4 The geodiversity of the Limestone Landscapes area

4.1 Major features of geodiversity importance within the area

4.1.1. The rocks themselves:

- The spectacular and varied coastal cliffs in the east provide exposures of Permian-age marine rocks that are without parallel in Britain and most of Western Europe; they are unrivalled for research and teaching purposes.
- Natural sections, cuttings and quarries within the undulating limestone plateau include important rock, mineral and fossil sites, many of which are recognised as SSSIs. A number of the fossil localities are of international significance because they have yielded fossils that are the 'type' material for the scientific classification of a taxonomic group and some of the rock types display the most bizarre geologically interesting structures.

The Permian Magnesian Limestone sequence represents a highly significant chapter in the evolution of the British Isles. Within the study area, it can be seen at its finest localities in Britain justifying it as the type area for the Magnesian Limestone in Britain (Pettigrew, 1980). In addition to the Permian Magnesian Limestone sites, the area also contains sites representing other areas of earth science interest, notably palaeontology, geomorphology and the Quaternary.

The limestone is also of great interest for its range of Permian marine fauna associated with the Ford Formation, particularly within the remains of the Zechstein submarine reef which is considered to be unique in Britain. Key sites for marine fossils are Tunstall Hills, Humbledon Hill and particularly Middridge Quarry in the Marl Slate Formation, which is the most important locality in Britain for Permian fossil reptiles and plants. A number of the fossil localities are of international significance because they have yielded fossils that are the 'type' material for the scientific classification of a taxonomic group.

The spectacular and varied coastal cliffs between Trow Point (South Shields) and Sunderland along with the coastal cliffs at Seaham and Blackhall are mainly in limestones and dolomites in the upper part of the Permian marine sequence. They also furnish magnificent examples of the disruptive effects of evaporite dissolution

(Plate 9) Coastal stacks in the Roker Dolomite Formation seen from Lizard Point.

(Plate 10) Collapse breccia in the cliffs at Marsden Bay.

4.1.2. The direct influence of geology in the shaping the broad landscape:

- The rocks form the foundation upon which the distinctive landscape of the area has been moulded by geological processes. This moulding was largely by glacial action at the beginning of the Quaternary Period from about two million years ago until about 11,500 my ago and, subsequently, by river and coastal processes.
- Durham County Council has undertaken a comprehensive landscape character assessment for that part of the Limestone Landscape area that lies within County Durham (http://www.durham.gov.uk/landscape/usp.nsf/pws/landscape+character+-+County+Character+Areas) showing that it can be divided into four broad landscape types:
    - In the north and to a lesser degree in the south where it merges with the eastern ridges of the Pennine fringe, the Limestone Escarpment is deeply divided by minor valleys giving rise to distinctive 'spur and vale' topography. In its central section it forms a more singular ridge (Plate 11)
    - East of the escarpment, on the Clay Plateau, the limestone is overlain by thick glacial drift and is rarely expressed at the surface.
- Towards the coast — roughly east of the A19 — the Magnesian Limestone crops out more frequently in the low rounded hills and steep-sided coastal denes of the Coastal Limestone Plateau.
- The Limestone Coast, with its cliffs and dunes, is defined inland generally by the coastal railway line.

The four broad landscape types are fundamentally associated with the underlying geology and can be extended across the entire area (see (Figure 2)). The low upland plateau of Magnesian Limestone falls eastwards to the sea and southwards to the Tees plain and defined in the west by a prominent escarpment. The soft Permian rocks that underlie the plateau are covered in most places by a thick mantle of glacial deposits but outcrop on the escarpment and coast. The escarpment is deeply divided in the north forming a spur and vale landscape which becomes less sharply defined in the south and merges with the low eastern ridges of the Pennine fringe. The topography of the plateau is gently undulating and is deeply incised in the east by coastal denes. The coastline is one of clay crested limestone cliffs, giving way in the south to low dunes, with a foreshore of sandy beaches and rock outcrops heavily despoiled in the north by tipping of coal wastes.

4.1.3. Links to biodiversity

- The chemical composition of the limestones and the nature of the thin soils that have formed upon them provide the unique substrate and conditions upon which a variety of specialised habitats can flourish. These include, but are not limited to, the important and well-documented rich and unique group of wildflowers and grasses known as magnesian limestone grassland.

Soils on limestone rock are very nutrient poor and slightly alkaline. As a result only certain plants can survive here. Two-thirds of the UK's remaining magnesian limestone grasslands are found in east Durham and Tyne and Wear. On the Durham Magnesian Limestone some of these limestone-loving plants are at the southern limit of their range and others at their northern limit. The most extensive associated areas of semi-natural grassland occur in south east Tyneside and County Durham, although even here quarrying and agricultural intensification has reduced the overall area with the result that good examples of Magnesian Limestone grassland, as at Pig Hill, tend to be small and fragmented.

The paramaritime Magnesian Limestone vegetation on the Durham Coast is unique in the mix of plant communities which it contains, and is very different from the other lowland areas of the Magnesian Limestone grassland found in County Durham.

The coastal cliffs and other features have particular flora and fauna associated with them due to their unique settings; this includes the Durham 'denes'. The Durham Coast between South Shields and Hart Warren is contains most of the paramaritime Magnesian Limestone vegetation in Britain, as well as a species-rich dune system, and supports nationally important numbers of wintering shore birds and breeding little terns which contribute to the internationally important populations of the north-east coast.

The heavy clay soils that cover much of the plateau support mixed, predominantly arable, farmland in an open rolling landscape of low hedges with few trees. Field patterns are fairly regular in places but more often fragmented by amalgamation into large arable fields. The shallow calcareous soils of the steeper escarpment slopes have a more pastoral emphasis and contain areas of older, more diverse, magnesian limestone grassland. It is almost certainly the abundance of magnesium within the rocks that accounts for the area's characteristic Magnesian Limestone Flora.

Tree cover is sparse and there is little woodland. Ancient semi-natural ash woodlands are found in the coastal denes and occasionally on escarpment spurs and valley sides together with areas of scrub. Cliffs, bays and headlands are rich in wildlife, although despoiled in places by former extensive dumping of colliery waste on beaches and foreshores. Accounts of the link between biodiversity and geodiversity can be found in Dunn (1980), the MAGical Meadows booklet (Durham wildlife Trust, 2007) and SSSI descriptions.

Until the arrival of humans on the magnesian limestone plateau, climatic change was probably the most important factor in determining the vegetation of the natural area. This is supported by evidence from pollen analysis taken from a number of sites that roughly correspond to the distribution of magnesian limestone. From the Mesolithic period onwards, people began to settle in the area and use the land for agricultural purposes. Management became the dominant influence on the vegetation as settlements grew and activities diversified.

As the area was largely covered with ice in the Devensian glaciation little is known about the vegetation prior to the Late Devensian. However, an area of peat, probably transported locally by ice, within the till at Hutton Henry has been dated to the Ipswichian interglacial (Bridgland et al.,1999). This highly compact peat contains a variety of pollen assemblages including those indicative of a pre-forest herbaceous fauna, forest with hornbeam, alder and holly, a period with bog peat and another dominated by heather and birch. Rapidly changing successional vegetation characterized the period of environmental transition and climatic amelioration from 15 000 to 10 000 BP, with a marked vegetation reversion to an open ground tundra herb flora in the cold interlude at the end of the period. In the temperate conditions of the Holocene various trees succeeded each other in the forests until a relatively stable mixture of elm, oak and hazel with birch and pine had established itself. Lime, near the northern limit of its range, became important the lowland limestone area around Bishop Middleham in the mid Holocene.

A lichen flora of natural outcrops, disused quarries and churchyards in the Magnesian Limestone has been described by Gilbert (1984).

4.1.4. The influence that the distribution of the rocks, both at and beneath the surface, has had on human activity and modification of the landscape

The geological distinctness of the plateau has meant that developments have occurred at different times and followed different routes from its surroundings to the north and west, thus giving the area a uniqueness which persists today.

- The rocks and minerals worked, both at the surface and from beneath the ground, have influenced the development and character of towns and villages and the social history of the area. The escarpment and parts of the plateau have been affected by the quarrying of limestone. A number of older quarries that have naturally re-vegetated are managed as nature reserves.
- The rise and fall of the coal mining industry in the nineteenth and twentieth centuries has had probably the most profound influence on the recent landscape, settlement pattern and infrastructure of the area, although today much of the direct evidence of the industry can be hard to find.

There is historical evidence that the Magnesian Limestone was being quarried in earnest in Durham for lime burning in the mid to late 18th century. With the increasing use of lime for agricultural purposes in the early part of the 19th century a number of quarries in the Raisby Formation and some new ones, including the large Tuthill Quarry in the Ford Formation near Haswell, supplied burnt or ground lime. The rocks were used also for building purposes, and many of the early settlements along the Permian escarpment were built of dolomitic limestone and dolomite worked in numerous small and a few large quarries. Old agricultural villages are scattered thinly across the landscape. In the mid nineteenth century a number of additional quarries were opened in the Magnesian Limestone to provide the specialist needs brought about by the industrial revolution — supplying flux for iron making, dolomite for refractory bricks and 'magnesia' for chemical processes. Today a number of large quarries continue to provide sand and aggregate for the construction industry and large active and disused quarries occupy prominent sites on the escarpment.

The Magnesian Limestone, by its presence, hindered early exploitation of the underlying coal seams, thereby leading to a dramatically different pattern of population and growth from that of the Tyne and Wear lowlands where the near surface coal seams could be more easily extracted. It was not until the end of the eighteenth century that improved pumping techniques permitted shafts to be sunk to depths of 200 metres, so that attempts could be made to prove coal beneath the Magnesian Limestone. The first successful sinking on the plateau was at Hetton Lyons colliery, south-east of Hetton village. The eight mile stretch of railway connecting the Hetton collieries with Sunderland over Warden Law was the longest in the world when it opened in 1822 (Moyes, 1972). Seaham Harbour, founded in 1828, provided an outlet for Lord Londonderry's colliery workings to the south of Sunderland. Improved technical skills in the sinking of shafts, largely developed in Durham, brought to the plateau a succession of new collieries that moved eastwards as it became necessary to dig deeper and deeper to reach unworked coals. The deep sinkings meant that shafts were expensive, limited in number, and individual collieries were large, employing many men. This tended to concentrate settlement, bringing to the area a group of large mining villages which contrast markedly with the smaller units of the older coalfield west of the escarpment (Roberts, in Dunn, 1980). The new mining villages infilled and expanded the older rural settlement pattern. Many were built on the site of older villages and some retain an older core. and in the substantial

areas of derelict and recently claimed land in the urban fringe.

4.2 Threats to geodiversity

Threats to the geodiversity of the area include:

- Development or quarrying that obscures or removes landscape features and/or important geological sites.
- Coastal erosion and/or inappropriate coastal protection schemes.
- Progressive deterioration of rock exposures and infilling or inappropriate restoration of quarries.

Planning procedures today are designed to take account of environmental concerns. Providing planners are made aware of the issues then the indiscriminate destruction of important sites and features should not happen. When applications for new mineral extraction operations are made, the opportunity should be taken where possible to interpret, enhance and preserve the geodiversity.

Sections of coastline undergo continual change, exposed to extreme weather conditions, erosion of the cliffs and beach sediments, and deposition of sediments on the beach. The active processes taking place on the coast are an important feature of geodiversity. Coasts are dynamic and the forces of nature balanced so that substantial intervention may damage adjacent areas. As well as solid rocks, the coastal exposures reveal sections through features such as buried valleys, karst fissures in the magnesian limestones, sand and gravel deposits and the oldest glacial deposits in northeast England. In general, it should be accepted that coastal sections are temporary, data should be collected and recorded when opportunity arises. For many years colliery waste was dumped over the edges of the cliffs along large sections of the northeast coast. In some places colliery waste has obliterated valuable sections through the deposits that constitute the cliffs. The deposition of large volumes of waste material has altered the morphology of the beaches and halted the erosion of the cliffs. Although the sediment has begun to be eroded from the upper parts of some cliffs the sediment has raised the level of the beaches to permanently cover the lower sections of cliffs unless substantial erosion by the sea commences.

Many of the cliff sections within county Durham contain unconsolidated Quaternary sediments in addition to, or instead of solid rock. In some localities the Quaternary deposits constitute the entire cliff as the bedrock level is below sea level giving rise to very different stability considerations (Plate 12) and (Plate 13).It has been estimated that until the beginning of the 20th century parts of the Durham coast were eroding at an average rates of between 2 and 3 metres per year. Progressive accumulation of large volumes of colliery waste, dumped onto the beaches, resulted in a marked reduction in this rate of coastal retreat. With the ending of tipping, and the clearing of much of the accumulated spoil from sections of the coast, erosion rates of between 0.3 to 0.6 metres per year have been predicted.

Many years of dumping of colliery spoil particularly from collieries in the Dawdon and Easington area led to huge and disfiguring accumulations of Coal Measures shale, sandstone, pyrite and some coal on the Durham beaches. Long-shore drift spread much of this material southwards along the coast. Through the 'Turning the Tide' project (http://www.turning-the-tide.org.uk/), much of this contamination has been removed and many of the county's beaches are now approaching their original composition. Significant concentrations of colliery spoil remain locally. High concentrations of pyrite in the beach sand and shingle remain in the Dawdon and Hawthorn areas.

Threats to quarries and natural sections arise from inappropriate development, vegetation enhancement, tree planting, instability and slumping of faces and sections, and in the case of disused quarries, landfill. The possibility of inappropriate recreational activities and wanton vandalism destroying sections also needs to be considered, especially in the vicinity of urban areas. The grassland at Tunstall Hills SSSI has been subjected to erosion by the use of motor bikes, rock faces at Tunstall Hills and Claxheugh rock have been defaced with graffiti and indiscriminate tipping of rubbish is quite common.

4.3 Enhancement of sites

In order to maintain the geological integrity at most sites it is necessary to have well exposed and easily accessible rock faces. Thus, it may be necessary to clear vegetation and in some cases to clean or re-excavate parts of sections. It is of course essential that landowners and where appropriate responsible bodies, such as Natural England, are involved at all stages. It is also vital that a trained geologist is involved. Additionally, the geological management of sites should be carefully considered in conjunction with any botanical, archaeological or other heritage needs especially when clearing vegetation or redistributing talus. 'Geological Conservation: a guide to good practice' (Prosser et al., 2006) is a good introduction to the principles involved. Careful consideration needs to be given to ensuring that the access to sites, and where possible, the content, is suitable for people with disabilities.

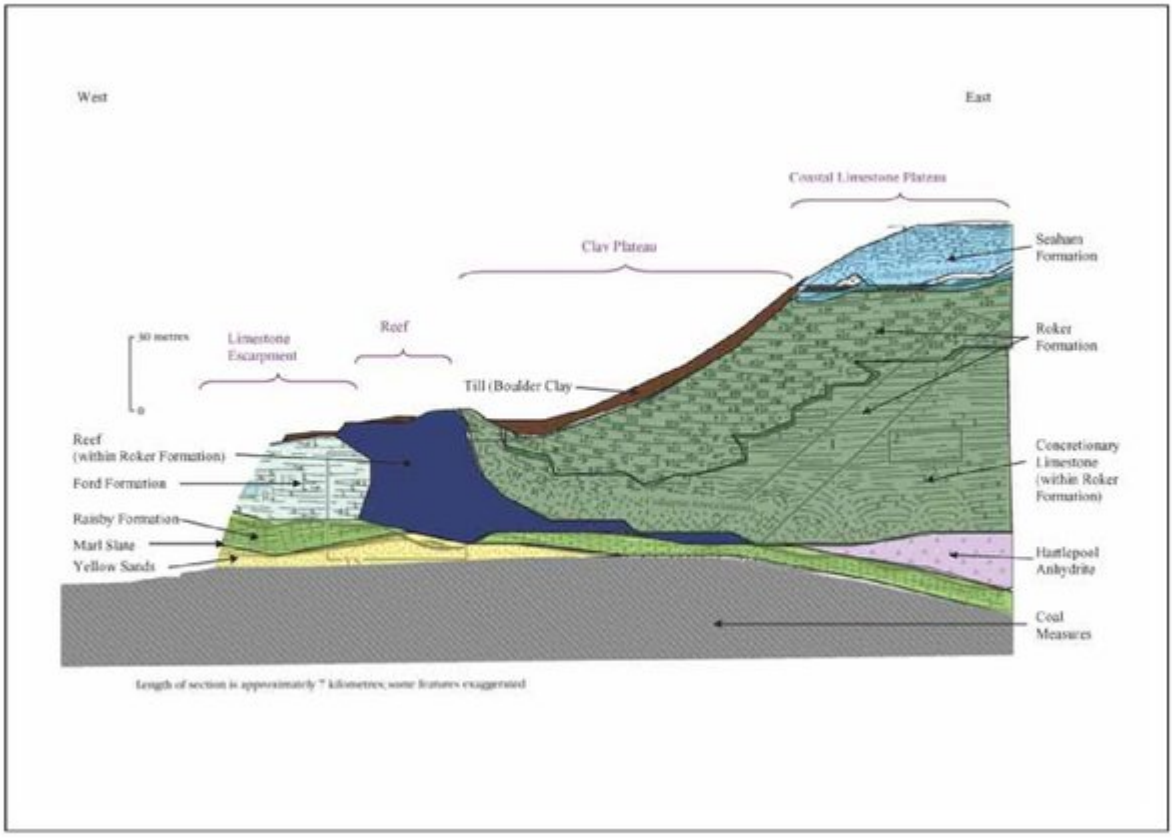
(Plate 11) The Escarpment seen from the south-west.

References

(Plate 9) Coastal stacks in the Roker Dolomite Formation seen from Lizard Point.

(Plate 10) Collapse breccia in the cliffs at Marsden Bay.

(Plate 11) The Escarpment seen from the south-west.



(Figure 2) Schematic diagram to show general relationship of geological units (adapted from Smith 1994).

(Plate 12) Till (Boulder Clay) slippage in the cliffs north of Seaham (November 2008).

(Plate 13) Wire mesh protection of the cliffs near the steps at Marsden Bay. The nature of the rocks can still be seen through the stabilisation measures (February 2009).