exercise have been incorporated into Part II of this report.

2.2 Explanation of data fields

The following sections explain the content of each section on the Natural Area profiles.

2.2.1 Geological significance

Four categories were identified to provide an assessment of the overall geological/geomorphological significance for each Natural Area. Table 1 (overleaf) summarises the criteria used to define each category together with our interpretation of the level of priority which should be attached to geological/geomorphological objectives within each Natural Area. The categories are provisional at this stage awaiting a 'final' definition of some Natural Area boundaries. However, the overall geological/geomorphological significance of the majority of Natural Areas is unlikely to change.

2.2.2 General geological character

A short summary of the Natural Area's overall geological/geomorphological interests and geological history, linking these especially with landscape features. The following abbreviations are used: Ma = millions of years old/ago; BP = years 'before present'.

2.2.3 Key geological features

The most important and main geological/geomorphological features and interests within the Natural Area. These features may be broad (eg. Upper Carboniferous stratigraphy and palaeontology) or specific and place-related (eg. the Whin Sill).

GEOLOGICAL SIGNIFICANCE	SELECTION CRITERIA
Outstanding	Earth heritage objectives should be of *very high priority* within the Natural Area because it:- 1. Contains at least 2 internationally important 'type' sites (eg. global stratotypes designated by the International Union of Geological Sciences; site with unique fossil fauna/flora of fundamental importance to evolutionary history, earliest mammals, hominid remains etc. 2. Includes 20 or more geological/geomorphological (P)SSSIs.
Considerable	Earth heritage objectives should be of *high priority* within the Natural Area because it:- 1. Contains at least 1 internationally important 'type' site (see above) 2. Includes 10 or more geological/geomorphological (P)SSSIs.
Notable	Earth heritage objectives should be regarded as a *medium priority* within the Natural Area, although conservation action for one or more sites (eg. British 'type' sites) may be of higher priority. The Natural Area:- 1. Contains at least 1 site recognised as a British 'type' site (eg. stratotype site defining the base of a Stage used for England/Britain/Europe-wide correlation) 2. Includes 5 or more geological/geomorphological (P)SSSIs.
Some	Earth heritage objectives are overall a *low priority* within the Natural Area although there may be exceptions where specific site conservation action is required. Typically the Natural Area includes less than 5 geological/ geomorphological (P)SSSIs.

Table 1. Criteria for defining geological/geomorphological significance of Natural Areas

2.2.4 Number of Geological Conservation Review (GCR) sites

A summary of the number of GCR sites against particular 'subject blocks' present within the Natural Area. (The GCR is subdivided into 102 different subject blocks, 84 of which are represented in England). This section demonstrates the variety or 'geodiversity' of the (inter)nationally important geological/geomorphological sites within the Natural Area.

2.2.5 Geological/geomorphological SSSI coverage

Brief highlights of the (P)SSSI coverage within the Natural Area, noting especially any renowned or classic localities and any international type or stratotype sections. The number of GCR SILs (Single Interest Localities) often exceeds the number of (P)SSSIs within a Natural Area indicating that some SSSIs contain more than one nationally significant geological/ geomorphological interest.

2.2.6 Key geological issues and objectives

A list of the main issues and objectives for the Natural Area aimed at safeguarding, and wherever appropriate, enhancing the geological/geomorphological features of the Natural Area. Several

of the objectives are 'generic' and can be applied as standard across all Natural Areas.

2.2.7 References

Some key sources of information relating to the geology/geomorphology of the Natural Area.

2.2.8 Earth heritage (P)SSSI within the Natural Area

A list of the geological/geomorphological (P)SSSIs within the Natural Area. The majority of sites listed here will already be notified as SSSIs but for completeness sake we have also included Earth heritage PSSSIs. This list is obviously subject to revision as Natural Area boundaries vary.

3. RESULTS

The Earth heritage data sheets for individual Natural Areas form Part II of this report. The geological/geomorphological significance and issues for each of the Upland, Lowland and Maritime Natural Areas are collated in Annex 1.

3.1 Earth heritage significance

Of the 116 Natural Areas, 70 (approximately 60%) are classified as being of either *outstanding* or *considerable* geological/geomorphological significance. Similar proportions are calculated for these significances in Upland, Lowland and Maritime Natural Areas indicating that all these areas are of crucial importance in conserving England's Earth heritage. Table 2 provides an overall summary of this data.

GEOLOGICAL/ GEOMORPH. SIGNIFICANCE	Upland	Lowland	Maritime	Total
Outstanding	7	18	9	34
Considerable	4	27	5	36
Notable	2	14	7	23
Some	5	15	3	23
Total	18	74	24	116

Table 2. Summary of the Earth heritage significance of England's Natural Areas

Similarly, 51 of the 116 Natural Areas (approximately 44%) are regarded to contain international/national type (reference) sites (data extracted from Annex 1). This supports the fact

that England's Earth heritage is of considerable significance on a world scale.

3.2 Key issues

Table 3 summarises the 'top' 12 main issues affecting England's Earth heritage. Not surprisingly some of these issues are 'generic' and can be applied across all categories of Natural Areas, eg. lack of maintenance of the existing resource, changes to natural processes, mineral extraction, landfill, development etc. This category also includes some issues which were previously thought to be quite localised until viewed within a Natural Areas format - thus issues such as over/misuse of available fossil resources figure relatively highly.

Other issues are obviously restricted to particular types of Natural Area eg. coastal defence works, (the total of 48 Natural Areas here includes overlap between coastal lowland and maritime Natural Areas and therefore appears artifically high). Some issues are in a practical sense, effectively impossible to manage (eg. rise in sea-level) but nevertheless it is worth noting that this process will obviously have an impact upon the existing Earth heritage resource. Further details concerning issues affecting the Maritime Natural Areas are detailed in Annex 2.

The table also identifies other key issues which occur in specific types of Natural Area. For example, lack of site recording is an important issue in Lowland areas but is apparently negligible on the coast. This could be a reflection of more readily accessible and better exposed sections along the coast attracting a greater proportion of geologists who record their findings.

KEY ISSUE	Upland	Lowland	Maritime	Total
Lack of maintenance of existing resource	18	74	24	116
Changes to natural processes	7	36	24	67
Poor quality/deterioration of exposures	6	29	24	59
Construction of coastal defence works	-	24	24	48
Mineral extraction, dredging, landfill, development	7	24	12	43
Lack of site recording	2	39	-	41
Underpromotion of educational/scientific value	6	25	8	39
Overuse/misuse of fossil resource	4	25	7	36
Underpromotion of heritage/landscape/archaeological links	12	19	-	31
Rise in sea level	-	-	24	24
Lack of conservation sections in (dis)used quarries	3	18	-	21
Risk of flooding	-	3	15	18

Table 3. Summary of the key issues affecting Earth heritage conservation in Natural Areas

Acknowledgements

The compilation of the Natural Area Earth heritage data sheets has involved all of the geologists within EIT. In particular we thank Alison Littlewood and Richard Leafe for their assistance with the geomorphological aspects of the Maritime Natural Areas. We are also grateful to the many staff in local teams who fedback useful comments especially relating to Natural Area boundary changes and (P)SSSI amendments.

Andy King
EIT

15 March 1996

PART II EARTH HERITAGE DATA SHEETS FOR ENGLAND'S NATURAL AREAS

Natural Area: 1. Northumberland Coastal Plain	**Geological Significance:** Notable **(provisional)**

General geological character: The Northumberland Coastal Plain Natural Area is a low-lying coastal plain, bounded to the west by the Fell Sandstone of Chillingham Ridge. The solid geology of the Natural Area is dominated by sandstones and limestones of Carboniferous age largely concealed by much younger boulder clay. The coastal sections provides the best exposures. These are dominated by Lower Carboniferous Dinantian rocks (362-333 Ma) and in the extreme south, by Upper Carboniferous Namurian rocks (333-318 Ma). Marine conditions dominated during the Dinantian and eventually give way to Namurian fluvial environments (Millstone Grit); originally rivers flowed south-westwards into the Northumbrian Basin. Late Carboniferous igneous activity, associated with the Hercynian mountain building phase, led to the intrusion of the Whin Sill which today forms the castle rocks of Bamburgh, Lindisfarne and Dunstanburgh as well as the Farne Islands. Most recently, Pleistocene-aged glacial erosion moulded the present landscape leaving behind a thick boulder clay cover.

Key geological features:

- Lower Carboniferous (Dinantian) stratigraphy and palaeogeography
- Upper Carboniferous (Namurian) stratigraphy and palaeogeography
- Late Carboniferous igneous activity (Whin Sill)
- Pleistocene glacial deposition features and coastal evolution

Number of GCR sites:

Permian-Carboniferous Igneous: 4 Coastal Geomorphology of England: 2
Pleistocene/Quaternary of Northeast England: 2 Holocene Sea Level: 1
Namurian of England and Wales: 1 Dinantian of Northern England and Wales: 1

Geological/geomorphological SSSI coverage: There are 7 (P)SSSIs in the Natural Area containing 11 GCR SILs representing 6 different GCR networks. Of the 7 (P)SSSIs all, except Longhoughton Quarry, are coastal sections. Lindisfarne SSSI exposes one of the finest Dinantian sections in England, critical for the understanding of changing environments of the Northumberland Basin, while Howick to Seaton Point SSSI provides the best exposure of Namurian rocks in Northumberland. The compositional variation of the Whin Sill, and its relationship with over and underlying rocks, is visible at Bamburgh and Lindisfarne SSSIs. As the first described 'sill' this is the world type (reference) area for all sills. Glacial depositional features (including an esker ridge) are well represented at Bradford Kames SSSI whilst a raised beach on Lindisfarne is important for understanding coastal evolution over the last 5000 years.

Key geological management issues:

- Maintain and enhance existing exposures
- Maintain natural coastal processes
- Agree conservation sections in working quarries
- Assess new sites
- Promote the educational value of the resource

Key geological objectives:

1. **Maintenance and enhancement of the geological resource** through a) development of Shoreline Management Plans ensuring continued maintenance of natural coastal processes, b) agreed conservation (present and future) in working quarries (e.g. Longhoughton), c) continued assessment of educational/research value of new sites (e.g. inland quarries and cuttings, temporary or permanent).

2. **Promotion of geological resource** through a) assessment and promotion of site educational value (e.g. coastal Whin Sill exposures), b) on-site interpretation (e.g. sign boarding, trail guides, leaflets), c) promotion of the link between geology, local habitats and scenery (e.g. Whin Sill and location of Dunstanburgh/Bamburgh castles).

Useful guides/references:

TAYLOR, B.J. *et al.* 1971: British Regional Geology, Northern England. British Geological Survey. HMSO, London

CARRUTHERS, R.G., DINHAM, B.A., BURNETT, G.A. & MADEN, J. 1927: The geology of Belford, Holy Island and the Farne Islands, Memoir of the Geological Survey of England and Wales, HMSO, London.

Earth science (P)SSSIs in the Natural Area:

- Longhoughton Quarry
- Bamburgh Coast and Hills
- Lindisfarne
- Castle Point to Cullernose Point
- Howick to Seaton Point
- Bradford Kames
- Low Hauxley Shore

Natural Area: 2. Border Uplands	**Geological Significance:** Considerable **(provisional)**

General geological character: The Border Uplands Natural Area has a complex geology which shares many affinities with the geology immediately to the north in Scotland. The north of the area is dominated by andesitic and basaltic lava flows of Devonian age (around 390-380 Ma). These were intruded by basic dykes and by the Cheviot Granite. Overlying these volcanics is a succession of Carboniferous rocks, comprising sandstones, siltstones, clay-rich limestones and dolomites. These beds form cyclic units and show evidence of both desiccation (in the form of mud cracks) and vegetation (in the form of thin coals and rootlet beds). They are believed to represent deposition in large saline lakes or freshwater lakes on an arid coastal plain. The overlying Fell Sandstone Group represents a series of lobate deltas migrating in a south westerly direction across the area. The overlying Late Carboniferous (330 Ma) Yoredale series (comprising sandstones, shales, limestones and thin coals) represents deposition on delta tops and margins with varying degrees of marine influence as sea levels fluctuated. The limestones form prominent landscape features in the southern part of the Natural Area. During the Variscan Orogeny (in Late Carboniferous times), earth movements resulted in the intrusion of several basalt dykes and a major sill (the Whin Sill) into fissures in the limestones. Later mineralization (associated with the circulation of basinal groundwater partly heated by the Weardale Granite) created extensive veins of lead and zinc within fissures in the limestones. These have traditionally been an important economic resource and give the area a rich mining heritage. The impervious sandstones and grits now support surface streams, many of which contain important information about the post-glacial (the last 10,000 years) environmental changes in the area. Much of the areas is capped by glacial sediments (sands, gravels and clays) deposited by earlier glaciations in the Quaternary (the last 2 million years).

Key geological features:

- Carboniferous stratigraphy
- Exposures of the Whin Sill and other igneous rocks
- Mineralization of the Carboniferous rocks

Number of GCR sites:

Dinantian of Northern England and Wales: 5 Pleistocene/ Quaternary of North East England: 3
Namurian: 3 Mineralogy of the Pennines: 3 Permian-Carboniferous Igneous: 2
Fluvial Geomorphology of England: 1 Palaeozoic Palaeobotany: 2 Westphalian: 1

Geological/geomorphological SSSI coverage: There are 18 (P)SSSIs in the Natural Area containing 20 GCR SILs which represent 8 different GCR networks. These sites include important exposures of the Permian-Carboniferous igneous intrusion of the Whin Sill at Roman Wall Escarpments SSSI, exposures of the Dinantian rocks at Ellery Sike SSSI, and the sites (such as Stonecroft Mine SSSI and Fallowfield Mine SSSI) which illustrate the development of mineralization of the Dinantian rocks. The Carboniferous fossil tree stumps preserved at Kingwater SSSI (around 340 million years old) are evidence of environmental conditions at this time. The famous Cheviot Tors and the cuesta landform developed by the scouring action of glacial ice at Roman Wall Escarpments SSSI are evidence of the effects of the recent cold climates during the Quaternary "Ice Ages".

Key geological management issues:

- Need to agree management options for mines and mine dump sites
- Strengthening links between geology and mining heritage in the area
- Safeguarding and enhancing existing geological sites and natural processes from development threats

Key geological objectives:

1. Maintain and where possible enhance the existing geological exposures by agreeing management plans with owners and occupiers and negotiating long-term conservation of exposures with mineral extraction companies at geological sites.

2. Encourage initiatives aimed at strengthening links between geology, mining heritage and industrial archaeology in the area

3. Promote responsible fossil and mineral collecting at vulnerable sites

Useful guides/references:

LEEDER, M.R. 1992: Dinantian *in* DUFF, P.McL.D. & SMITH, A.J. (eds). Geology of England and Wales. The Geological Society, London.

WHITLOW, J.B. 1992: Geology and Scenery in Britain. Chapman and Hall, London..

Earth science (P)SSSIs in the Natural Area:

- Brunton Bank Quarrry
- Cheviot
- Corbridge Limestone Quarry
- Fallowfield Mine
- Greenleighton Quarry
- Birky Clough
- Cottonshope Head Quarry
- Ellery Sike
- Harthope Burn
- Humbleton Hill and the Trows
- Jockie's Sike
- Kingwater
- Oakshaw Ford
- Redesdale Ironstone Quarry
- Settlingstones Mine
- Stonecroft Mine
- Whitberry Burn
- Roman Wall Escarpments

Natural Area: 3. North Pennines	**Geological Significance:** Outstanding **(provisional)**

General geological character: The North Pennines Natural Area is dominated by Carboniferous Limestone forming an open and rugged upland area. The Carboniferous rocks are divided by geologists into the following sequence (in ascending order): Carboniferous Limestone (Dinantian, 350-333 Ma), Millstone Grit and Shale (Namurian, 333-318 Ma), and Coal Measures (Westphalian, 318-303 Ma). All these rocks are found within the Natural Area. The boundary between the limestones and grits is known as the Yoredale Succession, and is made up of a rhythmic sequence of limestones, shales, sandstones, grits and coal. This sequence indicates the changes in the Carboniferous seas from clear water oceans (limestones), through increasingly muddy seas (shales) to swampy estuaries and deltas (current-bedded sandstones and grits). Also during the Carboniferous, volcanic activity intruded great sheets of dolerite into the limestones in the form of sills. These layers of dolerite (the Whin Sill) now form resistant layers in the limestone and survive as vertical 'steps' in the landscape. The area was faulted during the Variscan Orogeny (Late Carboniferous times) producing blocks of higher seabed (eg. the Alston Block) and lower basins. These have controlled later patterns of sedimentation and mineralization (associated with the circulation of basinal groundwater partly heated by the Weardale Granite) which created extensive veins of lead and zinc within fissures in the limestones. These have traditionally been an important economic resource and give the area a rich mining heritage. The impervious sandstones and grits now support surface streams, many of which contain important information about the post-glacial (the last 10,000 years) environmental changes in the area. These streams form underground caves where they drain into the limestones beneath.

Key geological features:

- Exposures of the Carboniferous (Dinantian, Namurian and Westphalian) rocks
- Mineralisation of the Carboniferous limestone and links with mining heritage
- The Whin Sill and its landscape value
- Extensive underground cave systems developed in the limestones

Number of GCR sites:

Mineralogy of the Pennines: 13 Namurian of England and Wales: 5
Fluvial Geomorphology of England: 5 Permian-Carboniferous Igneous: 3 Dinantian of England and Wales: 2 Pollen Stratigraphy of England: 2 Caves: 2 Karst: 1 Permian-Triassic: 1
Caradoc-Ashgill: 1 Pleistocene/ Quaternary of Cumbria: 1

Geological/geomorphological SSSI coverage: There are 26 (P)SSSIs in the Natural Area containing 36 GCR SILs representing 11 different GCR networks. The SSSI coverage is dominated by sites showing the mineralogy of the Natural Area. The mine dump at Blagill Mine shows the composition of Fiskas Rake and is the type site for the mineral barytocalcite, whilst West Rigg Open Cutting, Foster's Hush and River South Tyne and Tynebottom Mine all show different aspects of the mineralization of the Carboniferous limestones and shales. Mousegill Beck and Botany Hill are important sites for Carboniferous stratigraphy. The Carboniferous Limestone is punctured by natural underground cave systems such as those of Fairy Hole Caves SSSI and the famous maze cave of Knock Fell Caverns at Moor House and Cross Fell SSSI. The karst landform at Gods Bridge SSSI is a good example of a naturally developed river arch. Alston Shingle Banks SSSI shows the post-glacial environmental changes in the area and the links with mining heritage.

Key geological management issues:

- Need to agree management options for mines and mine dump sites
- Strengthening links between geology and mining heritage in the area
- Safeguarding and enhancing existing geological sites and natural processes from development threats
- Threats to cave systems from overuse and misuse by cavers

Key geological objectives:

1. Maintain and where possible enhance the existing geological exposures by agreeing management plans with owners and occupiers and negotiating long-term conservation of exposures with mineral extraction companies at geological sites

2. Support local caving groups in producing cave conservation plans for vulnerable cave systems

3. Encourage initiatives aimed at strengthening links between geology, mining heritage and industrial archaeology in the area

4. Promote responsible fossil and mineral collecting at vulnerable sites

Useful guides/references:

LEEDER, M.R. 1992: Dinantian *in* DUFF, P.McL.D. & SMITH, A.J. (eds). Geology of England and Wales. The Geological Society, London.

WHITLOW, J.B. 1992: Geology and Scenery in Britain. Chapman and Hall, London.

Earth science (P)SSSIs in the Natural Area:

- Botany Hill
- Crag Gill
- Fairy Holes Cave
- Greenfoot Quarry
- Alston Shingle Banks
- Appleby Fells
- Blagill Mine
- Burnfoot River Shingles and Wydon Nab
- Close House Mine
- Old Moss Lead Vein
- River Nent at Blagill
- River West Allen at Blackett Bridge
- Tipalt Burn
- Rogerley Quarry
- Foster's Hush
- God's Bridge
- Janny Wood Section
- Mousegill Beck
- River Belah
- Sleightholme Beck Gorge 'The Troughs'
- Melmerby Road Section
- Moor House and Cross Fell
- River South Tyne and Tynebottom Mine
- Small Cleugh Mine
- Upper Teesdale
- West Rigg Open Cutting

Natural Area: 4. Northumbrian Coal Measures	**Geological Significance:** Some **(provisional)**

General geological character: The Northumbrian Coal Measures Natural Area exposes an Upper Carboniferous to lower Permian sequence dipping eastwards at a shallow angle and capped throughout by Pleistocene clay, sands and gravels. The area is dominated by Namurian and Westphalian-aged (333-303 Ma) sandstones, shales and clays with numerous coal seams (the 'Coal Measures'). Fluviodeltaic environments dominated the tropical/humid climate of the Upper Carboniferous with occasional marine incursions characterised by marine shale bands. Towards the end of the Carboniferous Period, arid Saharan-like conditions dominated, Permian desert sands (Permian Yellow Sands) covering much of the area at this time. Igneous activity during the Tertiary (approximately 60 Ma) led to the intrusion of a number of E-W orientated dykes. During Pleistocene times (approximately 100,000 years BP) the area was covered by ice sheets which, on retreat, left a thick covering of glacial clays, sand and gravels today seen capping the coastal cliffs and filling former valleys. Present day processes are also important, the River Tyne exposing a uniquely thick sequence of flood plain sediments.

Key geological features:

- Namurian/Westphalian stratigraphy - Durham-Northumberland Coalfield
- Pleistocene stratigraphy - glacial boulder clays
- Economic resource - Coal Measures

Number of GCR sites:

Westphalian: 3 Quaternary of Northeast England: 1 Fluvial geomorphology of England: 1

Geological/geomorphological SSSI coverage: There are 4 (P)SSSIs in the Natural Area containing 5 GCR SILs representing 3 different GCR networks. The best exposures occur in coastal sections between Tynemouth to Seaton Sluice and Creswell and Newbiggin Shores. These display the most complete sequence of Westphalian rocks in the Durham-Northumberland coalfield and include numerous coal seams, mudstones and sandstones. Inland, uppermost Westphalian beds are exposed (Wear River Bank SSSI) unconformably overlain by the lowermost Permian Yellow Sands (also seen capping the cliffs at Tynemouth Priory). These sections are among the most important in the country for interpreting the complex environmental and palaeogeographical evolution of the Upper Carboniferous. The overlying glacial clay, sand and gravel is particularly well exposed at Sandy Bay (Creswell and Newbiggin Shores). This represents the most extensive Devensian (late Pleistocene) till on the Northumberland Coast. Inland, till also partially or totally fills a complex sequence of buried valleys.

Key geological management issues:

- Maintain and enhance existing exposures
- Maintain natural processes: fluvial and coastal
- Assess new sites
- Promote the educational value of the geological and geomorphological resource

Key geological objectives:

1. **Maintenance and enhancement of the geological resource** through a) continued maintenance of natural fluvial (e.g. River Tyne at Ovingham) and coastal processes (Shoreline Management Plans), b) development of local conservation strategies that include geology, c) continued assessment of educational/research value of new sites (e.g. inland quarries and cuttings, temporary or permanent).

2. **Promotion of geological resource** through a) assessment and promotion of site educational value (particularly relevant with the urban setting of the Natural Area), b) on-site interpretation (e.g. sign boarding, trail guides, leaflets), c) promotion of the link between geology and local habitats, scenery and the industrial development of the Natural Area (the link between geology and the former coal industry is particularly important).

Useful guides/references:

FOWLER, A. 1936: The geology of the country around Rothbury, Amble and Ashington. Memoir of the Geological Survey, UK.

LAND, D.H. 1974: Geology of the Tynemouth District. Memoir of the Geological Survey, U.K.

TAYLOR, B.J. *et al.* 1971: British Regional Geology, Northern England. British Geological Survey. HMSO, London

Earth science (P)SSSIs in the Natural Area:

- Creswell and Newbiggin Shores
- River Tyne at Ovingham
- Tynemouth to Seaton Sluice
- Wear River Bank