Natural Area: 83. White Peak	**Geological Significance:** Outstanding **(provisional)**

General geological character: The White Peak Natural Area is dominated by scenery produced through the erosion of the underlying Lower Carboniferous (Dinantian, 350-333 Ma) limestones. The limestones were originally deposited on the floor of a large tropical sea at this time. They are of a reef facies, marking the southern boundary of a large sedimentary basin which was later filled by the Millstone Grit delta complex (Namurian, 333-318 Ma). In places, the limestones show evidence of igneous activity during the Variscan Orogeny in the form of lavas and sills which are used in the correlation of these rocks. The capping of the Carboniferous limestone by the Millstone Grit also created a natural trap for mineralising fluids which precipitated minerals such as galena, sphalerite and fluorite into joints within the limestone. These remain today as mineral 'rakes'.

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 not glaciated during the last (Devensian) glaciation but shows evidence of intense periglacial conditions in the form of ice wedge casts, sediment wedge polygons, solifluction and slope deposits. Surface water flowing over the permanently frozen ground at this time cut many deep valleys into the limestone, and these form the dry valleys and dales which now characterise the Natural Area. In warmer interglacial periods over the last 2 million years, drainage of the area has occurred mainly underground through the porous limestone. This has lead to the development of intricate cave systems which are still evolving under present day conditions.

Key geological features:

- Geological exposures showing Carboniferous stratigraphy
- Karst features such as cave systems and dry valleys
- Mineralisation of the Carboniferous Limestone
- Geological influence on the White Peak landscape and scenery

Number of GCR sites:
Dinantian of North England and Wales: 12 Mineralogy of the Peak District, Leics. and Cheshire: 8 Karst: 5 Pleistocene Vertebrata: 3 Caves: 5 Permian-Carboniferous Igneous: 3 Mass Movement: 1 Pleistocene/Quaternary of the Pennines: 1 Tertiary Palaeobotany: 1 Namurian: 1 Permian-Carboniferous Fish/Amphibia: 1

Geological/geomorphological SSSI coverage: There are 28 (P)SSSIs in the Natural Area, covering 41 GCR SILs representing 11 different GCR networks. This coverage is dominated by exposures of the Carboniferous (Dinantian) rocks at sites such as Brownend Quarry SSSI and Caldonlow Quarry SSSI. Both these sites show aspects of the Dinantian stratigraphy, including the reef limestones of the area. Portway Mine SSSI is a good example of the mineralisation of the Dinantian rocks, showing the relationship between the minerals and the later karst erosion of the limestones. Wye Dale and Monsal Dale is a good example of a multi-interest SSSI, with a large mass movement interest at Hob's House, and exposures of the Carboniferous Limestone and Permian-Carboniferous Igneous lava flows within them. Upper Lathkill SSSI is a fine example of a karst landscape, with a well developed dry valley and cvae system. Hamps and Manifold Valleys SSSI also contains an extensive cave system and rock shelters within the valley such as Elderbush Cave are the location of important Pleistocene vertabrate remains including lemming, reindeer and hyaena. Mine dumps at Smalldale Pipe expose Carboniferous Limestone mineralisation notably fluorite-barite replacement of limestone. Bradwell Dale and Bradshaw Cavern and Stoney Middleton Dale both contain complex cave systems approaching 3km in length, the former is particularly noted for its straw stalactites and the latter distinct levels associated with the development River Derwent.

Key geological management issues:

- Need to maintain geological exposures within the Natural Area
- Potential conflict between conservation, quarrying, landfill and landscape issues in the NP
- Threats to underground cave systems from overuse or misuse by caving
- Need to ensure responsible fossil and mineral collecting

Key geological objectives:

1. Maintain and enhance the geological resource in the Natural Area by (a) safeguarding all existing geological exposures, (b) promoting the links between geology and scenery in the National Park, and (c) assessing new geological exposures in temporary or permanent sections.

2. Encourage local caving groups to produce cave conservation plans for the cave systems in the area

3. Encourage liasion with quarrying and mining industry to reduce threats to geological sites located in quarries and mines.

Useful guides/references:

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

FORD, T. & GUNN, J. 1990: Caves and Karst of the Peak District. BCRA Cave Studies Series Number 3. BCRA, London.

Earth science (P)SSSIs in the Natural Area:

- Bage Mine
- Bailey Croft Mine
- Bees Nest and Green Clay Pits
- Bradwell Dale and Bagshaw Cavern
- Brownend Quarry
- Caldonlow Quarry
- Calton Hill
- Cauldron Railway Cutting
- Colehill Quarries
- Cressbrook Dale
- Dale Quarry
- Dove Valley and Biggin Dale
- Duchy Quarry
- Fox Hole Cave
- Green Lane Pits
- Hamps and Manifold Valleys
- Kirkhams Silica Sandpit
- Lathkill Dale
- Magpie Mine
- Masson Hill and Masson Hill Mines
- Poole's Cavern and Grin Low Wood
- Portway Mine
- Smalldale Pipe
- Stoney Middleton Dale
- Tideswell Dale
- Upper Lathkill
- Waterswallows Quarry
- Wye Dale and Monsal Dale

Natural Area: 84. South West Peak	**Geological Significance:** Some **(provisional)**

General geological character: The South West Peak Natural Area is dominated by scenery produced through the erosion of the underlying Carboniferous (Namurian, 333-318 Ma) Millstone Grit Series. The Millstone Grit is part of a great arch-like structure in the rocks, which forms the 'backbone' of the southern Pennines at this point. The grit consists of a cyclic succession of marine bands in shales, siltstones, and cross-bedded sandstones. These represent river sediments deposited onto delta slopes (eg. the Roaches Grit) during delta migration and the deposits of delta tops Intermittent rises in sea level inundated these deposits, and the marine fossils (such as goniatites) which they contain are important for the stratigraphical correlation of these rocks. Following the marine inundation, further delta migration deposited large gritstone masses which now characterise much of the area in the form of edges and tors.

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 not glaciated during the last (Devensian) glaciation but shows evidence of intense periglacial conditions (in a tundra environment) in the form of ice wedge casts, sediment wedge polygons, solifluction and slope deposits. Tors formed on many summits as a result of deep chemical weathering in preglacial and interglacial times. A feature of many of the gritstone edges is the development of large screes and massive landslips, many of which are still active. The landslips are controlled by the impervious and incompetent nature of the shales and siltstones which underlie the gritstones. Today, much of the upland area of the South West Peak is covered by peat deposits up to 2 metres in depth.

Key geological features:

- Exposures of Namurian Millstone Grit
- Millstone Grit edges and tors
- Geological control on landslips and landslides

Number of GCR sites:

Namurian: 3 Westphalian: 2 Mass Movement: 1

Geological/geomorphological SSSI coverage: There are two (P)SSSIs in the Natural Area, covering 6 separate GCR SILs representing 3 different GCR networks. Goyt Valley SSSI shows important exposures of the Westphalian rocks, in particular the base of the economically important Staffordshire coal measures. Leek Moors SSSI is a large moorland area important for the exposures of Namurian Roaches Grit in the edges and tors. In particular, there are well developed marine goniatite bands in the grit here, which can be used for correlation with other Namurian deposits. There are also extensive landslips developed on the gritstone edges, including the famous Lud's Church mass movement site.

Key geological management issues:

- Management of existing sites to enhance and promote the geological exposures within the Natural Area.
- Promoting and publicising the geological heritage within the Peak National Park and surrounding area.

Key geological objectives:

1. Maintain and enhance existing geological exposures and natural processes within the Natural Area by encouraging on-site interpretation in this popular scenic and recreational area.

2. Encourage initiatives aimed at joint management of the geological and biological resources in the Natural Area.

Useful guides/references:

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

Earth science (P)SSSIs in the Natural Area:

- Goyt Valley
- Leek Moors

Natural Area: 85. Dark Peak	**Geological Significance:** Considerable **(provisional)**

General geological character: The Dark Peak Natural Area is dominated by scenery produced through the erosion of the underlying Carboniferous (Namurian, 333-318 Ma) Millstone Grit Series. The Millstone Grit is part of a great arch-like structure in the rocks, which forms the backbone of the southern Pennines at this point. The grit consists of a cyclic succession of marine bands in shales, siltstones, and cross-bedded sandstones. These represent river sediments deposited onto both delta slopes (eg. the Mam Tor Sandstones) during delta migration and delta tops (eg. Kinderscout Grit). Intermittent rises in sea level inundated these deposits, and the marine fossils, such as goniatites, which they contain are important for the stratigraphical correlation of these rocks. Following the marine inundation, further delta migration deposited large gritstone masses which now characterise much of the area in the form of edges and tors. The lower beds of the Coal Measures, which lie above the grits in the folded rock sequence, outcrop in small areas to the east and west of the Natural Area. These deposits were laid down on a wide, meandering river plain which was occasionally inundated by the sea. In the south of the Natural Area, a small area of older Lower Carboniferous (Dinantian, 350-333 Ma) limestone outcrops at the core of the fold. The limestones are of a reef facies, marking the southern boundary of the basin which was later filled by the Millstone Grit delta complex. The capping of the Carboniferous limestone by the Millstone Grit created a natural trap for mineralising fluids which precipitated minerals such as galena, sphalerite and fluorite into joints within the limestone.

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 not glaciated during the last (Devensian) glaciation but shows evidence of intense periglacial conditions in the form of ice wedge casts, sediment wedge polygons, solifluction and slope deposits. Tors formed on many summits as a result of deep chemical weathering in preglacial and interglacial times. A feature of many of the gritstone edges is the development of large screes and massive landslips, many of which are still active. The landslips are controlled by the impervious and incompetent nature of the shales and siltstones which underlie the gritstones. Today, vast areas of the upland Dark Peak are covered by peat deposits up to 2 metres in depth. The peats developed in blanket bogs during the Holocene (the last 10,000 years). Remains of alder and birch preserved at the base of the peat deposits demonstrate that the tops of the area were once wooded.

Key geological features:

- Upper Carboniferous stratigraphy and sedimentology
- Landslips and their geological context
- The development of the underground cave system in limestone areas
- Quaternary (Pleistocene and Holocene) development of the Pennines

Number of GCR sites:

Namurian: 8 Mass Movement: 4 Pleistocene/Quaternary of the Pennines: 3
Dinantian of Northern England and Wales: 2 Fluvial Geomorphology of England: 3 Karst: 2
Mineralogy of the Pennines: 2 Caves: 1 Pollen Stratigraphy of England: 1 Westphalian: 1

Geological/geomorphological SSSI coverage: There are 14 (P)SSSIs in the Natural Area covering 27 GCR SILs representing 10 different GCR networks. Most sites relate to the Namurian and Mass Movement networks. The exposures of the Upper Carboniferous rocks are mainly in stream sections and river cliffs (eg. Little Don Stream Section SSSI), and in exposures cretaed by landslips (eg. Mam Tor GCR site in the Castleton SSSI). Castleton SSSI also provides a superb example of landslips in the form of the Mam Tor rotational landslide as well as the development of undeground drainage in the Castleton Area cave system. The most recent Quaternary landscape evolution and environmental changes are shown in the peat and pollen remains preserved at sites such as Hathersage Moor SSSI. The recent damming of the Ladybower Reservoir has had significant affects on the River Derwent producing a number of complex fluvial geomorphological features in response to changing discharge and sediment levels.

Key geological management issues:

- Management of existing sites to enhance and promote the geological exposures within the Natural Area.
- Promoting and publicising the geological heritage within the Peak National Park

Key geological objectives:

1. Maintain and enhance existing geological exposures and natural processes within the Natural Area by encouraging on-site interpretation in this poular scenic and recreational area.

2. Encourage initiatives aimed at joint management of the geological and biological resources in the Natural Area.

Useful guides/references:

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

Earth science (P)SSSIs in the Natural Area:

- Canyards Hills
- Castleton
- Dark Peak
- Dirtlow Rake and Pindale
- Eastern Moors
- Edale
- Harewood Grange Stream Section
- Hathersage Moor
- Little Don Stream Section
- Ludworth Intake
- Rake Dike
- Jumble Coppice
- River Derwent at Hathersage
- Rowlee Bridge

Natural Area: 86. Urban Mersey Basin	**Geological Significance:** Notable **(provisional)**

General geological character: The Urban Mersey Basin Natural Area is dominated by low lying Triassic sandstones and siltstones in the west, largely concealed by glacial clays, sands and gravels. In the east the Carboniferous rocks of the Lancashire Coalfield dominate producing the main area of high ground in the area.

The oldest rocks found in the area belong to the Upper Carboniferous Westphalian (318-303 Ma). A sequence of sandstones, siltstones and coals deposited in an estuarine environment occasional inundated by rising sea levels. Extensive swamps developed in the tropical Carboniferous climate, prolonged accumulation of plant debris leading to the eventual formation of coal. The area was affected by folding and faulting towards the end of the Carboniferous (Hercynian Orogeny) and it wasn't until the Upper Permian (approximately 255 Ma) that rising sea levels once more lead to deposition in the area. Isolated outcrops of marine Permian sediments are found resting unconformably on the on the western edge of the Lancashire Coalfield, these are overlain by red Triassic sandstones and siltstones which dominate the rest of the area. The Triassic Period was dominated by continental deposition in an arid desert-like climate. It comprises two Groups; the Sherwood Sandstone Group (including the Kinnerton Sandstone, Chester Pebble Beds and Wilmslow Sandstone Formations) which was dominantly fluvial (braided river) in origin and the Mercia Mudstone Group (including the Tarporley Siltstone Formation)which is interpreted as becoming increasing intertidal in influence. Elsewhere Sherwood Sandstone rocks have yielded early reptile remains (skeletal and trace fossil), and recent footprint discoveries at Hilbre Island confirm the potential these rocks have for such finds. No younger Mesozoic or Tertiary rocks are known and it is likely that the area was a positive feature during the succeeding period.

The Triassic sequence underwent extreme denudation during the Pleistocene when the area was glaciated, ice sheets approaching southwards down the Irish Sea. Much of the low lying area is covered in glacial boulder clay, sands and gravels with erratics clearly originating from the Lake District and the Southern Uplands. Following the last glaciation rivers such as the Dee and the Mersey have adjusted their courses, sea levels have fluctuated but overall risen and erosion rates have remained high. Coastal features include sand dunes and associated sand bars.

Key geological features:

- Carboniferous Westphalian sequence - 'Coal Measures'(economic importance of Lancashire Coalfield)
- Isolated Upper Permian outcrops
- Triassic sandstones and siltstones
- Triassic reptile remains.
- Pleistocene and recent sediments and landforms.

Number of GCR sites:

Westphalian: 3 Permian-Triassic: 3 Holocene sea-level: 1 Coastal Geomorphology of England: 1

Geological/geomorphological SSSI coverage: There are 8 (P)SSSIs in the Natural Area covering 8 GCR SILs and representing 4 different GCR networks. Thurstaston Common SSSI exposes the Sherwood Sandstone Group and the Dungeon and Red Brow Cutting reveals rocks belonging to the Mercia Mudstone Group. Westphalian rocks are exposed at Lowside Brickworks, Tonge River Section and Ashclough (the last being the type exposure of the Ashclough Marine Band). Downholland Moss exposes a recent alternating tidal-marine environment documenting sea level changes between 8,000-4,000 years BP. Sand dunes are best exposed at Ainsdale.

Key geological management issues:

- Long-term degradation of inland sites.
- Threats to sites from development.
- Threats to coastal sites from protection works

Key geological objectives:

1. Integrate SSSI and RIGS system. Continued assessment of resource through recording and conservation of temporary and permanent exposures (eg. Hilbre Island).

2. Ensure geological conservation policies are included in local plans.

3. Adoption of geological policies in Shoreline Management Plans and maintenance of natural coastal processes.

4. Promotion of the link between geology, habitat and landscape and the link between geology and economic exploitation.

Useful guides/references:

BROADHURST, F.M., *et al.*, 1970: The area around Manchester. Geologists' Association Guide No. 7.

EDWARDS, W. & TROTTER, F.M. 1954: British Regional Geology, The Pennines and adjacent areas Geological Survey. HMSO. London.

JONES, R.C.B., *et al.*, 1938: The geology of the Wigan district. Memoir of the Geological Survey, England and Wales.

SOMERVILLE, I.D., *et al.*, 1986: Geology around the university towns: Liverpool. Geologists' Association Guide No. 6.

WEDD, C.B., *et al.*, 1923: The geology of Liverpool. Memoir of the Geological Survey, England & Wales (Sheet 96).

Earth science (P)SSSIs in the Natural Area:

- Ainsdale Sand Dunes
- Ashclough
- Downholland Moss
- Tonge River Section
- Lowside Brickworks
- Red Brow Cutting
- The Dungeon
- Thurstaston Common

Natural Area: 87. Lancashire Plain & Valleys	**Geological Significance:** Considerable **(provisional)**

General geological character: The solid geology of the Lancashire Plain and Valleys Natural Area is dominated by late Carboniferous sediments, which represent a transition from marine to non-marine (i.e. swamp) conditions, around 330-295 million years ago. The Natural Area includes the Ribble Valley and this divides the neighbouring Forest of Bowland Natural Area in two at this point. The Carboniferous rocks are divided into the following sequence: Carboniferous Limestone (Dinantian, 350-333 Ma), Millstone Grit and Shale (Namurian, 333-318 Ma) and Coal Measures (Westphalian, 318-303 Ma). This sequence of rocks indicates the changes in the Carboniferous seas from clear water oceans (limestones), through increasingly muddy seas (shales) to estuaries and river deltas (current-bedded sandstones and grits). The Dinantian rocks are famous for their reef knoll limestones which formed on mud mounds in the Carboniferous sea. Many of the non-marine rocks (the Namurian grits and shales) show the effects of episodic marine inundation in the form of marine bands rich in marine fossils such as bivalves. These bivalves are used in the dating and correlation of events in the Namurian. In the west of the Natural Area the solid geology is dominated by the Triassic rocks, which underlie the coastal plain of West Lancashire. Together with the glacial deposits in the area, these produce a low-lying and subdued landscape. The Triassic rocks are overlain by a thick layer of glacial sands, gravels and clays (known collectively as boulder clays) which were deposited by an unknown number of glaciers and ice sheets which advanced into the area from the Lake District mountains during the Quaternary (the last 2 million years). Large scale glacial landforms in the area include the famous drumlin fields (a collection of streamlined and ice-moulded hills) which indicate the passage of ice sheets over the area.

Key geological features:

- Exposures of Carboniferous rocks and their stratigraphical relationship
- Sites of international importance for Carboniferous palaeontology
- Important fossil localities in Carboniferous Limestone reef knolls
- Glacial deposits and glacial landforms

Number of GCR sites:
Dinantian of North England and Wales: 5 Namurian of England and Wales: 3
Quaternary of the Pennines : 1 Holocene Sea Level: 1 Westphalian: 1

Geological/geomorphological SSSI coverage: There are 10 (P)SSSI in the Natural Area covering 11 GCR SILs and representing 5 different GCR networks. The coverage emphasises the great importance of the Carboniferous (Dinantian and Namurian) sites. Darwen River Section SSSI shows marine bands within the otherwise non-marine Namurian rocks, whilst Ravenhead Brickworks SSSI is renowned for the marine fossils within these marine bands which are used in correlation of Namurian rocks. These include bivalves such as *C. extenuata* (Ravenhead Brickworks). Sites such as Clitheroe Knoll Reefs SSSI, Coplow Quarry SSSI and Salthill and Belmanpark Quarries SSSI are particularly noted for their exposures of the knoll reef limestones which formed on mud mounds in the Carboniferous sea. Mere Sands Wood SSSI is an important Quaternary site, showing the composition of the coversands (wind blown sands) which developed in the area during the Late Devensian. A more recent Quaternary site is that at Lytham Coastal Changes SSSI where Holocene (the last 10,000 years) changes in sea level can be reconstructed using the sequence of marine silts and terrestrial peats.

Key geological management issues:

- Maintaining and enhancing the exposures of Carboniferous rocks in the Natural Area by limiting site degradation due to landfill and vegetation growth
- Poor condition of many internationally important sites.

Key geological objectives:

1. **Promote and enhance the geological resource** in the Natural Area using appropriate site management clearances

2. **Maintain the natural processes in both rivers and coastal zone** within the Natural Area

3. **Ensure access is maintained to sites of international importance.**

Useful guides/references:

EDWARDS, M.A. & TROTTER, F.M. 1954: British Regional Geology, Pennines and adjacent areas. Institute of Geological Sciences. HMSO. London.

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

Earth science (P)SSSIs in the Natural Area:

- Clitheroe Knoll Reefs
- Coplow Quarry
- Darwen River Section
- Harper Clough & Smalley Delph Quarries
- Hodder River Section
- Lytham Coastal Changes
- Salthill and Bellmanpark Quarries
- Mere Sands Wood
- Stonehead Beck (Gill Beck)
- Ravenhead Brickworks

Natural Area: 88. Forest of Bowland	**Geological Significance:** Notable **(provisional)**

General geological character: The Forest of Bowland Natural Area is dominated by Carboniferous Limestone forming an open and rugged upland area. To the east, the Westphalian rocks of Pendle Hill are included as an outlier of the Natural Area and these are separated from the main portion by the Ribble Valley. The Carboniferous rocks are divided by geologists into the following sequence: Carboniferous Limestone (Dinantian, 350-333 Ma), Millstone Grit and Shale (Namurian, 333-318 Ma), and Coal Measures (Westphalian, 318-303 Ma). Of these rocks, the limestones and grits are primarily responsible for the character of the Natural Area. The Lower Carboniferous rocks include the knoll reefs (formed as mud mounds in the Carboniferous seas) famous for their rich echinoderm faunas, although these are better exposed in the adjacent Lancashire Plain and Valleys Natural Area. Pendle Hill forms a distinctive landform to the east of the Natural Area, with a steep escarpment capped by Millstone Grit. Higher levels include the Bowland Shale, famous for its goniatite fossils which are important in the stratigraphic correlation of these rocks across the area. During the Quaternary (the last 2 million years), successive glaciations have left variable thicknesses of glacial sands, gravels and clays spread across the older bedrock. The present day surface streams contain important information about the post-glacial (the last 10,000 years) environmental changes in the area, and about the development of drainage patterns in upland areas.

Key geological features:

- Exposures of Dinantian and Namurian rocks
- Global Stratotype Section and Point for the Pendleian Stage
- Development of river systems in this upland area

Number of GCR sites:

Dinantian of Northern England and Wales: 1 Namurian of England and Wales: 3
Fluvial Geomorphology of England: 1

Geological/geomorphological SSSI coverage: There are 4 (P)SSSIs in the Natural Area, covering 5 GCR SILs and representing 3 different GCR networks. The majority of the SSSIs are those showing the nature and structure of the Carboniferous (Namurian) rocks exposed on the flanks of Pendle Hill. Light Clough SSSI is recognised globally as defining the Pendleian Stage division of the Carboniferous (c. 333-331Ma) through a UNESCO project. Cock Wood Gorge SSSI is renowned for the marine fossils within these marine bands which are used in correlation of Namurian rocks. These include bivalves such as *Sanguinolites* (Cock Wood Gorge). Bowland Fells SSSI is a site important for its fluvial geomorphology, showing the recent development of alluvial fans, river bank erosion and channel changes since deglaciation.

Key geological management issues:

- Need to safeguard and maintain exposures in man-made quarries and cuttings
- Potential conflict between mineral extraction industry, landfill and conservation
- Promoting the geological heritage of this upland scenic area

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. Encouraging the creation and recording of both temporary and permanent exposures in the area as part of road schemes and other developments

4. Encouraging responsible fossil collecting at vulnerable sites

Useful guides/references:

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

Earth science (P)SSSIs in the Natural Area:

- Bowland Fells
- Cock Wood Gorge
- Light Clough
- Little Mearley Clough

Natural Area: 89. Cumbrian Fells and Dales	**Geological Significance:** Outstanding **(provisional)**

General geological character: The rocks of the Lake District provide an outstanding sequence of lower Palaeozoic (570 to 408 Ma) rocks and is especially noted for its Ordovician (464 to 439 Ma) and Silurian (439 to 408 Ma) rocks. These form a dome like structure, and are surrounded on their outer margins by younger Carboniferous limestones (aged around 340 Ma). The lower Palaeozoic is represented by slates, sandstones, limestones and volcanic rocks such as lavas and tuffs. These have subsequently been altered and deformed by movements of the Earth's crust during a mountain building period known as the Caledonian Orogeny in the late Silurian. Extensive metallic mineralisation occurs throughout the area associated with both the late Caledonian granite bodies and Carboniferous crustal extension. The Lake District mountains have been strongly affected by the major Quaternary 'Ice Ages' (over the last 2 million years), and erosion by several ice sheets has used the geology as a structural template, carving out its familiar deep valleys and troughs. The more resistant rocks such as the Borrowdale Volcanics now form the highest points in the Lake District as at Helvellyn. The limestone areas support caves and other classic karst landforms such as limestone pavements.

Key geological features:

- Upland exposures of deformed and fossiliferous lower Palaeozoic sequences
- Exposures of igneous rocks such as Borrowdale Volcanics Group
- Glacial erosional and depositional landforms and scenery
- Cave and karst features including limestone pavement

Number of GCR sites:

Mineralogy of the Lake District: 19 Ordovician Igneous: 14 Caledonian Structures of the Lake District: 11 Pleistocene/ Quaternary of Cumbria: 11 Dinantian of North England and Wales: 11 Karst: 5 Llandovery: 4 Caradoc-Ashgill: 3 Permian-Carboniferous Igneous: 3 Caledonian Igneous: 3 Wenlock: 2 Arenig-Tremadoc: 2 Fluvial Geomorphology of England: 2 Pollen Stratigraphy of England: 1 Non-Marine Devonian: 1 Caves: 1 Ludlow: 1 Permian-Triassic: 1

Geological/geomorphological SSSI coverage: There are 70 geological/geomorphological (P)SSSIs in the Natural Area, covering 95 GCR SILs and representing 18 different GCR nrtworks. This shows the remarkable geological diversity of the Natural Area. The importance of the Lake District mineralogy is illustrated by sites such as Coniston Copper Mines and Seathwaite Graphite Mine. Events during the lower Palaeozoic are shown by exposures at Ray and Crinkle Crags whilst the structural geology is illustrated by sites such as Tebay Road Cuttings. Later sedimentary rocks such as the Carboniferous limestones are shown in the important exposures at Great Asby Scar. The effects of the Quaternary glaciations on the Lake Districy scenery are shown by sites such as the glacially scoured Farleton Knott and the impressive accumulations at Wasdale Screes.

Key geological management issues:

- Maintain and enhance existing geological exposures and fluvial systems
- Agree conservation sections in working quarries
- Promote the heritage value of mineral sites
- Conservation of sensitive cave and karst sites

Key geological objectives:

1. Maintainance and enhancement of the geological resource through a) targetted site clearance, b) agreeing conservation faces in working quarries and c) protecting cave and karst features

2. Promotion of the geological resource of the Lake District using opportunities for site interpretation

3. Encourage links with Lake District scenic appeal, tourism and mining heritage.

Useful guides/references:

BOARDMAN, J. & WALDEN, J. 1994: Cumbria Field Guide. Quaternary Research Association, London.

COOPER, M.P. & STANLEY, C.J. 1990: Minerals of the English Lake District - Caldbeck Fells. British Museum (Natural History), London.

MOSELEY, F. 1978: The Geology of the Lake District. Yorkshire Geological Society Publication 3.

Earth science (P)SSSIs in the Natural Area:

- Carlingill
- Ash Fell Edge
- Backside Beck and Spen Gill
- Armboth Fells
- Bothel Craggs Quarry
- Bowness Knott
- Bramcrag Quarry and Wanthwaite Mine
- Browgill and Stockdale Becks
- Buttermere Fells
- Coombe Beck
- Eycott Hill
- Gill Beck
- Hawes Water
- Coniston Copper Mines
- Ashgill Quarry
- Barker Scar
- Beckfoot Quarry
- Birk Fell Hawse Mine
- Blea Tarn
- Blelham Tarn and Bog
- Brathay Quarries
- Buckbarrow Beck
- Coniston
- Farleton Knott
- Gait Barrows
- Hale Moss Caves
- Little Asby Scar and Potts Valley
- Great Asby Scar
- Langdale and Bowderdale
- Thornsgill Beck, Mosedale Beck and Wolf Crags
- Nab Gill Mine
- Pets Quarry
- Pinskey Gill
- Pooley Bridge Section
- Ray and Crinkle Crags
- River Calder Section
- Rosthwaite Fell
- Sandbeds Fan
- Scandal Beck and Stone Gill
- Seatoller Wood, Sourmilk Gill and Seathwaite Graphite Mine
- Shap Fell Road Cuttings
- Shap Fells
- Side Pike
- Skelghyll Beck
- Skiddaw Group

- Stenkrith Beck
- Stile End
- Tebay Road Cuttings
- Thrang Quarry
- Throstle Shaw
- Wasdale Screes
- Wast Water
- Florence Mine
- Yeathouse Quarry
- Helvellyn and Fairfield
- Hollows Farm Section
- Honister Crag
- Humphrey Head
- Hutton Roof Crags
- Iron Pit Spring Quarry
- Jumb Quarry Kentmere
- Little Mell Fell Quarry
- Low Wray Bay
- Meathop Woods and Quarry
- Naddle Forest
- Seathwaite Copper Mines
- Trowbarrow Quarry
- Waberthwaite Quarry
- Water Crag
- Yewdale Beck

Natural Area: 90. Eden Valley	**Geological Significance:** Notable **(provisional)**

General geological character: The Eden Valley Natural Area is bounded to its eastern side by a complex of faults (the Pennine Fault) downthrust to the west. These bury the Carboniferous rocks of the North Pennines under a cover of Permian and Triassic conglomerates, sandstones, marls and evaporites. The rocks dip gently across the Eden Valley, bringing the Carboniferous limestones back to the surface in the west of the Natural Area. The Pennine Fault brings Lower Palaeozoic rocks to the surface. This is a result of the Variscan Orogeny (between 380 and 300 Ma), when reverse faulting raised the rock strata on the western side of the fault and the overlying Carboniferous sediments were stripped away along the eastern side of the valley. Features such as Dufton Pike and Knock Fell Pike are the remains of fault bounded blocks of Borrowdale Volcanics. Some of these faulted inliers are noted for their fossiliferous Ordovician and Silurian marine sediments. Later extensional faulting allowed this eroded surface to subside and become buried by Permian and Triassic sediments. The Permian and Triassic sediments which underlie the centre of the Eden Valley are partly responsible for the relatively low and rolling topography of the area. The Permian rocks are a succession of breccia fans, known as Brockrams, consisting of Carboniferous Limestone clasts eroded from the surrounding areas. These fans are restricted to the margins of the area, whilst other sediments show that the area has been a dune field (Penrith Sandstone), desert lake and, towards the end of the Permian, a shallow marine sea. Thick evaporite sequences developed during this time which are now the location of gypsum mines.

The area was glaciated in the Quaternary ice ages, and much of the solid geology is masked by an even layer of glacial boulder clay. This produces a rich agricultural soil. Much of the current drainage of the area is based upon former glacial drainage patterns.

Key geological features:

- The Pennine Fault and associated Lower Palaeozoic inliers
- Carboniferous Limestones to the east of the Natural Area
- Permian and Triassic rocks in the central plain
- Glacial boulder clay plain

Number of GCR sites:

Caradoc-Ashgill: 4 Permian-Triassic: 4

Geological/geomorphological SSSI coverage: There are 8 (P)SSSIs in the Natural Area covering 8 GCR SILs representing 2 different GCR networks. The Caradoc-Ashgill sites (between 463 and 439 Ma) are important for their palaeontological and stratigraphical interests, containing a number of type site and type sections (eg. Pus Gill SSSI is the type for the Pusgillian stage of the Ashgill Series, Upper Ordovician in age). All the geological sites except one (Keisley Quarry, a man-made exposure) are found in naturally ocurring stream sections. The Permian-Triassic sites (between 256 and 241 Ma) are notable for their stratigraphic and sedimentological importance, and are located either in quarries or stream sections. One in particular (Hilton Beck SSSI) is noted for its Permian plant fossils.

Key geological management issues:

- Management of existing sites to enhance and promote geological exposures within the Natural Area
- Agreement of conservation sections in working quarries
- Assessment of new geological sites in permanent and temporary sections

Key geological objectives:

1. **Maintain and enhance the existing geological exposures and natural processes** within the Natural Area by agreeing conservation sections in working quarries and assessing new sites as appropriate.

2. **Encourage initiatives aimed at the joint management of the geological and biological resources** in the Natural Area and promote the links between geology, habitats and scenery.

Useful guides/references:

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

MOSELY, F. (ed) 1978: The Geology of the Lake District. Yorkshire Geological Society, Leeds.

Earth science (P)SSSIs in the Natural Area:

- Burrells Quarry
- Cowraik Quarry
- George Gill
- Harthwaite Sike
- Hilton Beck
- Keisley Quarry
- Pus Gill
- Swindale Beck