Geological structures

Geological structures are features within the rocks produced by distortion resulting from Earth movements. Such features include inclined, or dipping, rocks, folds and faults. They occur at a variety of scales from millimetre, metre and decimetre scale in local outcrops to regional kilometre scales affecting large tracts of the countryside. They may be very simple or highly complex structures, depending on the degree of distortion suffered by the rocks and their structural evolution over geological time.

Geological structures in Great Britain

Geological structures, at all scales, are ubiquitous through Britain and an appreciation of geological structures is vital to understanding the Earth processes that have shaped the landcape. The interpretation of large-scale region structures allows geologists to interpet the geological evolution of the nation, to understand linked processes of sedimentation, volcanism, mountain building and erosion, and to construct palaeoenvironments. In outcrop, the measurement of smaller visible geological structures enables the overall large structural evolution of a region to be deciphered. Such observations and deductions are fundamental to making geological maps, in predicting, exploring for, and working mineral deposits, including groundwater resources, and in the design of major civil engineering projects.

Geological structures in the district

The structures present in the rocks of Northumberland National Park and the surrounding areas can be attributed to three main events in the geological evolution of the area, namely, the Devonian Caledonian Orogeny, Carboniferous regional extension and subsidence, and late Carboniferous compression related to the Variscan Orogeny.

Geological SNCIs

Crindledykes [NY 781 670]

By far the biggest influence on the regional scale geological structure of the district can be attributed to Carboniferous extension and subsidence, which produced the blocks and basins that divided northern England into major structural units (p. 21). The Stublick–Ninety Fathom Fault System, which crosses the extreme south of the district, running eastwards from south of Haltwhistle, through Plenmeller Common to Stublick Moor, marks a line of major break- up at the southern margin of the Northumberland Trough. Subsidence within the trough was most intense in the south close to the fault system and diminished northwards. As a result the trough has a strongly asymmetric shape and the Carboniferous succession deposited in it thickens and dips southwards to south- eastwards. The best examples of southerly-dipping strata are to be seen the Carboniferous exposures of the Wall country where the rocks are inclined by up to 20°.

To the south of the Stublick–Ninety Fathom Fault System lies the Alston Block; a major structural unit roughly coincident with the present day Northern Pennines. During Carboniferous subsidence, the block remained relatively elevated, underpinned by the buoyant Weardale Granite, and subsided much less that the adjacent Northumberland Trough. As a result, the Carboniferous succession deposited on the Alston Block is significantly thinner than that of the trough and the strata today remain roughly horizontal.

The regional block and basin structure of the district was further modified by late Carboniferous Earth movements related to the Variscan Orogeny. The Alston Block and Northumberland Trough were regionally uplifted and locally faulted and folded; at the surface today, the late Carboniferous Westphalian Coal Measures of the trough are juxtaposed against the older Namurian sandstones of the block across the Stublick Fault. Northern Northumberland was raised into a considerable dome with the Cheviot massif at its centre. North-east of The Cheviot, the surrounding rocks dip northwards, towards the Tweed Basin, to meet the rocks dipping southwards from the Southern Uplands and form a regional ‘down-fold’ known as a syncline. To the east, south and west of The Cheviot, the dip is fairly constant and away from the massif.

The Cheviot massif presented a rigid block against which the softer Carboniferous rocks were compressed and buckled to form localised and highly asymmetrical folds. Good examples can be seen at Lemmington, west of Alnwick, at Holburn west of the Kyloe Hills and, outside the district, on the coast at Scremerston where the Eelwell Limestone has been pushed over towards the west. An exceptional example of folding is a powerful faulted 'up-fold' – or anticline – known as the Holburn Anticline, that runs along the east of the Cheviots for about 12 miles. This large structure locally elevates the Fell Sandstone as an escarpment, forming a barrier between the Cheviot Hills and the coastal plain.

Geological structures related to the earlier Caledonian Orogeny are restricted to the Silurian rocks of the district. These strata always appear strongly inclined and often tightly folded. They can be seen near the head of the Rede valley (at the road cutting above Catcleugh Reservoir), in the Canker Burn (a tributary of the Cottonshope Burn) and in the headwaters of the River Coquet (the Coquet Head Inlier). The Silurian sediments are typically very similar in appearance throughout the succession. This makes their structure somewhat hard to elucidate as there are no distinctive marker horizons within the sequence; minor folds are difficult to identify.

It is sometimes possible to identify overturned sequences using sedimentary structures within the steeply dipping beds, and, depending on the density of sedimentary structures and the amount of exposure, it is sometimes possible to position a fold axis to within a few metres, though in areas of poor exposure there is a wider margin of uncertainty. Several fold axes have been tentatively positioned, most notably a syncline south of Makendon [NT 80370 09331].

Across the district the large-scale regional structure is further complicated by smaller scale folds, faults and fractures. An excellent example of a small monoclinal (one sided) fold in the Great Limestone is exposed in the eastern quarry at Crindledykes [NY 781 670]. Small localised anticlines and synclines, known locally as 'rolls', are common in the limestones throughout the district. One such example may be seen in Mootlaw Quarry [NZ 01850 75560] where the great limestone is folded into an impressive syncline; structural deformation that appears not to have affected the overlying mudstones.

In addition to the major Stublick–Ninety Fathom fault System, numerous smaller scale faults cut the rocks of the district. These vary in scale from those with a displacement measurable in centimetres, to some with displacements of tens of metres. The direction of almost all the faults with displacements of ten metres or more is east-north-east. Notable examples are the large Swindon Fault through Rothbury, and those that cross the head of Redesdale, from the southern edge of the Cheviots to the North Tyne and beyond. Small faults are occasionally exposed in working quarries but good natural exposures are rare, although the position of these faults, and their effect upon the continuity of outcrops of geological units is conspicuous locally in the landscape and is clearly apparent on geological maps. In the Haydon Bridge area, in the south of the district, small scale faults provided pathways for late Carboniferous/ early Permian mineralising fluids. These mineralised faults, the only significant examples within the district, are termed veins and form an outlying part of the North Pennine Orefield (p. 73).

Joints are fractures along which there has been no displacement in the plane of the fracture. They are often regularly spaced and follow distinct trends through the rocks. They are extremely common in most of the limestones and sandstones of the district. The best examples of jointing within limestone can be seen an many of the small quarries of the Wall country. Here the joints usually run in two, roughly perpendicular, directions and, along with the bedding, divide the limestone into regular rectangular blocks.

In many intrusive igneous rocks joints form as the molten rock cools and crystallises. These joints are particularly conspicuous as they form regular patterns that divide the rock into hexagonal columns running perpendicular to the cooling surfaces. This style of jointing, know as columnar jointing, is spectacularly displayed in many exposures of the Whin Sills in the Wall country.

Impact on the landscape

Some of the district's most striking landscapes directly reflect the geological structure of the underlying rocks. The pronounced 'cuesta' landscape of the Wall country, with steep north-facing scarp slopes, and more gentle southerly dip slopes, mirrors the inclined alternating beds of resistant limestones, sandstones and the Whin Sill dolerite, with interbedded layers of weaker mudstones and siltstones. The change in the direction of the regional dip of the strata of the district, from a predominantly southerly direction west of the River North Tyne, to a predominantly easterly direction east of it, is reflected in the marked change in direction of the ridge features in the landscape. The abrupt termination or lateral displacement of ridges often identifies the position of faults that locally disrupt these trends.

The almost horizontal sandstone beds south of the Stublick–Ninety Fathom fault System locally give rise to a landscape with rather flat-topped hills, in places with evidence of terracing on their sides marking alternations of beds of differing resistance to weathering.

The area immediately east of the Cheviot massif provides a striking example of the way in which topography is affected by structural geological factors.

The Fell Sandstone, located on the faulted northeast limb of the Holburn Anticline, forms a rugged west-facing scarp overlooking the Wooler valley. The scarp acts as a drainage barrier separating the Cheviot Hills from the sea, and deflecting the drainage of local rivers, such as the Till, to the north. In the Cheviots, the long straight valley of the Harthope Burn [NT 955 225] marks the line of the Harthope Fault.

Small-scale geological structures influence landscape on a local scale throughout the district. Near vertical rock faces in cliffs and gorges are often the result of the weathering of joints and faults. Many examples can be found along the course of Hadrian's Wall, where joints and faults in the Whin Sill dolerite have been exploited by local drainage, and in the River Allen gorge, where the river has exploited major fractures within the hard sandstones.

Economic use

The mineral veins of the district occupy faults, and an understanding of the geological structure has lain at the heart of successful mining and prospecting. This understanding pre-dates the emergence of geology as an organised science, although the earliest miners undoubtedly understood and applied many of the concepts and principles of modern structural geology.

Geological structures place constraints upon the mining and quarrying of some rocks and minerals. This is especially true where faults displace, and thus effectively limit, the extent of workable rock units.

Anticlinal folds and faulted successions at depth may act as reservoirs, for hydrocarbon deposits. The geological structure of the Carboniferous rocks north of the Stublick Fault has invited speculation on commercial hydrocarbon potential. Geophysical interpretations, in part resulting from seismic investigations, have identified structures at depth which invite exploration as potential hydrocarbon reservoirs. A structure beneath the Hadrian's Wall area was investigated by drilling a deep borehole in the winter of 2004–5 at Errington, north of Corbridge.

Conservation issues

Major landscape features determined by the larger geological structures, for example the 'cuesta' landscape of the Wall country, are generally robust in conservation terms. Exposures of structures such as folds and faults are comparatively few and are typically restricted to working or abandoned quarries. Some of these features could be readily damaged or destroyed by inappropriate restoration of old workings. Opportunities may exist for conservation of suitable examples of these features in restoration plans for working quarries. A number of very striking folds have been exposed, and subsequently destroyed, during the working of the Great Limestone at Mootlaw Quarry [NZ 01850 75560] and the Stublick Fault was exposed briefly during the operation of the Plenmeller opencast coal site. Thus, recording the features by photography or clear field description is important.

Wider importance

The Stublick–Ninety Fathom fault System is a fundamental feature of the geology of northern England, in part inherited from the now deeply buried Iapetus Suture, and has influenced the geological evolution of the region since at least

Carboniferous times.

The structures exposed in the Wall country are a surface expression of the southern part of the Northumberland Trough, and thus give important clues to the regional structure of this major geological unit, and the fault system to the south.

The mineralised faults in the Haydon Bridge area comprise an outer portion of the Northern Pennine Orefield, and contain features of international importance in understanding orefields of this type.

Figures

(Figure 63) Synclinal fold formerly exposed in the Great Limestone at Mootlaw Quarry. Note how the bedding in the upper part of the mudstones overlying the fold is apparently unaffected.

(Figure 64) Monoclinal fold in the Great Limestone at Crindledykes Quarry.

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