17 The Carboniferous and Permian rocks in southern County Durham

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Purpose

To examine the Carboniferous and Permian rocks, and the Tertiary Cleveland Dyke, of the lower Tees valley and adjoining areas, southern County Durham.

Logistics

The complete excursion occupies two days but can be split conveniently into shorter sections. A vehicle is essential because the localities are widely spaced (Figure 17.1). Cars can be parked at or near the roadside, and all roads are suitable for small coaches. Localities 1 and 2 involve up to 3 km walking on paths and rough ground in the Butterknowle and Cockfield Fell area. Localities 3–10 entail a total of up to to km walking along riverside paths of the Tees and Greta between Barnard Castle and Piercebridge, finishing at a quarry at High Coniscliffe (Locality 11). The excursion has been ordered for convenience of travel but could be rearranged in geological sequence to finish with Localities 1, 2, 10 and 11 (Figure 17.3). It would be best undertaken in early spring, when vegetation least masks outcrops and views.

Barnard Castle has pubs, public toilets, shops, restaurants and buildings of historical interest. Most of the other localities are near to villages with pubs and shops.

Note: If the Rivers Tees and Greta are in flood, this excursion should not be attempted.

Maps

O.S. 1:25 000 sheets NZ 02/12 Woodland & West Auckland, NZ 01/11 Barnard Castle & Gainford, NZ 21/31 Darlington; O.S. 1:50 000 sheets 92 Barnard Castle, 93 Middlesbrough & Darlington; B.G.S. 1:63 360 Sheet 32 Barnard Castle (solid and drift editions).

Geological background

The area is dominated by the Carboniferous rocks on the northern flank of the broad, open Middleton Tyas Anticline, an east–west striking Variscan structure (Figure 17.2) within the Stainmore Trough. The major subdivisions of the Carboniferous form three distinct east–west belts across the excursion area, generally dipping and younging towards the north (Figure 17.1). Dinantian rocks occupy the core of the anticline south of the River Tees (Barnard Castle to Piercebridge), the Namurian a central area from the River Tees to the north side of Langleydale, and the coal-bearing Westphalian rocks in the north form the southern edge of the Durham coalfield.

The Carboniferous succession is dominated by numerous repetitions of lithological sequences, called cyclothems, which change in character from dominantly marine in the Dinantian to fluviolacustrine in the Westphalian. This cyclicity reflects eustatic rise and fall of sea level, probably driven by an extended period of glaciation in polar regions, locally modified by tectonic and sedimentological effects. Dinantian lithologies are characterized by thick marine limestones, shales and sandstones, so called Yoredale cyclothems. During the Namurian, fluvial systems prograded from the northeast and east, resulting in the increasing dominance of medium to coarse-grained, usually cross-bedded sandstones. By Westphalian times, a vast floodplain had developed, with deltaic complexes building out into lakes and frequent episodes of soil formation with the development of a rich, tropical vegetation. These Coal Measures cycles consist of inter-distributary sands, silts and muds with well developed seatearths and coals, cut by medium-grained channel sandstones. Marine influence is limited to occasional thin bands of shales with marine fossils.

Following the Variscan Orogeny and a prolonged period of late Carboniferous and early Permian erosion, the Permian sequence, now dipping gently eastwards, unconformably oversteps successively lower units of the Carboniferous to the south. The fine-grained dolostone of the late Permian Raisby Formation (formerly the Lower Magnesian Limestone) is succeeded by the oolitic dolostone of the Ford Formation (formerly the Middle Magnesian Limestone). Younger Permian and Mesozoic rocks lie beyond the eastern margin of the area. During the early Tertiary the tholeiitic Cleveland Dyke, the most southerly representative of the Mull dyke swarm, was intruded into the country rock.

Apart from the exposures in the banks of the Tees and Greta, the southern part of County Durham has few good continuous sections. This is due to a variably thick covering of glacial deposits left by the most recent, late Devensian, ice advance. Resistant rock types form features in the landscape that rarely project through this mantle of drift.

Excursion details

Locality 1, Butterknowle [NZ 115 255]

Park on the B6282 at the south side of the bridge, then follow the track along the River Guanless downstream to where it bends sharply to the north. Continue straight on into the linear quarry which worked the Cleveland Dyke, here 1 o m wide, for roadstone. Note the method of quarrying whereby 0.5 m of the dyke rock was left as a retaining wall on each side to prevent the collapse of the Westphalian country rock into the workings. Where the retaining wall has fallen away, weak contact metamorphism can be seen, the effect most pronounced in fine-grained lithologies. The dyke is a porphyritic tholeiitic dolerite with a microcrystalline ground-mass and plagioclase feldspar phenocrysts; vesicles are also present. It is a typically massive, hard, dark grey to bluish-grey rock when fresh, but tends to darken when weathered and is easily distinguished from the country rock. The pattern of joints is rather irregular but appears to be sub-horizontal columnar jointing at the quarry face [NZ 118 253].

On Cockfield Fell [NZ 122 251] the dyke is 22 m wide, but entry to the workings is not possible there.

Locality 2 [NZ 131 251]–[NZ 118 255]

From the quarry by the River Guanless, cross rough ground to the south to the dismantled Bishop Auckland to Tebay railway, which crosses Cockfield Fell, and follow its course eastwards until it crosses the river. Upstream along the south bank, several exposures of Westphalian sediments, between the Brockwell and Busty coal seams, can be seen. There is evidence of past coal mining activity, with many spoil heaps, and on the opposite bank, a dismantled railway (West Auckland to Butterknowle) which served the mines of the area. These mines were worked by pillar and stall. The coal in the pillars is now being removed by opencast mining throughout the area. Siltstones overlying a ripple cross-bedded sandstone crop out at [NZ 126 253], a cross-bedded sandstone at [NZ 121 255], and shales dipping 5° to the northwest at [NZ 118 255].

Return to the vehicle, drive south through Cockfield and take the A688 via Staindrop to Barnard Castle.

Locality 3, Barnard Castle [NZ 053 159]–[NZ 048 165]

There is ample free car parking on the Demesnes [NZ 052 161], on the north bank of the River Tees. From the footpath on the south bank, reach the riverside near the mill where a traverse through Yoredale cycles of the early Namurian can be examined (Figure 17.3). The waterfall at the mill is formed by the dark-grey, thin-beddded, fine-grained Bottom Little Limestone (2.5 m) dipping to° north. The g m shale with limestone ribs between the Bottom and Top Little Limestones is exposed between Demesnes and Thorngate Mills. Cross the footbridge to where the Top Little Limestone (5 m) can be seen on the north bank upstream of Thorngate Wynd [NZ 048 161] forming a natural ledge across the River Tees. The overlying shale (6 m), which is poorly exposed, is capped by the Ten Fathom Grit (9 m) and can be seen under the County Bridge. This is succeeded by the Bottom (11 m) and Top (7 m) Crag Limestones with intervening shales; the castle stands on this sequence.

Return to the vehicle and from the market cross in Barnard Castle, take the minor road towards Whorlton, turning off to Egglestone Abbey.

Locality 4, Egglestone Abbey [NZ 066 149]

Park just before the Abbey Bridge under which the River Tees has cut a gorge in the grey, massively bedded, bioclastic Great Limestone which marks the base of the Namurian. Upstream, the soft overlying beds are covered until, on the northern side and set back from the river bank, the White Hazle Sandstone forms a cliff. The overlying Bottom Little Limestone is not seen. The siltstones, shales and thin Coal Sills sandstones between the Great Limestone and the White Hazle Sandstone are exposed further upstream in the northern bank of the river.

Drive onto the A66, turn left then first right to Greta Bridge.

Locality 5, Greta Bridge and Brignall [NZ 076 119]–[NZ 086 132]

There is parking between the bridge and the Morritt Arms. Follow the River Greta upstream on the west bank to an exposure of the Five Yard Limestone [NZ 076 119], the lowest limestone seen in the western half of the Middleton Tyas Anticline. It is a grey, fine-grained, bioclastic limestone with a fauna of crinoid stems, corals and brachiopods, gently dipping to the north. It forms a pavement at the river edge with the characteristic blocky pattern of the well-jointed Carboniferous limestones. Further downstream a brown, medium-grained, limonitic sandstone between the Five Yard and overlying Three Yard Limestones [NZ 078 124] is exposed in a river cliff. Return to the footpath and continue to the Scotchman's Stone [NZ 081 125], where the blue-grey, fine-grained, crinoidal Three Yard Limestone is exposed (better seen on the eastern bank). The Scotchman's Stone is a joint block of a brown, thick bedded, coarse-grained sandstone that has broken away from the cliff section seen above the eastern bank. It is seen again on the opposite bank at [NZ 085 128]. The top of this sandstone is approximately 8 m below the base of the Four Fathom Limestone which is not exposed. From the bridge looking north, the high ground is formed by the outcrop of the Great Limestone, which is seen in the next locality.

Return across the A66 to the 'Meeting of the Waters'.

Locality 6, 'Meeting of the Waters' [NZ 085 145]

The metalled road to this locality is private but may be used as a footpath. Approaching the confluence with the River Tees, the River Greta has cut through the top 20 m of the east–west striking Great Limestone, and is generally flowing down the gentle northerly dip slope into the River Tees.

Return to the A66, turn left and take the first left to Whorlton.

Locality 7, Whorlton Lido [NZ 108 145]–[NZ 113 145]

This is private property and a charge is made during the summer months for use of facilities and parking. However, there is a right of way through the property following the River Tees downstream to Wycliffe. Here the Tees flows over two small waterfalls formed by the resistant dark grey bioclastic Top Little Limestone. This 4 m thick unit dips 6° north, and is made up of three limestones, separated by grey shales that contain brachiopods. Overlying the Top Little Limestone are beds of fossiliferous shale and sandstone, which can be seen in the north bank and in Whorlton Beck.

Continue through Whorlton and take the A67 to Winston

Locality 8, Winston Bridge [NZ 138 158]–[NZ 143 163].

There is ample car parking by the roadside, on each side of the bridge. Take the footpath upstream on the south side to the river bank, then continue upstream with care along the water's edge to a small waterfall, formed by the to m thick, grey, fine-grained, thin bedded Knucton Shell Bed Limestone. This unit is full of well preserved brachiopods, principally

Spirifer. Turn back towards the bridge to work up the easterly dipping succession. Note 5 m of fossiliferous shales with fine-grained sandstone ribs overlying the shell bed, succeeded by 6 m of medium-grained ferruginous sandstone. This sandstone dips into the river under the bridge, and with care can be viewed on the north bank upstream of the bridge. Above the path between the road and the southern river bank just downstream of the bridge, it is possible with care to view the overlying grey, fine to medium-grained, Rookhope Shell Bed Limestone. There is a brachiopod-rich block of the limestone beside the footpath.

Continue east on the A67 to a lay-by on the right at Gainford Spa.

Locality 9, Gainford Spa [NZ 162 173]

From the lay-by, take the footpath to the river. Adjacent to the spa is an exposure of yellow to brown-weathered, medium-grained, laminated Namurian sandstone, with abundant carbonaceous laminae at the base. The upper unit truncates the underlying unit, approximately t m above the footpath. This sandstone lies between the Lower and Upper Felltop Limestone and directly above the Yoredale Coal.

Continue east on the A67 to Piercebridge.

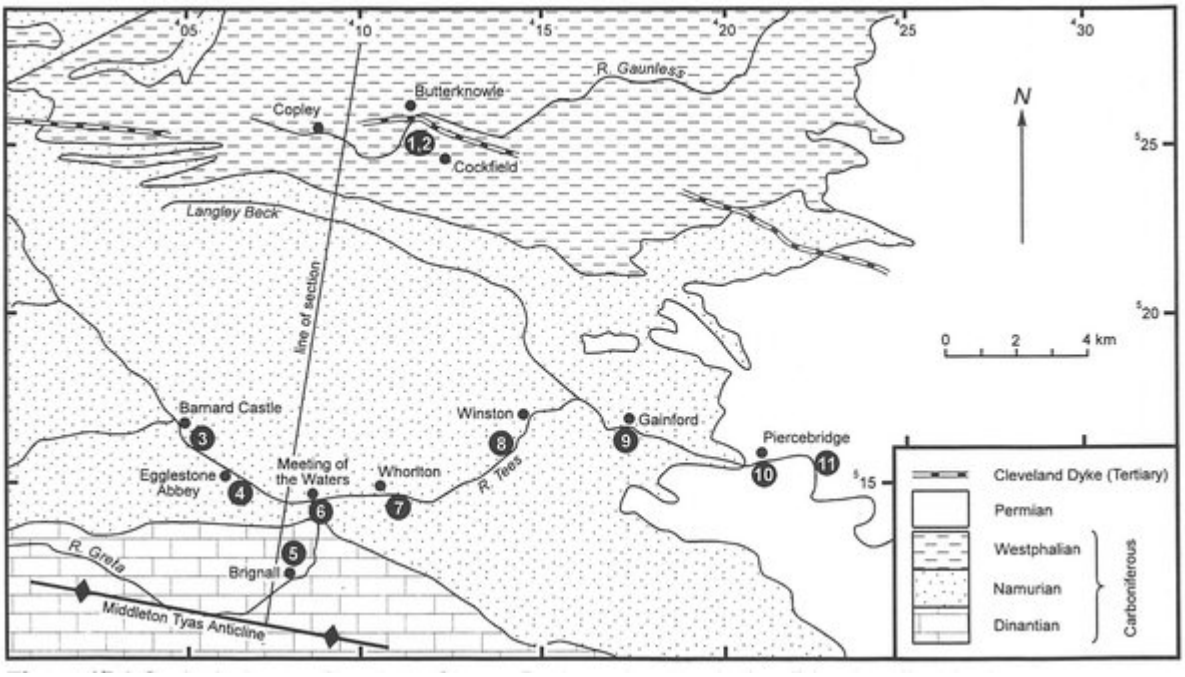
Locality 10, Piercebridge [NZ 2100 1545]

Park in the village (can be difficult) and walk to a gap in the wall at the southwest end of the bridge. Through the gap, take the slippery steep 'path' to the riverside and walk c.70 m upstream to a vertical cliff. The gently dipping rock exposed here is near the base of the late Permian Raisby Formation and just above the unconformity on the Carboniferous. The unconformity crops out to the west but is unexposed. The Raisby Formation comprises buff slightly calcitic dolostone that is mainly vaguely thin-to medium-bedded but is divided into 1–1.5 m major units by notch-forming thin beds of brown leathery clay. The rock is very finely crystalline and microporous and much of it has been fragmented by internal mineralogical changes ('autobrecciation'). Poorly-preserved moulds of brachiopods, bivalves, ostracodes and foraminifera are present in some beds.

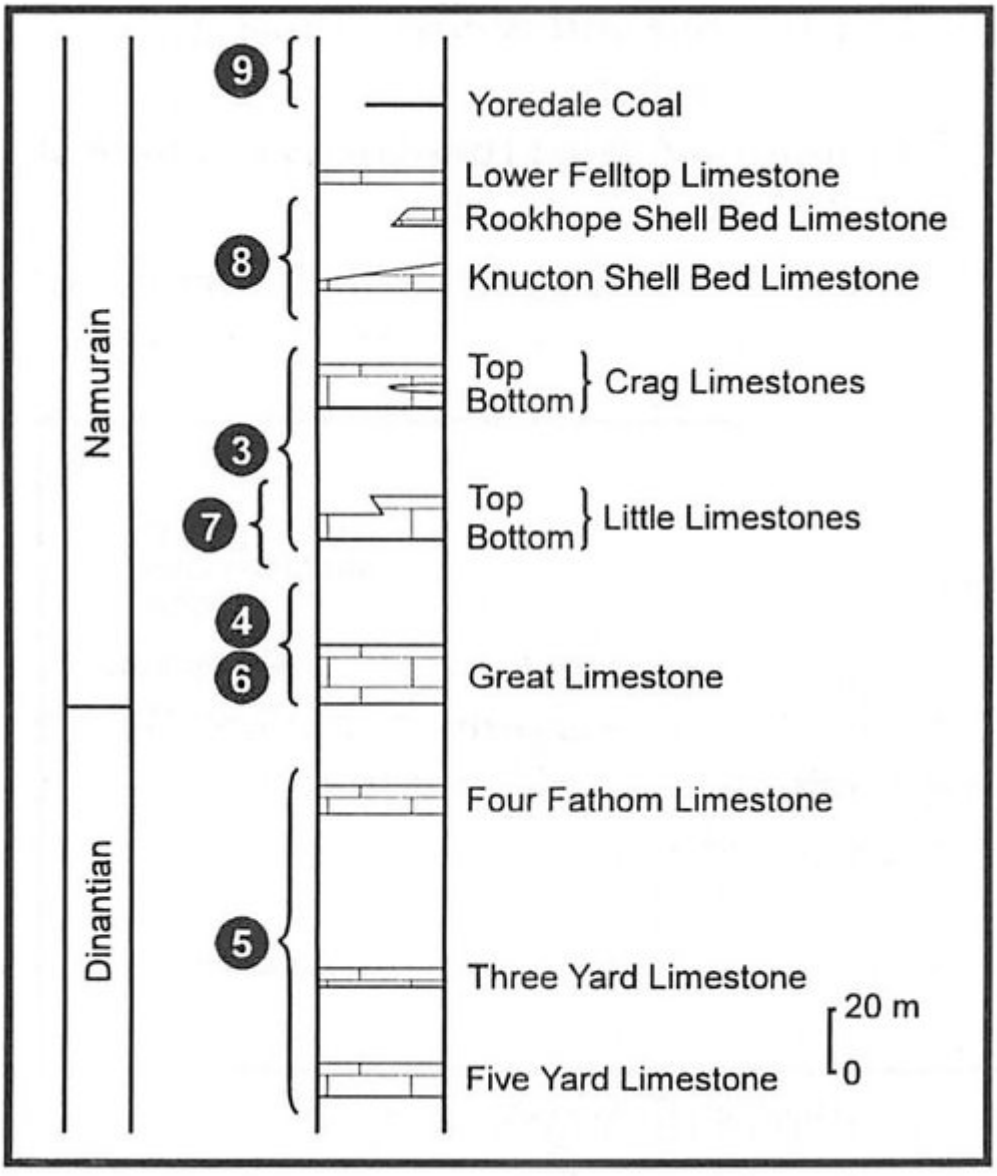
Continue east on the A67 to High Coniscliffe.

Locality 11, old quarry at High Coniscliffe [NZ 2251 1525]

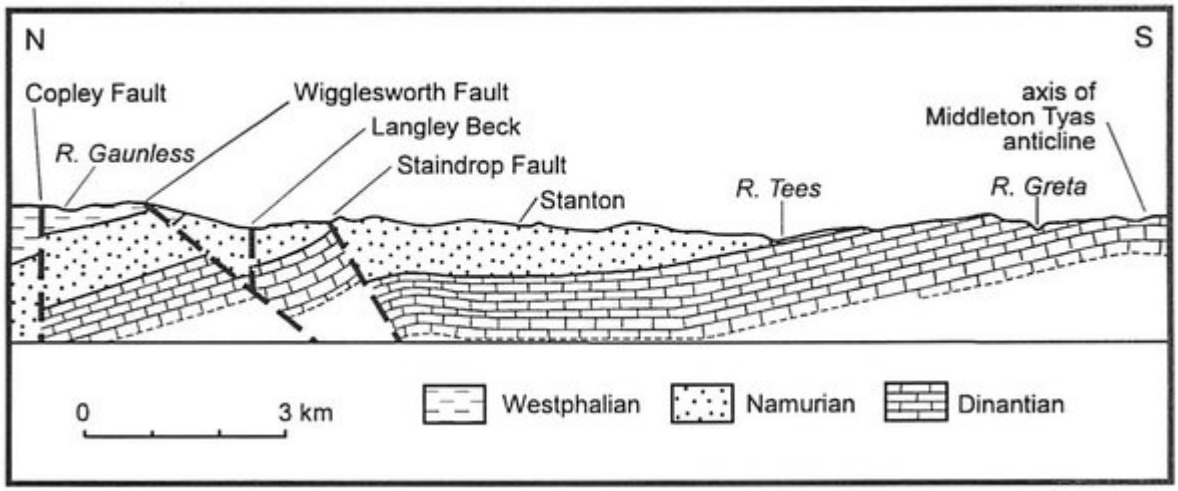
There is limited parking at the entry gate [NZ 2253 1530] on the A67 near the church. The enigmatic section in the main face is in lagoonal beds of the Ford Formation and comprises two rock units that meet at a sharp sub-horizontal very uneven surface (relief c.2 m). The lower unit (up to 3.5 m thick) is of soft, porous, finely oolitic buff dolostone in regular beds mainly 0.1–0.3 m thick, of which some are planar cross-bedded; the upper unit (up to 5 m) is generally massive finely crystalline pale grey hard limestone that bears faint hints of bedding (and ?cross-bedding) in a few patches. The massive unit has a reef-like appearance and it may be a lagoonal patch-reef, but samples of it have so far failed to reveal a diagnostic reef fauna. The limestone may be secondary ('dedolomite') and produced by the reaction between former dolostone and groundwater rich in dissolved calcium sulphate. Dome-shaped structures up to about 1.2 m across in a minor north face could be algal.



(Figure 17.1) Geological map of southern County Durham showing the localities described in the text (after Mills & Hull 1976).



(Figure 17.3) Succession of Carboniferous Limestone cyclothems between Barnard Castle and Piercebridge, indicating sections exposed at each locality.



(Figure 17.2) Geological cross-section of the northern limb of the Middleton Tyas anticline. Line of section on (Figure 17.1).