2 Geodiversity and its importance

International recognition of the need to conserve biological diversity led to the UN Convention on Biodiversity agreed at the Rio Earth Summit in 1992 and the subsequent signing by over 160 countries. Since the UK government published 'Meeting the Rio Challenge' in 1995, most local authorities or regions in the UK have prepared and implemented Biodiversity Action Plans (BAPs) for their areas, and biodiversity is now accepted as an essential element in sustainable development planning and management strategies. SNH define biodiversity as:

"the variety of life, protecting and enhancing a diverse range of plants, birds, animals and the habitats upon which they rely"

Until relatively recently the parallel concept of geodiversity had attracted little interest, despite its fundamental importance in underpinning biodiversity by providing the substrates. SNH define geodiversity as:

"the variety of rocks, minerals, fossils, landforms, sediments and soils, together with the natural processes which form and alter them"

An alternative definition given by Murray Gray (the author of the first geodiversity textbook) is:

"the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (land-form, processes) and soil features. It includes their assemblages, relationships, properties, interpretations and systems"

Geological and landscape features, other than those already afforded some measure of protection such as SSSIs, are often seen as sufficiently robust not to require active management or action planning. All geological features are potentially vulnerable. In addition to threats posed by inappropriate site development and the infilling of quarries, the encroachment of vegetation, natural weathering and general deterioration with time may threaten to damage or obliterate important geological features. This situation would not be tolerated in wildlife or archaeological sites of comparable scientific or educational value.

The geodiversity of an area may be considered as one of its chief natural resources. A key starting point is an appreciation of the most up to date available understanding of the area's geology, landforms and soils, together with the processes and phenomena which have formed them and continue to influence them. An area's geodiversity thus encompasses:

- sites or natural features which are deemed worthy of some form of designation or protection for the quality of Earth heritage features displayed
- sites or natural features at which representative examples of the area's Earth heritage may be seen
- sites and natural features currently employed in interpreting Earth science
- resource potential for geotourism
- the whereabouts and nature of past and present working of mineral products
- the influence of earth science in shaping the man-made environment, urban landscapes and architectural heritage
- natural hazard management
- the inter-relationship and inter-dependence between Earth heritage and other interests
- Documentation of an areas' geodiversity may include:
- materials collections and site and other records
- published literature and maps
- the historical legacy of research within the area

2.1 Geodiversity — why is it important?

Geodiversity is fundamental to almost every aspect of life — all raw materials that cannot be grown and all energy that cannot be generated by renewables have to be found using geological science.

A clear understanding of geology is also vital to the design and location of buildings, roads, railways and airports as well as to the safe control of waste disposal, and the management of a wide range of natural and man-made natural hazards. All are aspects of geodiversity.

An awareness of geodiversity helps us to understand our environment and predict environmental change in the future. Geological research demonstrates that surface environments are continually evolving through natural self-regulating systems involving the Earth's crust and mantle, oceans, atmospheric processes and life forms. Human activity imposes further pressures and changes to these natural cycles which pose great challenges to modern society. Exhaustion of finite resources such as fossil fuel and global climate change are two of the most pressing. Only by studying the geological record can we hope to predict the earth's response to these changing conditions.

The recognition of natural and cultural heritage features and their sustainable management are today accepted as important functions within a civilised society. The importance of the range and diversity of Earth heritage features — the 'geodiversity' - of any area is as important a facet of its natural heritage as its wildlife interests. Conservation, sustainable management, educational use and interpretation of geodiversity are thus as important as that of biodiversity or archaeology.

However, geodiversity is not, or should not be regarded merely as concerned with conservation of Earth heritage sites or features — it has a vital place in all aspects of natural heritage and impacts in fields as varied as economic development (for example, supporting the development of geotourism in the new UNESCO European Geopark Network; the North West Highlands Geopark is the first Scottish member), building stone resource development, education and lifelong learning, archaeology, art and wildlife. Geodiversity may be one of the most significant areas of heritage interest in areas of high landscape value, or areas previously or currently affected by significant mineral extraction.

Geodiversity interests need to be integrated into other policies and processess relating to sustainable development including:

- Strategic Environmental Assessment
- local authority local, structure and mineral plans
- the Water Framework Directive
- the forthcoming Soils Directive
- Local Biodiversity Action Plans

An appreciation of geodiversity is important to a comprehensive understanding of many aspects of biodiversity. It also offers substantial opportunities to enhance the conservation, management, educational use and interpretation of such related features. Because it has hitherto received little serious consideration, geodiversity needs to be addressed and evaluated by expert earth scientists.

2.2 Geodiversity — linking with biodiversity

It has long been known that there are strong ties between geodiversity and biodiversity. Recent ecological work has highlighted the complexity of these relationships and the large number of factors that come in to play.

At the physical level, geological processes such as glacial erosion and properties such as the relative resistance to erosion of different rock types, produce varying landforms and relief features within a landscape. These landscape features in turn provide diversity in physical conditions that support plant and animal communities, at all scales from small outcrops through to mountain ranges.

At the larger scale tectonic processes create pronounced relief which has a direct influence on regional and local climate, and in turn, on the ecosystems that develop. This also works at smaller scales, for example, microclimate differences

between the top and base of a cliff.

Landscape variety is continually modified by geomorphological processes acting at a variety of scales. Glacial, fluvial and other processes such as slope failure produce new habitats that promote ecological succession and cyclicity and increase overall biodiversity.

In locations where climate, relief and human management are constant, the variation in rock type can strongly influence vegetation distribution. The way in which a rock weathers and acts as parent material for soil development is the most obvious mechanism for influencing floral characteristics. The main factors that rock type influence are soil chemistry, grain size, texture, porosity and permeability. Exceptional soil conditions, such as the high calcium carbonate content in shell sands on the west coast of the Western Isles, together with the low-intensity, traditional agricultural management, have created the unique flora of the machair.

Differences in pH have a major impact on the uptake of various minerals by plants — this is probably the key factor in differentiating the floras from calcareous and non-calcareous rocks. Specific plant-rock associations do occur with rocks of a very distinct chemistry such as serpentine (for example Calaminarian grasslands of the Violetalia calaminariae). Rock type also influences chemistry of both ground and surface waters which give rise to differing aquatic communities.

In summary, the very diversity of rock types and geomorphological processes creates and leads to further diversity in their interaction with other processes. Ultimately biodiversity is a direct function of geological form and process.

2.3 Scotland's geodiversity

For its size Scotland has the most varied Earth heritage, natural landscapes, landforms and soils of any country on the planet. This variety has resulted in dramatically different landscapes and coastlines, such as the machair and beaches of the Western Isles, the fjords and mountains of the western Highlands, the Arctic plateau of the Cairngorms, the plains of Strathmore and East Lothian, to the rolling hills of the Southern Uplands.

The rocks that fashioned Scotland's landscapes have formed over millions of years. Some of the oldest rocks in the Highlands and the Western Isles were formed about 3 billion years ago. Scotland was once part of North America and for much of the Earth's history was separated from England by a large ocean, closure of which did not take place until Mid-Silurian times ((Figure 1)A). Over the last 600 Ma (million years), the Scottish landmass has drifted slowly from south to north across the equator with the successive deposition of various rock types (see (Figure 1)A for geological timescale), including: limestones and quartzites of the North West Highlands (Cambrian and Ordovician); greywackes of the Southern Uplands (Ordovician and Silurian); Old Red Sandstone of Orkney, Caithness and the Moray Firth (Devonian).

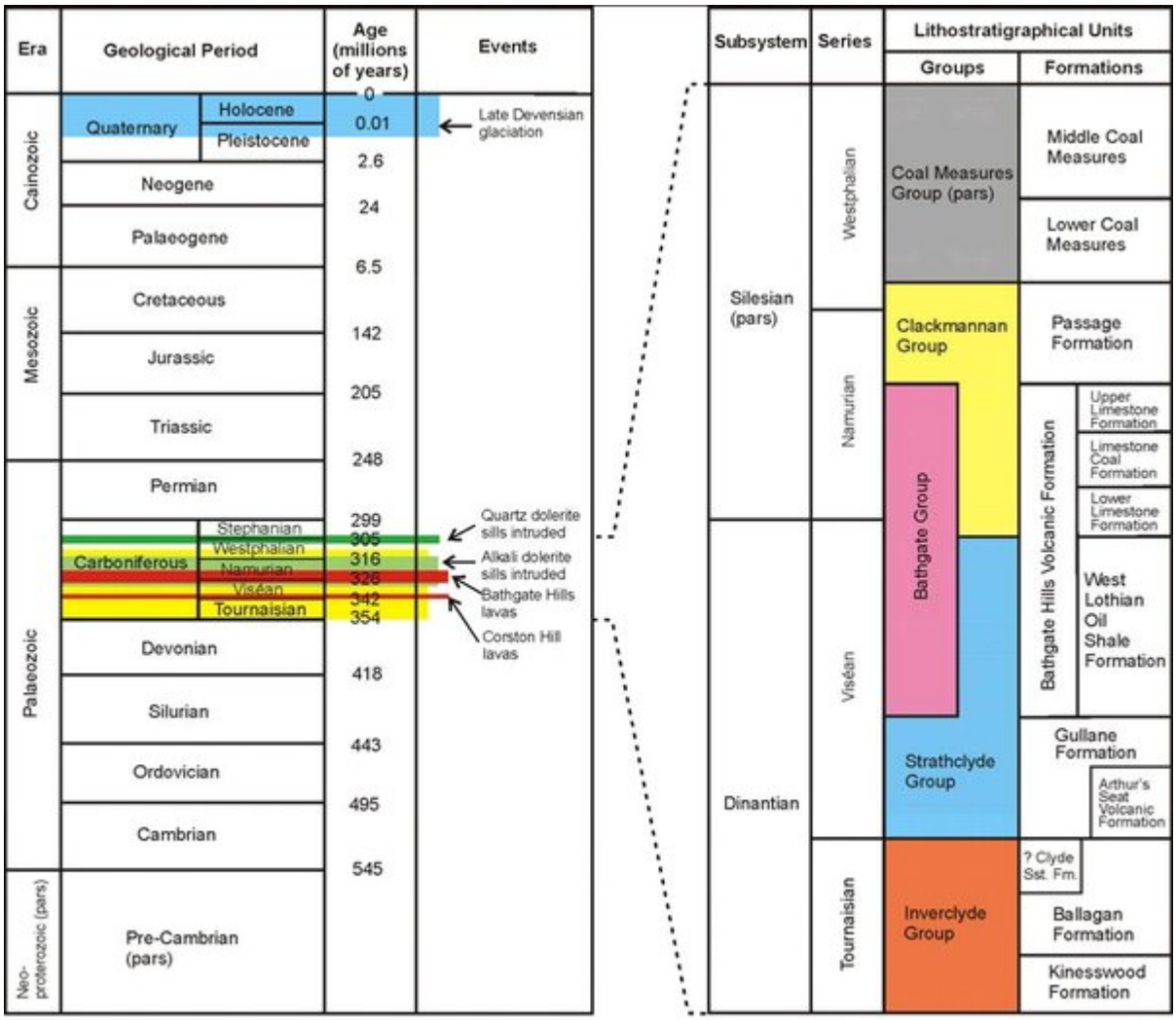
The Midland Valley's coal reserves formed during the Carboniferous (around 300 Ma), when Scotland was sitting at the equator, covered in tropical forests. As Scotland 'drifted' northwards and passed through the northern desert belt, red sandstone rocks were formed. The dynamic earth forces that drove Scotland north across the globe produced heat and pressure and caused earthquakes and volcanic eruptions. These forces folded, faulted and heated rocks, producing volcanoes such as Edinburgh's Arthur's Seat. Many of the rocks altered or produced by these forces are hard and resistant to erosion. They thus have a strong influence on the landscape.

The rocks that underlie the surface are sometimes exposed on hillsides, in coastal cliffs, in river banks and in artificial excavations such as quarries and road cuttings. Rocks can also be seen in building stones, giving areas their own local architectural distinctiveness. The effects of past land-uses such as mining or quarrying can be seen as an eyesore, but may provide excellent habitats especially for pioneer species, and have good restoration potential. Quarries also provide excellent locations for recreation and Earth heritage interpretation, and oil-shale bings can provide distinctive habitats in which orchids, lycopodium and staghorn mosses can thrive.

Scotland has been covered by ice sheets many times in its history. Moving ice rounded the hills and scratched and polished the rocks. It also created the wide straths and glens that today have small 'misfit' streams within them. As ice

shaped the existing rocks, it left behind the eroded material (i.e. 'subsoils') as mounds of sand and gravel on the floodplains. These deposits often have distinctive terraced or mound shapes and can be very important for habitat. They are also an important economic resource. However, because the processes that formed them are no longer active, they are a finite resource that cannot be re-created (unless Scotland is once again covered by ice-sheets). When the ice sheets melted, the resultant rise in sea level of up to 45 m left old shorelines and raised beaches around the Scottish coast.

Soils are also an important component of the natural heritage. They are an integral part of the landscape, reflecting not only the natural processes from which they have been formed, but also the influences of human activities present and past. In Scotland, all the soils we see today have formed since the last glaciers melted around 10,000 years ago. The ever-evolving nature of soils, however, means that they are being continually formed and modified both by natural processes and by human activities. These interactions are responsible for the wide range of soils which exist in Scotland today.



(Figure 1) A: Part of the geological timescale with colour bars representing the rocks of West Lothian. Yellow bar = Carboniferous sedimentary rocks; red bars = extrusive igneous rocks; green bars = intrusive igneous rocks. B: Classification of Carboniferous strata in West Lothian.