Natural Area: 76. Shropshire Hills	Geological Significance: Outstanding (provisional)

General geological character: The Shropshire Hills Natural Area is a classic area for geology and contains many sites of international importance. Many of the pioneering geological investigations were carried out in south Shropshire and Series names such as Wenlock and Ludlow define internationally accepted periods of geological time. The south-eastern corner of the Natural Area is coincident with the River Teme; from here the area stretches north-westwards encompassing Ludlow, the Clee Hills, Wenlock Edge, Longmynd, Stiperstones, the Shelve Inlier and a tract of land east of Long Mountain and Welshpool. The varied topography is a reflection of the diverse underlying geology. Generally south Shropshire is formed of relatively hard, resistant rocks (between 300 to 700 Ma) but the variety of the geology is such that each 'hill mass' has its own distinctive feature, from the gaunt crags of the Stiperstones and the Longmynd Plateau to the spectacular ridge and vale country around Wenlock Edge. Clee Hills and Stiperstones form the highest ground in the area attaining heights in excess of 530m AOD. The geological structure of the Natural Area is dominated by two NE-SW trending faults; the Pontesford Linley Fault ('PLF' - which borders the Shelve Inlier and Longmynd) and the Church Stretton Fault ('CSF' - which separates the Longmynd from Ordovician-Silurian strata of the Caer Caradoc-Wenlock Edge region).

The oldest rocks in the area are late Precambrian (Uriconian) age, approximately 600 to 650 Ma, and comprise a series of thick lavas (rhyolites, andesites and basalts) and volcanic ashes (tuffs). These were produced during a phase of intense volcanic activity and crop out in two distinct belts along the PLF and CSF where they form conspicuous 'hog-back' hills. Other Precambrian strata in the Shropshire Hills is referred to the Longmyndian Supergroup of sedimentary rocks (approximately 590 to 575 Ma) which forms the large, deeply dissected moorland plateau of the Longmynd. The strata consist of about 8000m of shales, mudstones and sandstones with thin volcanic bands. The succession is divided into two groups; an upper Wentnor Group (or Western Longmyndian) separated from a lower Stretton Group (Eastern Longmyndian) by an unconformity. The sediments were deposited in shallow marine conditions in a sinking trough between the PLF and CSF. The only fossils recorded from the Longmyndian are fossil algal mats, worm burrows/tubes and occasional impressions of jellyfish.

During Lower Palaeozoic times (Cambrian to Silurian, 570 to 405 Ma), Shropshire lay almost continuously under the sea which deepened westwards. Upland areas such as the Longmynd periodically stood out as islands. On the sea floor thicknesses of sandstones, shales and limestones accumulated containing the fossil remains of marine organisms. The outcrops of Cambrian rocks broadly follow those of the Uriconian Volcanics, overlying them along the line of the CSF and faulted against the whole length of the PLF. The lower Cambrian sediments are assigned to the Comley Series and these contain the earliest abundant fossils found in Britain. Quarries around Comley (the type area) have yielded fossil trilobites, brachiopods and gastropods. The oldest Ordovician sediments are the Shineton Shales (approximately 495 Ma) and these yield a fossil fauna including trilobites and graptolites. The Ordovician Period (495 to 435 Ma) is one of the most interesting in Shropshire because of the variety of rock types, and because the Ordovician sequence of the classic Stiperstones-Shelve area west of the PLF is very different from that of the type Caradoc area east of Church Stretton. The Shelve area shows a virtually complete Ordovician sequence (with the Stiperstones Quartzite near the base), deposited in deep water and associated with volcanic lavas and tuffs; whereas east of Church Stretton the sequence does not start until the Caradoc Series. The latter area was a land mass not covered by the sea until Caradoc times, when a shallow shelf sea transgressed from the west laying down a thin shelly facies of sedimentary rocks rich in fossil trilobites and brachiopods. A period of important earth movements (termed the Taconian) affected Shropshire in late Ordovician times and caused the strata to be buckled by large scale folds and faults.

Lead-zinc and barytes mineralisation is a well-known feature of the Shelve area, which gave rise to a thriving mining industry in the nineteenth and early twentieth centuries. The minerals occur within the Ordovician strata as veins, thin vertical sheets of igneous material injected into the surrounding rocks at a late stage of igneous activity. These are probably related to a large igneous body (probably granite) which is present at depth under the Shelve area. The main ore minerals are galena (lead sulphide), sphalerite (zinc sulphide) and barytes (barium sulphate). Radiometric dates for the veins suggest that the mineralisation is actually of late Devonian or early Carboniferous age (approximately 370-350 Ma).

The Taconian earth movements caused the sea to retreat westwards but marine conditions were re-established in early Silurian (Llandovery) times when the sea transgressed over Shropshire from the west to form shallow water deposits which are fairly uniform over the whole county. The Silurian Period (435 to 405 Ma) is divided into four smaller time (chronostratigraphic) divisions which are in ascending order: Llandovery, Wenlock, Ludlow and Pridoli (or 'Downton'). Two of these terms are based on classic type sequences around Ludlow and Wenlock Edge. Silurian-aged sediments crop out in three main areas: the area east of Church Stretton including Wenlock Edge and Ludlow, west of the CSF around the flanks of Longmynd and Stiperstones-Shelve area, and Long Mountain. The strata are different in all these areas but essentially comprise alternating marine shales and limestones. Some of the latter are coral reef limestones and spectacularly fossiliferous containing abundant brachiopods, trilobites, corals, gastropods, crinoids and bryozoans. During late Silurian and Devonian times (405-355 Ma) environmental conditions changed again when the whole of Shropshire rose above sea level. The beds at the top of the Ludlow Series and into the Downton consist of red and green sandstones, marls and limestones which were deposited in lakes and shallow lagoons. These are the 'Old Red Sandstones' which in Shropshire crop out in the Clee Hills area. The base of the Old Red Sandstone is marked by the famous Ludlow Bone Bed which is a fine grained sandstone with fossil fish remains. Above the Downton is the Ditton Series and Clee Group which comprise up to 1000m of reddish sandstones and marls with calcareous nodules (termed cornstones) and limestones (such as the Psammosteus Limestone which delineates the base of the Devonian System in Shropshire). The main fossils within the Old Red Sandstone are non-marine bivalves, plant remains and early fish.

Once again, most of Shropshire was covered by the sea during Carboniferous times (355 to 290 Ma) and small patches of Carboniferous Limestone and Millstone Grit crop out in the Clee Hills (around Titterstone Clee). Here basal shales pass up into grey Oreton Limestones (with marine brachiopod and coral fossils) which are overlain by the Cornbrook Sandstone (with Namurian plant remains). Upper Carboniferous Coal Measure strata also crop out around the Clee Hills and in the far north-west of the Natural Area, although the main Shropshire Coalfields are located around Ironbridge and Telford. The sediments comprise sandstones and shales with ironstone nodule bands and thin coal seams. These deposits were formed in extensive swamp and delta environments where the great 'Coal Measure forests' flourished. It is this rotting vegetation that produced peat which became compressed and lithified to eventually form coal.

The youngest sediments exposed in the Natural Area are of Quaternary age (late Pleistocene age, Devensian, 100,000 to 12,000 years BP). During this 'Ice Age' time much of the area was covered by a thick ice sheet which moved southwards from southwest Scotland. This Devensian glaciation had profound effects on Shropshire and the evidence for it is widespread; ice sheets reached as far south as the Church Stretton Valley. The high ground of the Shropshire Hills (above about 300m AOD) protruded as nunataks above the ice but was affected by periglacial conditions. The frost shattered tors of the Stiperstones show excellent examples of freeze-thaw shattering of the rocks and the widespread screes exhibit stone stripes and polygons. The Longmynd plateau has extensive periglacial head deposits. The Church Stretton valley, prior to the arrival of ice, was deeper than it is today by about 30-60m. Its bottom is now full of sand, gravel and boulder clay left after the retreat of the Devensian ice sheets.

Key geological features:

- Precambrian (Uriconian/Longmyndian) stratigraphy and volcanic activity
- Lower Palaeozoic palaeontology, palaeoenvironments and stratigraphy (especially type areas for Cambrian, Ordovician and Silurian strata and 'time' divisions of international importance)
- Structural geology, including PLF, CSF and Late Ordovician (Taconian) events
- Pleistocene stratigraphy and palaeoenvironments

Number of GCR sites:

Precambrian of England/Wales: 6 Arenig-Llanvirn: 6 Caradoc-Ashgill: 1 Silurian-Devonian Chordata: 4 Wenlock: 5 Llandovery: 4 Westphalian: 2 Ludlow: 2
Mineralogy of the Peak District/Leicestershire/Cheshire: 2 Cambrian: 1 Palaeozoic Palaeobotany: 1
Permian-Carboniferous Igneous: 1 Pleistocene/Quaternary of the Pennines: 1 Llandeilo: 1
Precambrian Palaeontology: 1

Geological/geomorphological SSSI coverage:
There are 31 SSSIs in the Natural Area containing 38 GCR SILs. These represent 15 different GCR networks which indicates the outstanding variety of geological interest to be found in the area. The majority of sites are selected for their stratigraphical/palaeontological interests as listed below (those marked with a * are type sections for particular series, formations etc):

Precambrian	Longmynd*, Earl's Hill and Habberley Valley;
Cambrian	Comley Quarry*;
Ordovician	Hope Bowdler Outcrops, Marsh Wood Quarry*, Onny River Section*, Soudley Quarry*, Coundmoor Brook, Becton Dingle and Gulley Green, Granham's Moor Quarry, Meadowtown Quarry*, Hope Valley (part)*, the Stiperstones and the Hollies* (part), Shelve Church Section;
Silurian/ Devonian	Hillend Quarry, Hughley Brook, Longville to Stanway Road Section*, Hope Valley, Eaton Track*, Upper Millichope Stream Section, Green Farm Quarry, Oak Dingle, Temeside*, Tar Grove Quarry;
Carboniferous	Cornbrook Dingle, Titterstone Clee*

In addition to these sites the following are selected: Clee Hill Quarries for Permo-Carboniferous igneous interests; Huglith Mine and Snailbeach Mine for mineralogy and The Stiperstones and the Hollies (part) for Pleistocene/Quaternary periglacial features.

Key geological management issues:

- Maintain, and where possible enhance existing exposures, ensuring appropriate management of established type sections (faces clear of vegetation)
- Management of key palaeontological sites avoiding overuse and misuse of sensitive fossil locations
- Recording/data collecting of new and/or temporary sections
- Promotion of the value of the geological resource, habitats and landscape
- Promotion of the link between geological resource and economic exploitation (mineralisation, coal fields)

Key geological objectives:

1. **Maintain, and where practical enhance, the geological resource** setting main priorities with type and key sections

2. **Promote the strengthening of links** between geology, landscape and local economic development

3. **Encourage responsible fossil collecting,** especially on sensitive integrity sites with limited resource

Useful guides/references:

EARP, J.R. & HAINS, B.A. 1971: British Regional Geology: The Welsh Borderland. Institute of Geological Sciences. NERC

TOGHILL, P. 1990: Geology in Shropshire. Swan Hill Press, Shrewsbury

SIVETER, D.J., OWENS, R.M. & THOMAS, A.T. 1989: Silurian field excursions: a geotraverse across. Wales and the Welsh Borderland. National Museum of Wales, Geological Series No. 10. Cardiff

Earth science (P)SSSIs in the Natural Area:

- Hillend Quarry
- Betton Dingle and Gulley Green
- Coundmoor Brook
- Earl's Hill and Habberley Valley
- Granham's Moor Quarry
- Hope Valley
- Meadowtown Quarry
- Snailbeach Mine
- Clee Hill Quarries
- Comley Quarry
- Cornbrook Dingle
- Eaton Track
- Green Farm Quarry
- Hughley Brook
- Huglith Mine
- Longmynd
- Titterstone Clee
- Hope Bowdler Outcrops
- Longville to Stanway Road Section
- Marsh Wood Quarry
- Oak Dingle
- Onny River Section
- Prescott Corner
- Soudley Quarry
- Spy Wood and Aldress Dingle
- Tar Grove Quarry
- Trewern Brook
- Upper Millichope Stream Section
- Shelve Church Section
- The Stiperstones and the Hollies
- Wenlock Edge

Natural Area: 77. Central Marches	Geological Significance: Outstanding (provisional)

General geological character: Like the Shropshire Hills, the Central Marches Natural Area is an important area for geology and contains many sites which are regarded as 'standards' in defining accepted periods of geological time and lithologies. The eminent Victorian geologist Sir Roderick Murchison originally defined the Silurian System (in 1839) and much of his pioneering work was based on sections exposed in the south Shropshire area. The western boundary of the Central Marches Natural Area is defined by the Rivers Teme and Lugg (and their tributaries), northwards the area incorporates higher ground around Clun Forest and Bishops Castle (approximately 410m AOD) and then swings south-westwards incorporating the southern edge of the Longmynd plateau and the western Ludlow region. The south eastern margin runs along the ridge of Silurian strata (Woofferton-Mortimer's Cross-Kington) which borders the flatter terrain to the east fromed by the Old Red Sandstone of the Hereford Plain. The geological structure of the Natural Area is dominated by the southern extension of the NE-SW trending Church Stretton Fault ('CSF' - *see* Earth science information sheet for 'Shropshire Hills' Natural Area).

The oldest rocks present in the Central Marches are late Precambrian-aged (590 to 575 Ma) sediments belonging to the Stretton Group of the Longmyndian. The strata comprise about 4300m of mudstones and sandstones interbedded with thin conglomerates and volcanic tuffs. They crop out in the north of the Natural Area as a southern extension of the Longmynd plateau adjacent to the CSF. A small fault-bounded outcrop of Longmyndian-aged sediments is also exposed in the Pewardine Inlier. Here the sediments are associated with early Ordovician (Tremadoc, approximately 495 Ma) shales and mudstones assignable to the Shineton Shales. These were deposited in marine conditions and contain the fossilised remains of graptolites, brachiopods and hyolithids. The next youngest Ordovician sediments present in the area are of Caradoc age (463-443 Ma). These crop-out adjacent to the Longmyndian strata bounded by the CSF noted above and consist of sandstones, shales and thin flaggy limestones containing a very rich shallow marine fossil fauna with brachiopods, trilobites and graptolites. Similar-aged deposits occur in the Pedwardine Inlier but here the sediments comprise coarse conglomerates and grits which overlie the Shineton Shales with a marked unconformity. The strata are regarded as evidence of the same Caradocian marine transgression event that occurred in south Shropshire.

The solid geology of the Central Marches is dominated by Silurian-aged strata which are assigned mainly to the Wenlock, Ludlow and 'Downton' (Pridoli) Series (430 to 405 Ma). Two distinct regions may be differentiated: the Clun Forest region (west of the CSF) and the Leintwardine-Ludlow region (west of the CSF). The rocks in the Clun Forest region are entirely of Ludlow and Downton Series age. The Ludlow comprises a great thickness (2000m) of siltstones and mudstones with many slumped beds; these sediments contain fossil graptolites and are interpreted as representing deep-water turbiditic environments. The Downton is represented by about 600m of fluvial/lacustrine siltstones, shales and mudstones forming large outliers around Clun. The Ludlow Bone Bed and basal beds of the Downton Castle Sandstone are represented by fossiliferous silty beds which yield fossil fish and important plant remains. No beds younger than Downton Series occur in the area. Strata in the Leintwardine-Ludow region are of key importance and represent the type areas for both the Ludlow and Downton Series. The Wenlock and Ludlow sediments comprise shallow marine shales and limestones (including the Much Wenlock limestone) which yield abundant fossil brachiopods, trilobites, gastropods and corals. Numerous names exist for the Ludlow sediments but essentially the sequence is (in ascending order): Elton Formation, Bringewood Formation, Leintwardine Formation and Whitcliffe Formation. The Downton Series ('Lower Old Red Sandstone') comprises a sequence of fluviatile and lacustrine sandstones, siltstones and nodular limestones ('cornstones'). In ascending order the beds are assigned to the Downton Castle Sandstone Formation (with Ludlow Bone Bed at its base), the Temeside Shales Formation and the Ledbury Formation. These beds yield fossil fish, eurypterids, plants and non-marine bivalves.

The youngest sediments exposed in the Natural Area are late Pleistocene-aged (Devensian, 80,000 to 10,000 years BP) or younger. Devensian sands and gravels were deposited in fluvioglacial and periglacial environments in front of the ice sheet which covered much of Shropshire during this last 'Ice Age'. Younger alluvial sands and silts are related to recent river deposition and chiefly occur along the rivers Teme and Lugg.

Key geological features:

- Lower Palaeozoic stratigraphy (especially type areas for Caradoc, Ludlow and Downton Series)
- Downton fossil fish and arthropods (eurypterids)

Number of GCR sites:

Ludlow: 16 Silurian-Devonian Chordata: 8 Arthropoda: 5 Wenlock: 3 Caradoc-Ashgill: 1 Palaeozoic Palaeobotany: 1

Geological/geomorphological SSSI coverage: There are 13 (P)SSSIs in the Natural Area containing 34 GCR SILs which represent 6 different GCR networks. The majority of sites are selected for their Ludlow (and to a lesser extent Wenlock) interest which is defined from several type localities within the Natural Area: Burrington Farm Stream Section, Burrington Sections, Church Hill Quarry, Downton Gorge, Elton Lane Cutting, Mocktree Quarries, Mortimer Forest, Rockhall Quarry, Teme Bank and View Edge Quarries. The area is also renowned for its Silurian-Devonian chordate (fish) and arthropod (eurypterid) fossils, especially the following sites: Bradnor Hill Quarry, Church Hill Quarry, Downton Gorge and Teme Bank. In addition to these sites the following are selected: Coston Farm Quarries for Caradoc-Ashgill stratigraphy (type locality for the Costonian Stage) and Rockhall Quarry for the presence of a Silurian-aged fossil dasycladacean algae (Palaeozoic Palaeobotany network).

Key geological management issues:

- Maintain, and where possible enhance existing exposures, ensuring appropraire management of established type sections (faces clear of vegetation)
- Management of key palaeontological sites avoiding overuse and misuse of sensitive fossil locations
- Recording/data collecting of new and/or temporary sections
- Promotion of the link between the geology, habitats and landscape

Key geological objectives:

1. **Maintain, and where practical enhance, the geological resource** setting main priorities with type and key sections.

2. **Promote the strengthening of links between geology and landscape**.

3. **Encourage responsible fossil collecting,** especially on sensitive integrity sites with limited available resource.

Useful guides/references:

EARP, J.R. & HAINS, B.A. 1971: British Regional Geology: The Welsh Borderland. Institute of Geological Sciences. NERC

TOGHILL, P. 1990: Geology in Shropshire. Swan Hill Press, Shrewsbury

SIVETER, D.J., OWENS, R.M. & THOMAS, A.T. 1989: Silurian field excursions: a geotraverse across Wales and the Welsh Borderlands. National Museum of Wales, Geological Series No. 10. Cardiff

Earth science (P)SSSIs in the Natural Area:

- Bradnor Hill Quarry
- Burrington Farm Stream Section
- Burrington Sections
- Church Hill Quarry
- Coston Farm Quarries
- Downton Gorge
- Elton Lane Cutting
- Mocktree Quarries
- Mortimer Forest
- Rockhall Quarry
- Teme Bank
- Temeside
- View Edge Quarries

Natural Area: 78. Oswestry Uplands	**Geological Significance:** Some **(provisional)**

General geological character: The Oswestry Uplands Natural Area comprises easterly dipping Carboniferous rocks (mainly 355 to 300 Ma) disappearing under the Triassic rocks of the Cheshire Plain. The western and southern boundaries of the area are marked by outcrops of folded Carboniferous Limestone unconformably overlying Silurian and Ordovician rocks which outcrop to the west. The Carboniferous Limestone consists of a succession of shallow water carbonates containing a fauna of brachiopods, crinoids and corals. Overlying the Carboniferous Limestone is the Millstone Grit which comprises over 180m of fluvial sandstones and conglomerates deposited by rivers with occasional interbedded shales which are marine in origin. On the eastern side of the area are the Coal Measures which, in the lower part, are productive (Oswestry Coalfield). The succession of shales and coal seams was deposited by a broad delta plain that was periodically inundated by the sea. Uplift and erosion towards the end of the Carboniferous led to the deposition of red marls, sandstones, conglomerates and breccias which overly the productive Coal Measures while continued uplift produced the folded hills of the Oswestry Uplands. The area was glaciated during the Pleistocene and, except where dissected by rivers, has an extensive boulder clay cover.

Key geological features:

- Carboniferous Upland of the Welsh Border

Number of GCR sites: None

Geological/geomorphological SSSI coverage: None

Key geological management issues:

- Improvement of the limited exposure
- Improvement of awareness of the geological resource and its relationship to landscape

Key geological objectives:

1. Maintenance and enhancement of the geological resource through a) enhancement of existing exposures (especially RIGS), b) development of local conservation strategies that include geology, c) assessment of educational/research value of new sites (eg. quarries and cuttings, temporary or permanent).

2. Promotion of geological resource through a) assessment and promotion of site educational value, b) on-site interpretation (eg. sign boarding, trail guides, leaflets), c) promotion of the link between geology and local habitats and landscape development of the Natural Area.

Useful guides/references:

WEDD, C.B., SMITH, B. & WILLS, J.L., 1927 & 1928. The Geology of the country around Wrexham Parts 1 and 2. (Sheet 121). Memoir of the Geological Survey of Great Britain.

SMITH, B. & NEVILLE, T.G. 1961: British Regional Geology: North Wales. Geological Survey and Museum. HMSO, London.

TOGHILL, P. 1990: Geology in Shropshire. Swan Hill Press, Shrewsbury.

Earth science (P)SSSIs in the Natural Area:

None

Natural Area: 79. Mosses and Meres	**Geological Significance:** Considerable **(provisional)**

General geological character: The Mosses and Meres Natural Area is dominated by the Cheshire Plain, which is composed of Mesozoic (mainly Triassic) rocks and a surficial cover of late Pleistocene clays, sands and gravels. These sediments produce the characteristic Mosses and Meres.

The North Shropshire and Cheshire Plains are almost entirely formed of red to brown Triassic sandstones, silts and muds. The Triassic saw the influx of a major river system from the south. Extensive sandstones (reworked earlier Permian desert sands) were deposited (Sherwood Sandstone Group) and in the Upper Triassic siltstones and mudstones accumulated in a lagoon or shallow gulf. Evaporation of this lagoon lead to the extensive salt deposits today associated with these Triassic silt and mudstones (Mercia Mudstone Group). Rise in sea level once more inundated the area during the Jurassic, the only evidence of which is a small patch of early Jurassic shales and limestones in the Prees area. Tertiary sediments are not found though the area was affected by Tertiary igneous activity (approximately 50 Ma). A number of Tertiary dykes cut through the Triassic rocks which have also been affected by Tertiary mineralisation.

During the late Pleistocene (Devensian 100,000-12,000 years BP) the whole area was covered by a thick ice sheet which moved southwards from southwest Scotland. On retreat, extensive deposits of sand, gravel and clay were left behind including a number of glacial landforms. Subsidence of these Pleistocene sediments, following the solution and collapse of underlying Triassic salt deposits, produced a number of water logged hollows preserving successive layers of peat - the 'Mosses and Meres'. Peat pollen records record the vegetational history of the area over the last 12,000 years. The present day complex geomorphology of the Rivers Dane, Dee and Severn are also important for understanding modern fluvial geomorphology.

Key geological features:

- Carboniferous stratigraphy, palaeoenvironments and palaeontology
- Triassic stratigraphy , palaeoenvironments and palaeontology (early reptiles)
- Pleistocene stratigraphy and palaeoenvironments
- Triassic mineralisation
- Present day fluvial geomorphology

Number of GCR sites:

Fluvial Geomorphology of England: 2 Pollen Stratigraphy of England: 2 Karst: 2
Permian-Triassic: 3 Permian-Triassic Reptilia: 1 Westphalian: 1
Pleistocene/Quaternary of the Pennines: 1 Mineralogy of the Peak District, Leicestershire and Cheshire: 1
Fluvial Geomorphology of Wales: 1

Geological/geomorphological SSSI coverage: There are 14 (P)SSSIs within the Natural Area covering 14 GCR SILs; these represent 9 different GCR networks. Late Carboniferous fluvial sandstones are exposed at Tyrley Canal Cutting. Triassic sandstones form the escarpment of Raw Head and the Grinshill Quarries, the latter is also noted as Britains most prolific mid Triassic reptile locality. Mines at Alderly Edge SSSI are internationally important for their Triassic mineralisation. Pleistocene sediments are represented at Aqualate Mere, which contains one of the best esker systems in England (late Devensian). Crose Mere and Wybunbury Moss (composed of a floating peat raft) contain important Flandrian pollen records detailing changes in flora over this time. Rostherne Mere and Sandbach Flashes are both good examples of salt subsidence beneath the Cheshire Plain: Rostherne Mere is a subsidence basin partly controlled by the depth of glacial deposits, whilst Sandbach Flashes is particularly important for showing the anthropogenic influence on salt subsidence through brine pumping.

Key geological management issues:

- Need to safeguard established type localities within the Natural Area
- Need to protect palaeontological and mineralogical resource
- Need to secure conservation sections in working quarries
- Continued site assessment at new sites (eg. new quarries and cuttings)
- Promotion of the value of the geological resource, habitats and landscape

Key geological objectives:

1. Maintenance and enhancement of the geological resource through a) enhancement of existing exposures through site clearance, b) development of local conservation strategies that include geology, c) continued assessment of educational/research value of new sites (eg. quarries and cuttings, temporary or permanent).

2. Promotion of geological resource through a) assessment and promotion of site educational value, 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.

Useful guides/references:

HAINS, B.A. & HORTON, A. 1969: British Regional Geology, Central England. Institute of geological Sciences. HMSO, London.

EARP, J.R. & TAYLOR, B.J. 1986: Geology of the country around Chester and Winsford. Memoir of the British Geological Survey, Sheet 109.

Earth science (P)SSSIs in the Natural Area:

- Alderley Edge
- Aqualate Mere
- Dee Cliffs, Farndon
- Frodsham Railway and Road Cuttings
- Grinshill Quarries
- Raw Head
- River Dane
- River Dee (CCW lead)
- River Severn at Montford
- Rostherne Mere
- Sandbach Flashes
- Sweat Mere and Crose Mere
- Tyrley Canal Cutting
- Wybunbury Moss

Natural Area: 80. Staffordshire Uplands	**Geological Significance:** Some **(provisional)**

General geological character: The Staffordshire Uplands Natural Area is composed of Carboniferous aged Westphalian Coal Measures (310 to 300 Ma) sandwiched between the older Namurian millstone grits (around 333-318 Ma) and the younger Triassic rocks (formed around 240 Ma). The Namurian rocks are mainly sandstones, shales and grits deposited in fluvial deltas as a result of the erosion of a rocky upland to the south. The Coal Measures are the remains of organic deposits laid down in a swamp environment and are an economically important mineral resource. The later Triassic rocks, deposited in an arid environment, consist of Bunter Sandstones and Keuper Sandstones (now known collectively as the Sherwood Sandstone Group) and Keuper Marls (now known as the Mercia Mudstone Group). They were transported and deposited by rivers flowing through a relatively arid area, and may represent the results of flash flood events. The Mercia Mudstones are calcareous clays variously interpreted as being laid down in ephemeral lakes, in an inland sea or saline lake; they constitute both the thickest and most extensive of the Triassic deposits in the area, giving rise to a subdued and generally low lying landscape. Although the Natural Area was almost certainly covered by glaciations in the early Quaternary (the last 2 million years), there is little landform evidence of this episode. The area was probably not glaciated during the last (Devensian) glaciation but shows evidence of intense periglacial (tundra) conditions in the form of ice wedge casts, sediment wedge polygons, solifluction and slope deposits.

Key geological features:

- Carboniferous stratigraphy including Coal Measures and gritstones
- Exposures of Triassic rocks
- Quaternary landform evolution of the central Pennines

Number of GCR sites:

Namurian of England and Wales: 1 Westphalian: 3 Permian-Triassic: 1
Pleistocene/Quaternary of the Pennines: 1

Geological/geomorphological SSSI coverage: There are 5 (P)SSSIs in the Natural Area covering 6 GCR SILs and 4 different GCR networks. Gannister Quarry SSSI is an example of the Namurian (320 million years old) sediments, showing the sequence of sandstones and shales deposited at this time. Metallic Tileries, Parkhouse SSSI shows the composition of the mid Carboniferous Westphalian coal measures and their association with the Permian-Triassic rocks. The Permian-Triassic stratigraphy is shown at Hulme Quarry SSSI where the fluvial Bunter Pebble Beds (the Sherwood Sandstone Group) are well exposed. This site is also important for the insight into Triassic palaeoenvironments. Exposures at Cawdor Quarry on the show the youngest Carboniferous Limestone. Periglacial erosion is important at Wyns Tor, a number of tors formed in dolomitic Carboniferous Limestone.

Key geological management issues:

- Management of existing geological sites to safeguard exposures of Carboniferous, Triassic and Quaternary sediments
- Lack of exposures in Triassic sandstones and marls
- Potential conflict between mineral extraction industry, landfill and geological conservation

Key geological objectives:

1. Maintain and where possible enhance the existing geological exposures by agreeing management plans with owners and occupiers

2. Negotiating long-term conservation of exposures with mineral extraction companies at key geological sites

3. Encourage the creation and recording of both temporary and permanent exposures in the poorly-exposed Triassic sediments of the area as part of road schemes and other developments

Useful guides/references:

AUDLEY-CHARLES, M.G. 1992: Triassic. *In* DUFF, P.McL.D. and SMITH, (eds). Geology of England and Wales. The Geological Society, London.

SYLVESTER-BRADLEY, P.C. & FORD, T.D. (eds) 1968: The Geology of the East Midlands. Leicester University Press.

Earth science (P)SSSIs in the Natural Area:

- Gannister Quarry
- Cawdor Quarry
- Metallic Tileries, Parkhouse
- Hulme Quarry
- Wyns Tor

Natural Area: 81. Upper Trent Valley	Geological Significance: Some (provisional)

General geological character: The Upper Trent Valley Natural Area is dominated by rocks of Triassic age, formed around 240 Ma. Thet were deposited in an arid environment and consist of Bunter Sandstones and Keuper Sandstones (now known collectively as the Sherwood Sandstone Group) and Keuper Marls (now known as the Mercia Mudstone Group). These rocks were transported and deposited by rivers in a relatively arid environment, possibly during flash floods. The Mercia Mudstones are calcareous clays variously interpreted as the product of deposition in ephemeral lakes, in an inland sea or saline lake; they constitute both the thickest and most extensive of the Triassic deposits in the area, giving rise to a subdued and generally low lying landscape. To the north of the Natural Area, older Carboniferous Coal Measures (310 to 300 Ma) appear sandwiched between the older Namurian millstone grits (around 333-318 Ma) and the younger Triassic rocks. The Namurian rocks are mainly sandstones, shales and grits deposited in fluvial deltas as a result of the erosion of a rocky upland to the south. The Coal Measures are the remains of organic deposits laid down in a swamp environment and are an economically important mineral resource in the area. Although the Natural Area was almost certainly covered by glaciations in the early Quaternary (the last 2 million years), there is little landform evidence of this episode. The area was marginal to the last (Devensian) glaciation and shows evidence of intense periglacial conditions in the form of ice wedge casts, sediment wedge polygons, solifluction and slope deposits. The changing climate over this time is also recorded in the various river gravel terraces of the River Trent.

Key geological features:

- Carboniferous stratigraphy including Coal Measures and gritstones
- Exposures of Triassic rocks
- Quaternary landform evolution of the central Pennines

Number of GCR sites:

Quaternary of the Midlands: 1

Geological/geomorphological SSSI coverage: There is only 1 (P)SSSI in the Natural Area representing the Quaternary of the Midlands GCR network. Hilton Gravel Pits SSSI is the type site for the Hilton Terrace of the River Trent, a gravel assemblage of both fluvial and fluvioglacial composition. The gravels are famous for the Palaeolithic artefacts they have yielded and for the evidence they provide about the changing environments in the Quaternary.

Key geological management issues:

- Management of existing geological sites to safeguard exposures of Carboniferous, Triassic and Quaternary sediments
- Lack of exposures in Triassic sandstones and marls
- Potential conflict between mineral extraction industry, landfill and geological conservation

Key geological objectives:

1. Maintain and where possible enhance the existing geological exposures by agreeing management plans with owners and occupiers

2. Negotiating long-term conservation of exposures with mineral extraction companies at key geological sites

3. Encourage the creation and recording of both temporary and permanent exposures in the poorly-exposed Triassic sediments of the area as part of road schemes and other developments

Useful guides/references:

AUDLEY-CHARLES, M.G. 1992.:Triassic. *In* DUFF, P.McL.D. and SMITH, A.J. (eds.) Geology of England and Wales. The Geological Society, London.

SYLVESTER-BRADLEY, P.C. & FORD, T.D. (eds) 1968: The Geology of the East Midlands. Leicester University Press.

Earth science (P)SSSIs in the Natural Area:

- Hilton Gravel Pits

Natural Area: 82. Derwent Valley	**Geological Significance:** Some **(provisional)**

General geological character: The Derwent Valley Natural Area is dominated by Carboniferous rocks; bounded to the west by Dinantian Carboniferous Limestone (approximately 350-333 Ma) which is overlain by the Namurian Millstone Grit (approximately 333-318 Ma) and bounded to the east by the Westphalian Coal Measures (approximately 318-303 Ma). This sequence of limestones and sandstones produces the typically high topography of the area.

The Carboniferous Period was initially dominated by shallow tropical seas lapping against the Derbyshire High. The resultant development of extensive carbonate reefs and mudbanks lead to the widespread deposition of the fossiliferous Carboniferous Limestone. During Namurian times a river delta sequence advanced across the area from the north depositing a thick sequence of sandstones, the Millstone Grit, interrupted by occasional marine shales associated with local delta retreat and sea level rise. Fluvial conditions persisted into the Westphalian when the development of swamps in the tropical climate lead to the accumulation of vast quantities of plant material which was eventually compressed to form coal.

Late Carboniferous uplift, folding and faulting has meant the area has been subject to erosion rather than deposition for much of its subsequent history. Between the Carboniferous and the Jurassic joints and faults acted as conduits for mineral-rich brines leading to complex mineralisation of areas of limestone. The same joints and faults (and also bedding planes) have been eroded to form complex and extensive cave systems in excess of three kilometres in length. The relationship between cave development and Pleistocene climate is also demonstrated, the sequence of cave levels in Stoney Middleton Dale being related to rejuvenation of the River Derwent. There is only clear evidence for glaciation of the area during the Lower Pleistocene, associated boulder clays ('Older Drift') capping hills. During the Upper Pleistocene the area was certainly subjected to extreme periglacial erosion forming a number of Millstone Grit tors in the north and dolomitic tors in the Matlock area.

Key geological features:

- Carboniferous stratigraphy and palaeoenvironments
- Mineralisation of Carboniferous Limestone
- Periglacial erosion, cave and karst development
- Modern fluvial geomorphology of the River Derwent

Number of GCR sites:

Westphalian: 2 Mineralogy of the Peak District, Leicestershire and Cheshire: 1

Geological/geomorphological SSSI coverage: There are 2 (P)SSSIs in the Natural Area covering 3 GCR SILs representing 2 different GCR networks. In the southeast of the area Ambergate and Ridgeway Quarries expose rocks belonging to the lowermost Coal Measures, notably the Crawshaw Formation which to the east forms an important gas and oil reservoir. Mine dumps at Fall Hill expose Carboniferous Limestone mineralisation notably fault associated mineralisation

Key geological management issues:

- Conservation in working quarries (eg. Ambergate)
- Conservation of mine dumps
- Site assessment, new sites (e.g. new quarries and cuttings)
- Promotion of the value of the geological resource

Key geological objectives:

1. Maintenance and enhancement of the geological resource through a) enhancement of existing exposures and agreed conservation in working quarries, b) development of local conservation strategies that include geology, c) continued assessment of educational/research value of new sites (eg. quarries and cuttings, temporary or permanent).

2. Promotion of geological resource through a) assessment and promotion of site educational value, b) on-site interpretation (eg. sign boarding, trail guides, leaflets), c) promotion of the link between geology, local habitats and scenery.

Useful guides/references:

FROST, D.V. & SMART, J.G. O. 1979: Geology of the country north of Derby. Memoir of the Geological Survey of Great Britain. Sheet 125.

SMITH, E.G., Rhys, G.H. & EDEN, R.A., 1967: Geology of the country around Chesterfield, Matlock and Mansfield. Memoir of the Geological Survey of Great Britain. Sheet 112.

STEVENSON, I.P. & GAUNT, G.D. 1971: Geology of the country around Chapel en le Firth. Memoir of the Geological Survey of Great Britain. Sheet 99.

Earth science (P)SSSIs in the Natural Area:

- Ambergate and Ridgeway Quarries
- Fall Hill Quarry