# Part 2: The geodiversity of County Durham

## The geological evolution of County Durham

Before embarking upon a detailed exploration of County Durham's geodiversity, and in order to help view the rocks in their true context, it is worth very briefly considering the main events which have shaped the county. A detailed discussion of the geological evolution of County Durham is not appropriate here: good accounts can be found in the literature references cited below.

The diversity of County Durham's rocks, their composition, structure, the fossils and minerals they contain, and the processes which have shaped, and continue to shape them, enable geologists to decipher the history and evolution of the county. It is a story which can be traced back over almost 500 million years.

Geologists divide time into three Eras, each of which is subdivided into Periods. By combining evidence from successions of rocks with the more or less precise ages for some of these rocks, obtained by sophisticated analytical methods, it is possible to arrive at the geological timescale shown here. Enormous though this is, extending back over 543 million years, this represents only that part of earth history during which fossils give us evidence of life. Almost 4,000 million years of geological time are known before the beginning of the Cambrian Period.

The highlighted colour bands on the timescale indicate those periods of geological time which are represented by rocks in County Durham.

The Earth is believed to be about 4,200 million years old, an almost impossible age to imagine. A good way to grasp this is to think of the age of the Earth as a single day. On this scale the oldest rocks we see in the North Pennines formed around 10.15pm, with the rocks which make up much of the county dating from around 10.40–11.00pm. The 24 hour clock in this figure helps to put the enormity of these time periods into context.

The record, as contained in the rocks, is however incomplete. In (Figure 6), which illustrates the main periods of geological time, those periods for which there is clear evidence preserved in the rocks of the county are highlighted. For much longer periods of time, the county contains no rocks and thus no direct evidence of events or conditions. For any interpretation of these periods in County Durham, we must rely upon information gathered from the rocks formed elsewhere at these times.

The oldest rocks known in County Durham date from the Ordovician period of earth history, between 495 and 443 million years ago. The configuration of landmasses across the earth was then very different from today. At this time the area which was to become North-East England lay south of the equator, where it formed part of a deep ocean, known to geologists as the Iapetus Ocean, on the northern edge of a continental plate known as Eastern Avalonia. Mud and sand, which accumulated in this ocean, are preserved today as the mudstones and sandstones of the Skiddaw Group. Eastern Avalonia was then moving gradually northwards towards another huge continent, known as Laurentia, which included what would eventually become Scotland and much of North America. Huge stresses in the earth's crust, caused by the movement of these continents, resulted in the enormous volcanic eruptions which created an enormous thickness of volcanic rocks, known as the Borrowdale Volcanic Group. As these continents finally collided, the Iapetus Ocean was destroyed, and crumpling of the rocks brought into being a new mountain chain across what is now northern England.

Associated with the creation of these mountains was the emplacement, about 410 million years ago, deep beneath the surface, of a huge body of granite known as the Weardale Granite. As we shall see this granite was to have a profound influence on the area's subsequent geological history and upon the formation of its mineral deposits.

The Ordovician rocks, which are known to underlie much of Northern England, are best seen at the surface today in the Lake District, but are also exposed along the foot of the Pennine escarpment and in a small part of Upper Teesdale, where they emerge from beneath their cover of Carboniferous and younger rocks. These areas of older rocks surrounded by younger rocks are known as the Cross Fell and Teesdale inliers respectively. Ordovician rocks have also been proved in a handful of deep boreholes in County Durham and adjoining areas.

Rocks formed during the Silurian period, between 443 and 418 million years ago, are not exposed in County Durham, though, as they are present within the Cross Fell Inlier, it is possible that such rocks may lie deeply buried beneath parts of County Durham. There are few rocks in northern England which can be reliably dated to the next period of earth history known as the Devonian period, between about 400 and 360 million years ago. However, conglomerates exposed locally on the Pennine escarpment may represent accumulations of boulders and gravels deposited amongst the eroding mountains. Representatives of these may also lie concealed beneath County Durham.

By the beginning of the Carboniferous Period, roughly 360 years ago, the area which was destined to become County Durham had moved to a position almost astride the equator. At this time much of what is today northern England began to be progressively submerged beneath a wide, shallow tropical sea, in the clear, warm waters of which beds of limestone accumulated. Periodic influxes of sand and mud, deposited by deltas building from a landmass to the north or north east, periodically established swamp or delta top environments, occasionally with the development of lush tropical forests. The evidence for these conditions is preserved today as the layers of sandstone and mudstone of the Carboniferous rocks. As Carboniferous times progressed, tropical forest cover became much more frequent, the remains of which are preserved today as the coal seams of the Coal Measures.

The Weardale Granite exerted a very strong influence on the nature of Carboniferous rocks of the developing northern England, particularly in early Carboniferous times. Granite is less dense than most rocks in the earth's crust. It is therefore rather buoyant, tending to rise relative to the rocks which surround it. Because of this, as the area which was to become the North Pennines gradually subsided at the beginning of the Carboniferous Period, the 'block' of Ordovician rocks, together with the Weardale Granite, tended to subside rather less rapidly than the surrounding areas. As a result a much thinner succession of Carboniferous limestones, mudstones and sandstones accumulated on this 'block' than in the adjoining areas. Geologists term this area the 'Alston Block'. A similar 'block', here too partly underpinned by an old granite, comprises the area known as the 'Askrigg Block' of the Yorkshire Pennines. Separating these, is the belt of much more rapid Carboniferous subsidence, and thus of much thicker Carboniferous sediments, known as the Stainmore Trough. County Durham encompasses much of the Alston Block and parts of the Stainmore Trough.

Towards the close of Carboniferous times, about 295 million years ago, continuing stretching of the earth's crust allowed the up-welling of huge volumes of molten rock from deep within the earth. This basic magma did not reach the surface, but spread out as sheets and layers between the existing Carboniferous rocks. As it cooled and crystallised to form the dolerite of the suite of intrusive rocks collectively known as the Whin Sill, its heat profoundly altered many of the adjoining rocks, turning limestone into marble, known in Teesdale as the 'Sugar Limestone' and shales into 'hornfels', or as it is known locally, 'whetstone'.

Shortly after the formation of the Whin Sill, mineral rich waters, warmed by heat from the Weardale Granite, began to circulate through cracks and faults in the rocks deep within the earth's crust. As they cooled, their dissolved minerals crystallised forming the veins and associated deposits of the North Pennine Orefield.

Major earth movements towards the end of Carboniferous times once more created mountains across what became northern England. By about 280 million years ago, during the Permian Period, the area that is today the Northern Pennines probably consisted of mountains, with valleys choked with rock debris broken from the rapidly eroding mountains. Huge wind-blown sand dunes formed in a desert, which covered much of the comparatively low ground in what is today central and eastern County Durham. These are today the 'Yellow Sands' seen in quarries in the east of the county.

This Permian desert was soon inundated by the rapidly advancing waters of a sea, known to geologists as the Zechstein Sea. This occupied an area which included that of the modern North Sea. Sediments deposited in the Zechstein Sea record repeated cycles of sea level change, in part due to periods of evaporation of substantial parts of the sea. The earliest Zechstein sediments in County Durham comprise the grey bituminous limestone known locally as the 'Marl Slate'. This comparatively thin bed is believed to have accumulated in rather stagnant oxygen-poor sea- floor conditions. The bed is renowned for the local abundance within it of beautifully preserved fish, which lived in the much better oxygenated surface waters. Overlying the 'Marl Slate' in the Durham area, was deposited a succession of limestones which, from the common occurrence within them of the magnesium carbonate mineral dolomite, are collectively termed the Magnesian Limestone. A variety of types of limestone, each indicative of rather different depositional conditions, make up this succession. A well-known feature of the Durham Magnesian Limestone is the presence of a very well-preserved fossilized reef composed not of corals as in modern reefs, but mainly of bryozoa and algae, together with a rich marine fauna of bivalves, brachiopods etc. On occasions severe evaporation of the Zechstein sea resulted in the deposition of beds of anhydrite or gypsum, and when evaporation became particularly extreme, beds of rock salt or halite. These rocks, known from their mode of formation as evaporites, are particularly soluble rocks. Dissolution of thick beds of evaporites, possibly during Palaeogene times, resulted in foundering of the overlying limestones producing the strikingly jumbled masses of broken limestones known as 'collapse breccias' which are such a notable feature of parts of the Magnesian Limestone.

Numerous sites in east Durham, and the adjoining Sunderland area, offer some of the world's finest opportunities to study these Permian rocks and to investigate the processes which formed them. They have long been, and continue to be, an important focus of research.

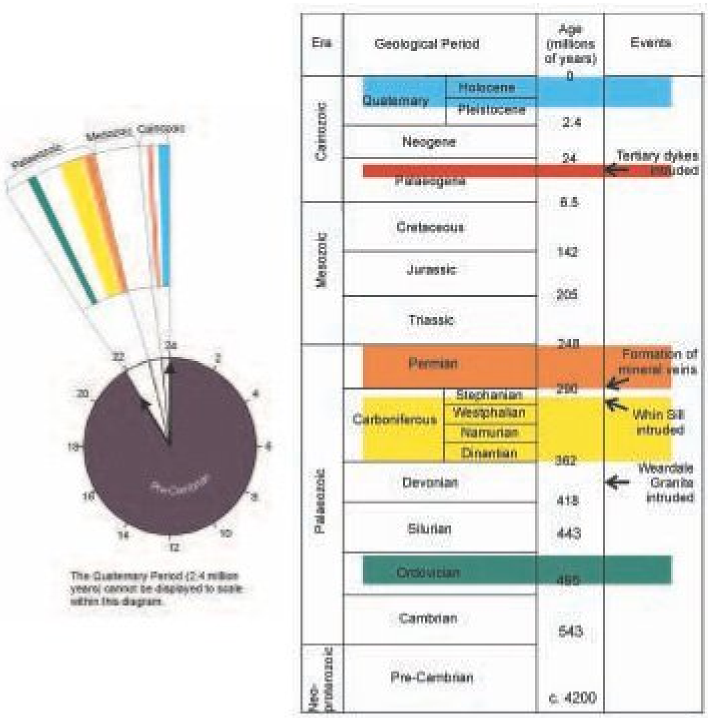
From about 250 million years ago evidence for the county's geological evolution falls largely silent. We know that the county's rocks were again uplifted and tilted gently towards the east, accompanied by some faulting, and that during the Palaeogene Period, about 65 million years ago, narrow dykes of basaltic rock were injected into fractures as distant manifestations of the violent volcanic activity that was then shaping the Hebrides and Northern Ireland. Apart from this we have no tangible evidence of our area's geological history until the deposits left by ice sheets during the glacial period which began here about two million years ago. Much of the form of the present day physical landscape derives from the effects of this prolonged period of ice cover and its subsequent melting.

Centuries of human occupation, and exploitation of the area's natural resources, have further modified the landscape to that which we see today, and which through continuing human influence, continues to evolve.

## Selected references

British Geological Survey, 1992, 1996; Duff and Smith, 1992; Burgess and Holliday, 1979; Cleal and Thomas, 1996; Dunham, 1990; Dunham and Wilson, 1985; Forbes et al. 2003; Johnson and Dunham, 1963; Johnson, 1970; 1995; Mills and Holliday, 1998; Mills and Hull, 1976; Smith, 1994; Smith and Francis, 1967; Taylor et al. 1971.

**Full references**



*(Figure 6) Simplified geological timescale of County Durham.*