16 The geology and landscape of Upper Teesdale

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Purpose

To study the Carboniferous cyclothemic sediments on the edge of the Caledonian Alston Block; the Variscan tectonics, Whin Sill and synchronous mineralisation; the Tertiary Cleveland Dyke; the effects of late Quaternary glaciation and the control of landscape by the underlying geology. Parts of the sequence are very fossiliferous, with corals, crinoids and brachiopods.

Logistics

A one-day excursion which may profitably be divided into smaller, more intensive itineraries. Parking places are indicated throughout the text. Food may be obtained in Middleton-in-Teesdale, at High Force and at Holwick.

Note: Although the paths are recognized rights of way they pass through two large estates (Raby and Strathmore). Please observe the countryside code. During the pheasant and grouse shooting seasons, sections of the proposed routes may be temporarily closed.

Maps

O.S. 1:50 000 Sheet 92, Barnard Castle; O.S. 1:25 000 Sheet NY 82/92, Middleton-in-Teesdale; B.G.S. 1:50 000 Sheet 31, Brough-underStainmoor; B.G.S. 1:63 360 Sheet 32 Barnard Castle; B.G.S. 1:25 000 Sheet 17, Middleton-in-Teesdale.

Geological background

Upper Teesdale is situated on the southern margin of the Alston Block, part of a structural block and trough system developed in Northern England following the Caledonian Orogeny. The foundation of the block in the Teesdale area comprises Ordovician meta-sediments (exposed in the Teesdale inlier at Cronkley Pasture; [NY 846 296]) and volcaniclastic deposits (Borrowdale Volcanic Group) into which the Weardale Granite has been emplaced.

This buoyant structural unit is bounded on its southern margin by the Lunedale–Butterknowle Fault zone, separating it from the Stainmore Trough, a substantial depositional basin during the Carboniferous period. In the subsiding Stainmore Trough some 2850 m of cyclic Carboniferous sediments are still preserved; equivalent strata on the more stable Alston Block are appreciably thinner. In Teesdale and adjacent areas each Yoredale cyclothem commences with a marine transgression (usually a limestone which gives a generic name to the whole unit; e.g. Five Yard Limestone Cyclothem) followed by sediments of increasing deltaic influence (shales, silt-stones, flagstones, sandstones or grits, seatearths and perhaps thin coals). The terrestrially derived sediments represent the infilling of a shallow marine gulf by a southerly prograding deltaic complex. The number of such Yoredale cyclothems in the North Pennine area suggests that sedimentary basin infill was followed by regional subsidence and/or increase in sea-level, with many repetitions of the sedimentary cycle over many millions of years.

The end-Carboniferous Variscan Orogeny led to reactivation of basement faults and general uplift of the Northern Pennines area. A late orogenic extensional phase resulted in the injection of basic magma into deep-seated fault zones, some of which acted as feeder dykes for the extensive Whin Sill, a very important doleritic intrusion in North East England. Upper Teesdale, the southern limit of this igneous body, was where the intrusive nature of a sill was first recognized by Adam Sedgwick in 1827. The important Northern Pennines mineralization is chronologically associated with this reheating of the basement rocks of the block areas by these basic magmas (Dunham 1990). Mineral veins (base metals lead, zinc and iron with a little copper, silver and cobalt) are to be found in fault zones cutting the Carboniferous sediments and indeed replacing some of the limestones in particular. The legacy of intensive mining in the past litters the Teesdale landscape.

Post-Variscan faulting in the Teesdale area is complicated by subsequent tectonic episodes (Triassic, intra-Jurassic, early Tertiary and even late Quaternary eustatic movements) so many faults show different phases and directions of movement and there are some cases of fault inversion. Into one such fault zone were injected basic magmas believed to have originated from the early Tertiary (Palaeocene) Mull volcanic centre. This Cleveland–Armathwaite Dyke echelon is well represented in Upper Teesdale.

Only features associated with the latest Quaternary (Devensian) glaciation are represented in Upper Teesdale but these have had a profound effect. Much of the landscape is masked by deposits of till which is of local (Pennine) origin except in the Lunedale and Middleton-in-Teesdale area where distinctive glacial erratics of Shap Granite and green andesitic tuffs (Borrowdale Volcanic Group) witness the passage of Lake District ice through the Stainmore pass and Lunedale area onto the South Durham–North Yorkshire plains. Geomorphological features in Upper Teesdale suggest a late Quaternary valley glacier phase with marginal moraines, linear ice moulded debris, glacial spillways and modified river patterns, as well as outwash sand and gravel deposits which choke the Tees valley.

Excursion details

Locality 1, Eggleston Burn [NY 989 252]

Approach from Eggleston village via either the B6282 (Middleton-in-Teesdale road) or B6278 (Stanhope road) and the linking minor road (Figure 16.2). Park on the roadside [NY 990 249], 150 m east of the spectacular gritstone viaduct across Eggleston Burn. Walk along the narrow path on the north side of the road (just to the east of the viaduct) for too m to a small ill-defined quarry. Here the Cleveland Dyke crosses the valley and burn in an east–west direction, emplaced into coarse feldspathic gritstones around the level of the Firestone Sill (Upper Carboniferous). The porphyritic tholeiitic dolerite of this minor intrusion has been modestly quarried on the east side of the burn for roadstone (trackways lead southwards from the lower section near the burn) and there are signs that the adjacent grits have also been quarried for local walling.

The full c.15 m thickness of the dyke is best seen in the river cliff on the west side of the valley, where it has chilled (tachylitic) margins and the adjacent grits have been mildly contact metamorphosed. It is, however, difficult from a distance to distinguish the sedimentary bedding of the host rock from the horizontal joints of the dyke. In the quarry on the east side of the burn the marginal contacts are not well exposed, but the quarry face does exhibit good examples of spheroidal weathering in the dyke.

Locality 2, Whistle Crag [NY 978 247]

From the lay-by on the B6282 is a panoramic view southwards of the southern marginal area of the Alston Block. Crags of Whin Sill can be seen below the skyline to the right, whilst the Lunedale–Butterknowle Fault runs just below the skyline on the left and out through the Lune Valley to the south. The Tees valley in the foreground is filled by late Quaternary tills and outwash alluvial deposits.

Localities 3–5, Hudeshope Beck [NY 947 258]–[NY 948 275]

Park in Middleton-in-Teesdale. Walk north from the town on the Stanhope road past the parish chruch. Viewed from the wall on the west side of the road after the last house, the disturbed limestones at river level mark the position where a fault (downthrowing to the southwest) cuts the deep valley of Hudeshope Beck. Take the first pathway on the west side of the road through the woods on the east side of the beck to the first footbridge.

Locality 3 [NY 947 258]

The footbridge is sited on the thickest post of the Three Yard Limestone (Lower Carboniferous, Alston Group) where it also forms a small waterfall (Figure 16.1a). Downstream the base of the limestone is exposed where it overlies the sandstones, ganister and thin shale partings at the top of the Five Yard Limestone Cyclothem. In the low river cliffs on the east side of the valley upstream of the footbridge a sequence of thin limestones with intercalated calcareous shales (with scattered corals and crinoidal debris) is gradually replaced vertically by deltaic non-marine shales with ironstone nodules followed by flaggy sandstones, all part of the Three Yard Limestone Cyclothem.

Further upstream the sandstone of the Three Yard Limestone Cyclothem forms a low river cliff. This disappears where a fault (the continuation of the Holm Head Vein), downthrowing c. [o m southeast, cuts the valley in a northeast–southwest direction and results in the repetition of the geological succession so that the second footbridge [NY 947 262] is also sited on the thickest post of the Three Yard Limestone. Around the second footbridge, a c.0.4 m bed of calcareous shale separates the two principal posts of the Three Yard Limestone. As the river bed gradient is the same as the local dip the stream bed follows the top of the limestone for 150 m upstream where a small fault causes flexure in the top of the upper post.

Locality 4 [NY 947 264]

A series of tufa-depositing springs are associated with this same fault on the western side of the valley. A large mound of tufa from a former lower spring source is known locally as the 'Growing Stone' (Figure 16.1) a.

The calcareous shales upstream provide many well preserved examples of crinoid sections, brachiopods, bryozoan colonies and occasional fish teeth. Among boulder debris in the beck are examples of exotic clasts derived from the till cover in this valley, including green andesitic volcaniclastic rocks (Borrowdale Volcanic Group) and Shap Granite from the Lake District, as well as locally derived material including clasts of Frosterley Marble.

Further upstream [NY 948 269] the nature of the Three Yard Limestone Cyclothem changes with non-marine ferruginous shales with septarian sideritic nodules followed by siltstones, flagstones then a more substantial sandstone that forms the lip of a prominent waterfall.

Walking up the Hudeshope valley along the road, the limestones of the succeeding Four Fathom Limestone Cyclothem have been worked in a rather overgrown quarry [NY 949 269] and although somewhat disrupted by faulting these same limestones can be seen forming low cliffs on the west bank of the beck (Figure 16.1)a.

Locality 5 [NY 948 272]

The Four Fathom Limestone is extensively exposed in the river bed upstream of Skears Bridge, where it is also markedly disrupted by calcite-filled tension gashes associated with mineralized faulting. Higher upstream, the sedimentary sequence between the Four Fathom Limestone and the Great Limestone (Namurian, Upper Carboniferous) is seen in a poorly accessible west-facing river cliff. At Skears Scars [NY 948 276] Hudeshope Beck has cut a spectacular gorge through the Great Limestone which commences on the north side at a well exposed partly mineralized fault with i8 m downthrow to the northeast (Hall's Vein; (Figure 16.1)a. Beds here and in nearby Skears Quarry [NY 949 272], rich in the solitary coral *Dibunophyllum bipartitum,* constitute the Frosterley Marble horizon.

Return to the vehicle and leave Middleton-in-Teesdale on the B6277 for Bowlees.

Locality 6, Bowlees Picnic site [NY 907 283]

Around the old limestone quarry [NY 908 284] there is a wealth of geological detail (summarized on (Figure 16.1)b) which requires careful observation.

Walk upstream on the well-made path from the quarry. Above the quarry fault waterfall, Bow Lee Beck runs over the cross-bedded and channel fill sandstones of the Scar Limestone Cyclothem the top of which is at Gibson's Cave [NY 910 287] where the limestones of the succeeding Five Yard Limestone Cyclothem form the lip of the waterfall.

Leave the picnic area and walk eastwards on the B6277 for 0.6 km before taking the footpath southwest to the River Tees (Figure 16.2).

Locality 7, Scoberry Bridge [NY 910 273]

Here the Cockleshell Limestone is exposed with the brachiopod *Gigantoproductus* and compound corals (do not hammer this locality). Cross the bridge and walk upstream on the Pennine Way. The gentle downstream dip brings in successively lower strata of the Single Post Limestone Cyclothem and into the top of the Tyne Bottom Limestone Cyclothem. Note the waste heaps from Wynch Mine trials into the Single Post Limestone (iron and zinc replacement ores) to the southwest side of the path some 300–550 m upstream from the bridge (Dunham 1990).

The River Tees changes its character some 200 m upstream from the bridge, caused by the exposure of the top margin of the Whin Sill. The sill has been injected into the sandstones of the Tyne Bottom Limestone Cyclothem and now forms the bed of the River Tees for 1.7 km upstream to Holwick Head Bridge [NY 889 283]. The indurate nature of the upper margin of the Whin Sill causes the river to flow over a series of rapids, small waterfalls and through small sharply defined valleys.

Locality 8 [NY 904 278]

Here there is a large 2–2.5 m thick raft of metamorphosed sandstone in the upper part of the Whin Sill. This 74 m long section of detached roof rock has tilted to an angle of c.20° as it slowly foundered into the crystallising basic magmatic intrusion, producing glassy tachylitic chilled margins to the edge of the sill and in turn being metamorphosed.

Locality 9, Wynch Bridge [NY 903 280]

Cross over the nineteenth century bridge to view Low Force, a well loved river feature effected by the hard nature and crude columnar jointing of the Whin Sill. Pause on the bridge to note the full extent of the sandstone raft at Locality 8. (The walk can be terminated here. Return to the Bowlees Picnic area, noting in passing the long low, partly wooded hill to the east of the path at the start of the fields: a northwest–southeast oriented, extended, ice moulded heap of glacial debris.)

Walking upriver on the west bank from Wynch Bridge, many features associated with the erosion of the upper contact of the Whin Sill can be noted in the river course. Also the wet nature of the associated valley alluvial deposits makes this section of Teesdale an ideal area for the study of summer wetland plants.

Locality 10, Holwick Head Bridge [NY 889 283]

Here the nature of the Tees valley changes where the river enters a deeply incised gorge which terminates with the waterfall of High Force [NY 880 284]. Near this bridge the river crosses a major north-northwest–south-southeast fault complex which has the combined effect of some c.75 m downthrow to the east (Figure 16.2). Indeed the continuation of the Teesdale Fault controls the northwest–southeast direction of the first section of the High Force Gorge.

This locality may also be approached from the public car park and picnic site at High Force [NY 886 287].

Locality 11, High Force [NY 881 284]

Park as above and take the woodland walks and paths maintained by the Raby Estate to the waterfall. This approach will allow you to see at close hand the bottom section of the Whin Sill where the quartz dolerite magma has been injected into the sandstones of the Tyne Bottom Limestone Cyclothem (again the bottom contact of the sill has a chilled tachylitic margin). The disposition of the rock types viewed at this classic locality can be seen in Figure 16.3.

Continuing upstream on the west bank from Holwick Head Bridge, the path ascends a steep slope to a position about halfway up the Whin Sill intrusion, some 73 m thick in this area. The well defined path passes through preserved areas of juniper scrub, remnant areas of woody plant colonisation left after the last, Devensian, glaciation. There are several places where ***with extreme caution*** High Force can be viewed from the rim of the gorge.

Locality 12, Top of High Force [NY 880 284]

Views of the waterfall and the gorge beyond are spectacular and *dangerous.* Flash floods generated by summer storms in the Pennines often surprise the unwary at this locality.

Following the Pennine Way upstream, Bleabeck Force is seen to cascade over the Whin Sill on the south side of the valley [NY 875 278] and on the north side of the Tees there is the active Force Garth Quarry. Here almost the whole thickness of the Whin Sill (often showing working faces with excellent columnar jointing) is worked for roads tone.

The low and ill-drained ground around Pasture Foot (Figure 16.2) is part of a pre-glacial buried channel now partly choked by till.

Locality 13, Bracken Rigg [NY 863 281]

The Pennine Way ascends this small but steep hill, an erosional outlier of dolerite, that with Low Crag to the north [NY 863 287] has become detached from the main outcrop of the Whin Sill by post-glacial erosion of the River Tees. The south-facing columnar dolerite cliffs of Dene Holm Scar and the adjacent Tees valley are a splendid sight from the top of Bracken Rigg. Leave the Pennine Way at the western end of Bracken Rigg and walk southwards across the marshy ground of Fell Dike Sike (a continuation of the Pasture Foot buried channel) to join the well defined drove road 'Green Trod'. This possibly Iron Age trans-Pennine routeway can now be followed eastwards across the grouse moors to Holwick. Green Trod follows the Scar Limestone Cyclothem sediments above the Whin Sill and many swallow holes may be seen developed in the Scar Limestone.

Locality 14, Low Currick Rigg [NY 895 275]

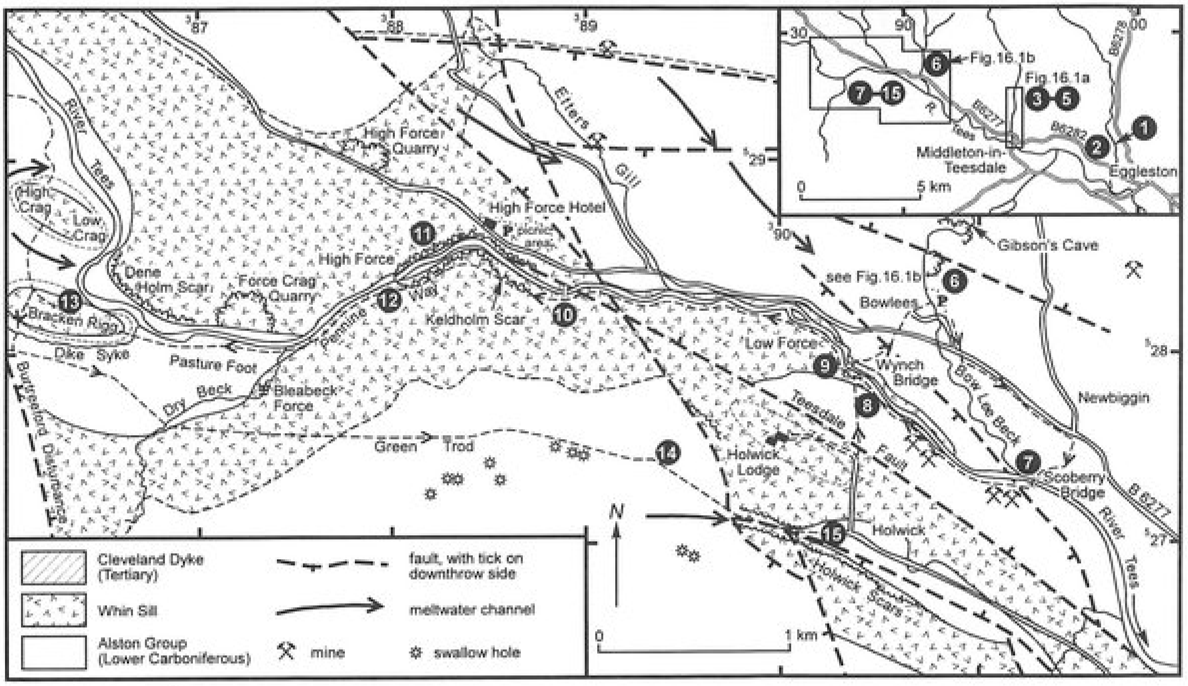
Below lies the dour gritstone Royal hunting lodge, Holwick House, prominently situated on top of a northwest–southeast elongated ice-moulded mound of glacial debris (one of many such glacial features in this part of Teesdale). On the skyline to the northeast is Coldberry Gutter, a man-made 30 m deep valley which cuts the watershed. This prominent feature is a 'hush', produced by mining and repeated flushing which removed some 2.5 million tonnes of waste in the 17th–19th centuries to produce lead ore concentrate.

Locality 15, Holwick [NY 901 271]

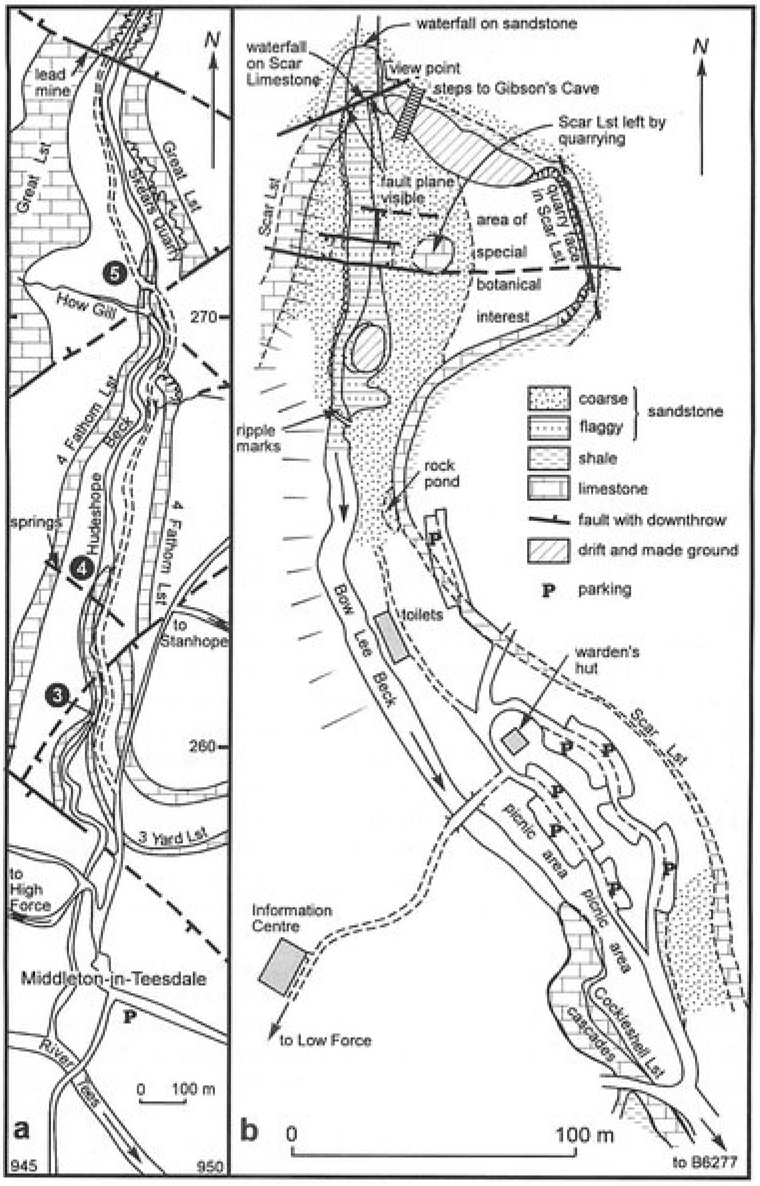
Fine cliffs of columnar dolerite form Holwick Scars and Crossthwaite Scars. These and the side valleys are probably fault controlled (Figure 16.2), but accentuated by the Devensian glaciation of the valley margin, which also accounts for the modified drainage, glacial deposits and periglacial scree slopes at the foot of these north-facing cliffs (Figure 16.4).

Walking northwards from Holwick Scars to Low Force (Locality 9) the route passes over two and possibly three faults of the Teesdale Fault complex, with a composite downthrow to the north of c. 100 m.

Bibliography



(Figure 16.2) Geological map of upper Teesdale around High Force. Inset showing localities described in text.



(Figure 16.1) (a) Geological map and localities in Hudeshope Beck, Middleton-in-Teesdale. (b) Geology of Bowlees Quarry and picnic area.

(Figure 16.4) The Whin Sill forming Howick Scars, looking east (Locality 15). Photo: J. Senior.