

# TAYSIDE – A LAND MOULDED FROM ROCK AND ICE

## THE LINKS BETWEEN BIODIVERSITY AND GEODIVERSITY

Tayside's complex biodiversity only exists because of its underlying 'geodiversity'. Scotland's geological history is recorded in its wide diversity of rock types – in fact for its comparatively small size, Scotland has the most varied geological and natural landscapes of any country on Earth. From such beginnings it is possible to see how Tayside's own rich natural diversity came about, which in turn has moulded our use of the land over many years.

An understanding of the geology beneath us is fundamental to the wider goal of sustainable development because earth heritage features and processes have created many of our important finite resources. It will also put into perspective our efforts to plan for effective biodiversity conservation. For instance, protecting a vulnerable plant or insect community from erosion from the sea will be unsuccessful if it was the erosion processes that created the habitat niche in the first place. Many species have evolved in dynamic environments and some are able to withstand sudden habitat change. The Freshwater Pearl Mussel, for example, buries itself deeper into the riverbed when water levels start to rise.

Tayside's rocks, soils and landforms are resources that provide the essentials for life. These include water, raw materials for manufacturing and construction, soil for agriculture and land for recreation. They also support the all-important variety of habitats and species for which the area is renowned.

The conservation of geodiversity is therefore intrinsically linked to the soil and what is living and growing on it. It is therefore of direct relevance to the conservation of biodiversity. Areas such as the coastal cliffs of Angus are important tools in teaching the earth sciences. Many Geological Conservation Review sites are now protected as Sites of Special Scientific Interest. Other sites receive limited protection through the non-statutory designation of a Regionally Important Geological and Geomorphological Site (RIGS).



ANGUS CLIFFS

LORNE GILL/SNH

## TAYSIDE'S GEOLOGICAL HISTORY

Cutting through the Tayside region is a prominent topographical feature, the Highland Line, which traces a major geological fault (the Highland Boundary Fault) from Stonehaven in the north-east of Scotland to the inner Firth of Clyde in the south-west. This ancient fault line separates the rugged and elevated mountains of the Scottish Highlands to the north-west from the relatively subdued topography of the Midland Valley to the south-east. Erosion has emphasised the more resistant nature of the mainly metamorphic rocks of the Highlands in contrast to the generally softer sedimentary rocks of the Midland Valley. Topography, weather, vegetation and land use in the Tayside region are therefore all very clearly framed in the underlying geology.

### Tayside's Rocks in the Making

Rocks have diverse and varied origins that reflect the original nature of the material deposited or formed and the processes that have happened since their formation. They can be classified as one of three types:

- **Igneous rock** is formed as molten magma rises and cools. This forms a variety of rock types depending on the chemical make-up of the rising magma and the depth of cooling. Deep cooling tends to produce coarser-grained rock types such as granites, whilst shallow cooling tends to give finer-grained rocks such as basalt.
- **Sedimentary rock** is, as its name implies, formed from sediment and as such is often laid down in horizontal layers. It may be derived from erosion of earlier rock types such as sandstone or shale, or by chemical precipitation (for example, limestone).
- **Metamorphic rock** is formed when any rock type is subjected to pressure, heat or chemical attack by hot fluids. This can occur in the deep core of a mountain range as it is being formed. The resulting metamorphic rock can be a slate, schist or gneiss, depending on its original composition and the pressure and temperature reached. If rock is heated above c.700°C it may melt and form granite.

Each of these rock types - sedimentary, metamorphic and igneous - is found within Tayside.

### Tayside Through Time

The rocks of the Perthshire and Angus Highlands consist mainly of metamorphosed, sedimentary and igneous rocks originally formed during the Precambrian and Cambrian era, collectively known as the 'Dalradian Supergroup'. Major earth movements created by continental collisions led to the Caledonian Mountain range forming 490 – 425 million years ago (Ma). These mountains extended from what is now Northern Scandinavia through Northern Britain to the Appalachians in North America. Around the same time the Dalradian rocks were intruded by large masses of granite. Further south lie sedimentary and volcanic rocks of mainly Devonian and Carboniferous age (360 – 290 Ma); these were intruded by thick basaltic rocks in the Late Carboniferous (c.295 Ma) period.

### Evidence of Early Life – Tayside during the Precambrian to Cambrian

Underlying Highland Tayside are Dalradian rocks which were originally many kilometres thick and laid down as shallow marine sands, muds, silts and limestones some 700 Ma - 510 Ma ago. Evidence for one of the earliest life-forms ever found in the world comes from elsewhere in Scotland - small dung pellets have been discovered which were probably produced by a worm-like species inhabiting these ancient sediments.

These ancient rocks were strongly folded later during the Caledonian Mountain building and much of the rock sequence is now inverted. The oldest Dalradian rocks in Tayside, 'the Grampian Group' mostly consist of metamorphosed sandstones. They underlie the mainly peat- and glacial till-covered plateaux, glens and peaks in the north-west. Rocky crags and abundant scree slopes are common in the deeper valleys and on the higher peaks. Soils are thin and acid except in a few wider glens where small pockets of sand and gravel occur. The overlying 'Appin Group' rocks are metamorphosed quartzites, siltstones, black shaley mudstones and limestones. Many of these rocks have been changed to schists. They are again strongly folded and their outcrop displaced by the Loch Tay Fault. These give rise to variable topography and soils with the quartzites forming the sharp, scree-curtained peaks of Carn Liath and Beinn a' Ghlo, and the schistose rocks weathering to form the valleys and lower ground.

The limestones are locally thick and extensive enough to give rise to rare limestone pavements around Schiehallion and Blair Atholl. The limestone areas weather to deep brown lime-rich soils which support species-rich calcareous grassland. The succeeding 'Argyll Group' rocks are also a mixture of metamorphic rock types with quartzites, schistose graphitic mudstones and limy siltstones and mudstones dominant. Although the harder more resistant rock forms prominent peaks such as Schiehallion and Carn Maig, the highest peak, Ben Lawers is formed of softer limy schistose mud rocks which are prone to landslips. The resultant richer limy soils and scree provide a haven for rare alpine and relict arctic flora.

### **World Famous Fish, Insects and Plants - Devonian and Carboniferous**

Between 410 – 290 Ma Scotland was located 10 – 20° south of the Equator. Rainforest covered much of the Midland Valley to the south and coral reefs flourished in the surrounding tropical seas. The sedimentary and igneous rocks of this era dominate the geology of Tayside south of the Highland Border. The source of these sediments is, at least in part, the erosion of the adjacent terrain and the rising mountains in what are now Scandinavia and Greenland.

The sedimentary sandstone and mudstones represent the deposits of local alluvial fans and major regional river systems. Such deposits occurred when the climate was hot and semi-arid with seasonal rainfall. Plants, including early 'trees', were restricted to boggy hollows and freshwater lake margins. Some of these lakes were formed when volcanoes erupted and the lava flows dammed the river system. The flagstones from the Carmyllie quarries near Forfar were laid down in such lakes. World-famous fossil fish and plants have been found in these rocks.

The Early Devonian lavas formed the Ochil and Sidlaw Hills, occurring also along the Highland Border. These lavas were part of an extensive volcanic province that stretched intermittently from Montrose in Angus to Ayrshire in the south-west of Scotland.

Small volcanoes, laying down more lava flows and volcanic ash, were briefly active about 340 Ma; these can be seen on the northern slopes of the Cleish Hills. Subsequently, molten rock intruded between layers of sedimentary rocks to form sills. These now make prominent landforms such as the upper part of the steep northerly-facing scarp of Benarty Hill above Loch Leven and the Cleish Hills. These rocks have long been exploited for hardrock aggregate.

The solid rock record in the region terminates with the intrusion of the Midland Valley Quartz-dolerite Sill and related dolerite dykes of the late Carboniferous such as that seen at Corsiehill Quarry, near Perth. Soon afterwards Scotland drifted northwards out of the Tropics and was well on its journey to its present latitude where ice ages were to become inevitable in the last two million years. Very few rock types of this younger age are present in Tayside, though there is some evidence for the former presence of some chalk cover which was eroded away leaving only flint fragments in some recent gravel deposits in North East Grampian.

### **The Ice Ages – The Making of our Modern Landscape**

On a number of occasions during the last two million years Tayside, like the rest of Scotland, has been covered by kilometre-thick ice-sheets. The build up of the last main ice sheet dates to about 28,000 years ago. The ice, which originated in the Highlands (notably Rannoch Moor), radiated outwards, flowing south and eastwards through the major Highland glens of Tayside.

In Lowland Perthshire the ice flowed mainly eastwards along the main straths, including the Almond, the Earn and Strathmore. Armoured with rock debris like sandpaper it eroded the bedrock into streamlined landforms such as roche moutonnée (glacially scoured and striated rock) and the crag and tail features seen in the Lomond Hills of nearby Fife. Individual boulders from the ice now litter the landscape as far-travelled erratics; these include Samson's Stone and the Cradle Stones at Crieff.

The characteristic mountain landscape with glacially eroded U-shaped straths was fashioned by a number of glaciations in this late period. Frost action developed corries and arêtes. The last main ice sheet left extensive areas of glacial debris called till or boulder clay blanketing most of the low-lying ground. Its sandy clay matrix is derived from the softer mudstone; the angular and rounded boulders and pebbles tend to be from the harder surrounding metamorphic rocks.

As the last main ice sheet retreated from its maximum extent 19,000 years ago, meltwaters were released and deposited sand and gravel spreads in the Earn valley below Crieff and in the Tay around Meikleour and Battleby. Some of these spreads are in the form of mounds and ridges (eskers) and others as staircases of river terraces. A feature of the moundy landscape is the presence of closed hollows (kettle holes), often with lochans where buried ice melted in situ about 14,000 years ago. Loch Monzievairst is one such feature; Loch Leven the largest. Loch of the Lowes is one of several between Dunkeld and Blairgowrie.

In coastal areas such as Montrose and in the Tay and Earn valleys, local sea level was particularly high as the main ice cleared from the firth and estuary. Consequently there are raised beaches and estuarine deposits well inland of the present coastline. Some of the 'raised' clays have been exploited - at Montrose, Dundee, Strageath and Pitfour for brick and tile manufacture and the sands have been quarried at Friarton Bridge (just east of Perth), Barry and Forgandenny. About 13,500 years ago the sea extended inland up the Earn to Crieff and occupied the Methven depression between this town and Perth. The sea also reached north of Scone Palace in the Tay. Montrose Basin would have been an even more impressive sea inlet than it is today. Pollen records show that vegetation was present and although affected by fluctuations in climate and the acidity of the surface material, species such as Birch and Willow were beginning to re-colonise the land, followed by Ash, Hazel and then later by Pine, Oak and Elm.

There is evidence elsewhere in Scotland that around 8,500 years ago brown bears, lynx and reindeer were present in a forest of pine, hazel and birch. The sea still reached Scone in the Tay even 6,000 years ago when the extensive former tidal flats of the carselands were deposited up to about 10m above present levels.

At about this same time, post-glacial lochs also came into existence, some of the smaller ones having been either drained or filled naturally with clays, silts and sands, their former locations perhaps now marked only by alluvial flats. The larger lochs, including Loch Tay and Loch Earn, owe their origins and great depth, in some measure, to the erosional power of the ice sheets. In fact Loch Tay is, at its deepest point, 55m below sea level. Loch Faskally, on the other hand, is artificial and occupies a dammed river valley.

As sea level reached modern levels about 4,000 years ago, modern flood plains formed along rivers and burns with resulting deposits of alluvial gravel, sand, silt and clay. Peat also accumulated in waterlogged hollows and as raised bogs or mosses (for example, Methven Moss). On higher ground blanket peat formed, as did extensive heathland.

With the colonisation of plants and trees, the land became more stable and less debris was carried away by the rivers to the sea. The advent of a wetter climate was, however, compounded with man's activities in tree felling. Man has also probably transformed parts of the River Tay from being a braided river system to a meandering one by installing flood embankments.

## ROCKS OF THE FUTURE

Geodiversity is a dynamic subject. Animals and plants growing today, plants decaying to form peat bogs and soil washed off the fields during storms – all are part of the process of creating rocks of the future. Such processes support soil development, then plant and animal growth which in turn decay and become part of the soil and rock formation cycle. All are parts of the biodiversity cycle of life. Tayside's incredible array of habitats and species – now and in the future – cannot exist without this cycle.

***“Biological diversity is the key to the maintenance of the world as we know it. This is the assembly of life that took a billion years to evolve. It has eaten the storms – folded them into its genes – and created the world that creates us. It holds the world steady.”***

Professor Edward O. Wilson, *The Diversity of Life* (1992)  
(originator of the term 'biodiversity')