14 The Permian rocks of south-central Yorkshire

Denys Smith GEOPERM and Durham University

Purpose

To examine the Permian sequence at outcrop in south-central Yorkshire and to infer its depositional environments.

Logistics

A one-day excursion that may be followed in either direction and takes a minimum of about 8 hours (including a 1 hour break and travel totalling about 32 km between stops). All the exposures are close to the road with parking nearby.

Maps

O.S. 1:50 000 Sheets 105 York, and 111 Sheffield & Doncaster; B.G.S. 1:50 000 Sheets 70 Leeds, 78 Wakefield, and 87 Barnsley.

Geological background

The route follows the relatively narrow north–south outcrop of the Magnesian Limestone close to the depositional strike and the At and A 1(M) roads. The rocks to be seen (Table 14.1) are mainly of dolomite and comprise the carbonate units of cycles t and 3 of the English Zechstein (EZ) sequence (Smith *in* Rayner & Hemingway, 1974)

All the statigraphical units thicken gradually eastwards and contain ovoid cavities up to 0., m across on the sites of former anhydrite patches.

The unconformity, seen at Locality 5, is a gently rolling mature peneplane with a low eastward slope and, in the excursion area, only a few minor eminences. It represents up to 35 Ma of sub-equatorial desert weathering during which the underlying Carboniferous rocks were uplifted, folded, faulted, reddened and eroded. Scattered angular pebbles of Coal Measures rocks litter this old land surface and wind-blown sand (subsequently redistibuted during the ensuing marine transgression and seen at Locality 1) forms low sub-parallel ridges 2–8 km apart.

The long phase of desert conditions ended about 255 Ma ago when the area was rapidly flooded by the almost landlocked tropical Zechstein Sea in late Permian time, initiating about 5 Ma of intermittent marine transgressions and regressions as sea levels rose and fell and the floor of the Zechstein Basin gradually subsided. Shorelines extended as far west as the eastern slopes of the ancestral Pennines at times during Cycles EZ i and EZ3, but receded eastwards by up to 50 km during phases of low sea level such as those during much of Cycle EZ2.

The scarp-forming lower (Wetherby) member, seen at Localities 1, 2, 3, 4, 5 and 7, is here almost entirely a shallow water to beach deposit that shows slight onlap against eminences on the flooded old land surface. It built up a basin-margin shelf of varied carbonate sediments (now dolomitized) including muds (Localities t, 5), shelly oolites (Localities 2, 3, 4), shell banks or coquinas (Localities 2, 5) and patch-reefs (Localities 3, 4, 5). Cutting of the Hampole Discontinuity during a brief phase of slightly lower relative sea level initiated a relatively stable phase during which the Hampole Beds (Locality 7) were formed. This was then followed by a rapid re-inundation that led to the formation of the Sprotbrough Member; the crop of this lies so close to the depositional strike that all its exposures in the excursion area lie in a single facies belt, that of offshore large oolite sand waves (Locality 7).

Changes in the level of the sea or the sediment surface resulted in the main shoreline migrating far to the east near the end of Cycle EZ1 time and the Cadeby Formation was succeeded by the continental to lagoonal muds, silts, sands and evaporites (mainly gypsum but with some rock-salt) of the Edlington Formation (not seen on this excursion). Further

relative sea level change led to a widespread gentle re-transgression and the deposition of the partly dolomitized carbonate muds to sands of the shallow-water Brotherton Formation of Cycle EZ3 (Locality 6).

Excursion details

Locality 1 [SE 487 066], part of former Bilham Sand Quarry S.S.S.I. (25 mins)

Park in the gateway [SE 4870 0672] opposite the sharp bend in the lane and walk 120 m to the southeast. This is a small conserved exposure straddling the contract of the Basal Permian (Yellow) Sands and the overlying Wetherby Member of the Cadeby Formation (Cycle EZ i). The Carboniferous/Permian unconformity was formerly exposed here but now lies 1–1.5 m below the quarry floor.

The Basal Permian Sands here are about 3.3 m thick (including the part now covered) and comprise almost level-bedded, yellow-brown, mainly medium-grained arkosic quartz sand with a patchy very weak carbonate cement; most of the grains are sub-angular to sub-rounded but some of the larger grains are rounded to well-rounded. The deposit is thought to have been a desert dune sand that was redistributed when the Zechstein Sea flooded the area.

The contact with the Wetherby Member here is smooth, sharp and almost horizontal and the exposed basal part of the Wetherby Member comprises about 3.5 m of thin-bedded buff finely crystalline dolomite; the lowest 0.8 m of this may be an altered oolite. The dolomite contains several films and thin beds of brown dolomitic clay and scattered, poorly preserved casts of small bivalves; it is interpreted as a marine deposit, formed under relatively shallow water of low to moderate energy.

Locality 2 [SE 483 074], an old quarry in Second Plantation, Hooton Pagnell (20 mins)

Park on the wide verge at the sharp corner of the lane and scramble 15 m to the north-northwest. This small quarry is cut into the escarpment of the Wetherby Member of the Cadeby Formation and supplied building stone. About 6 m of mainly thick-bedded buff shelly oolitic dolomite is exposed, the lowest beds lying an estimated 3–4 m above the unconformity (Basal Permian Sands being thin or absent). Some of the beds are so rich in shelly remains, mainly of the bivalves *Bakevellia, Liebea, Permophorus* and *Schizodus,* that they constitute coquinas and must have been shell-banks when they were formed. Where joints are widely spaced, these thick beds yielded blocks large enough to be used for window and door lintels and gate posts, all to be seen in and around nearby Hooton Pagnell village (Locality 3). Fully marine but very shallow-water and at least moderate energy conditions probably prevailed here when these sediments were accumulating.

Fields immediately southeast of Locality 2 comprise a dip-slope, which is cut by a southwest–northeast fault that throws up Coal Measures to the southeast and brings in a second Permian escarpment at Bilham Sand Quarry (Locality 1).

Locality 3 [SE 4808), Hooton Pagnell village (45 mins)

There are several parking places, the largest just north of the church. *No hammers please!* This picturesque village, which has changed little for several centuries and featured in the Domesday Book, is built on solid rock in the scarp and crest of the Permian Escarpment. A leisurely stroll around the houses (but watch out for traffic in the narrow roads) reveals a host of small rock exposures, scarcely two the same, and close scrutiny of the locally-derived shelly building stone and stone gateposts is particularly rewarding.

The rocks exposed are about 7 m thick, the lowest lying an estimated 3–4 m above the unconformity. They comprise a highly varied complex of small patch reefs, some compound, and surrounding shelly oolite. The reefs are roughly oval in cross-section and up to perhaps 40 m across; they mainly comprise buff finely crystalline dolomite arranged in a disorderly pile of sack-like masses ('saccoliths') each typically 1–3 m across and 0.6 m thick and containing a sparse framework of the small twig-like bryozoan *Acanthocladia* (an attached filter-feeder). The reefs interfinger with, and sharply abut against, the oolite which is generally similar to that seen at Locality 2 but is less shelly and contains, additionally, laminae and lenses of very finely crystalline dolomite (formerly carbonate mud) that fills shallow channels

and drapes low-amplitude current ripples.

The most instructive building stones are in walls of buildings at the south end of the main street where a spectacular range of grains include algal-coated shell debris, algal-coated fragments of local Permian oolite up to 50 mm across, and almost infinitely varied ooliths, pisoliths and compound grains.

The exposures at Hooton Pagnell convey a vivid image of a shallow, white-floored tropical sea with scattered small sub-circular to elongate darker-coloured reefs rising less than a metre above the surrounding sea floor. These provided ecological niches for abundant small organisms that would not have survived in the current-swept exposed areas between and around the reefs.

Locality 4 [SE 483 116], Field Lane Quarry S.S.S.I. South Elmsall (40 mins)

Park at the roadside beside the quarry. *No hammers please; hard hats recommended*. This unique exposure of an almost complete cross-section of a patch-reef near the middle of the Wetherby Member of the Cadeby Formation is typical of reefs at this stratigraphical level and lies in bedded oolitic and pisolitic shelly dolomite. It comprises a core (C on (Figure 14.2)) of massive dolomite with a densely packed but poorly preserved framework of small twiggy bryozoans (as at Hooton Pagnell), overlain by a mantle of conspicuously domed stromatolites (S on Fig. (Figure 14.2)). The latter contain no shelly fossils but grade laterally into the surrounding bedded dolomite in which the remains of the bivalves *Bakevellia, Liebea* and *Schizodus* are locally abundant.

The rocks exposed at South Elmsall, like those at Hooton Pagnell, were probably all formed in clear sea water no more than a few metres deep; there is no evidence of subaerial exposure or erosion.

A notice board gives additional information and interpretation.

Locality5 [SE 487 177], Wentbridge road cutting and quarry (45 mins)

Park at the roadside, preferably on the west side north of the bend. The cutting is on the old At where it cuts through the escarpment of the Cadeby Formation; the scarp face here is particularly impressive, especially when viewed from the south of the River Went valley. The quarry is cut into the scarp in woodland on the east side of the road and some 70–100 m southeast of the cutting. Both cutting and quarry are somewhat overgrown in high summer, but well repay a little clearance.

The cutting exposes about 10 m of regularly bedded, partly cross-bedded oolitic dolomite of the Wetherby Member lying disconformably on Ackworth Rock sandstone of the early Upper Coal Measures. Some of the lower beds of the oolite contain many bivalves, especially *Bakevellia* and *Schizodus*.

The quarry exposes a typical bryozoan patch-reef lying in shelly oolitic dolomite as seen in the cutting. The reef is about 35 m across and 3 m thick and is formed of an untidy assemblage of sack-like masses, similar to those in the reefs at Locality 3; it abuts sharply against the surrounding oolites which contain very little reef-derived debris. A second, smaller, reef is also present and about 0.3 m of yellow-buff friable fine- to medium-grained sandstone beneath the oolite near the quarry entrance may be Basal Permian Sand.

The carbonate rocks at this locality were formed soon after the Zechstein Sea was created, probably under shallow clear sea water of normal salinity and moderate energy. The great abundance of bivalve casts near the base of the section is typical of the area and no reefs were formed before this shelly unit. The shells probably afforded a firm sea floor for the attachment of the reef-building bryozoans.

Locality 6 [SE 4713 2788], Fairburn village

Fairburn village, two exposures at the foot of the high wall on the northeast side of the road and about 60–go m northwest of The Three Horse Shoes public house (20 mins). There is parking almost opposite the exposure. *No hammering please*.

The Brotherton Formation (Cycle EZ3) is extremely uniform in this part of Yorkshire and where seen here is typical of much of the surrounding area except that it is dolomite. It comprises unevenly flaggy to thin-bedded finely crystalline buff dolomite with a variety of sedimentary structures (cross-lamination, ripples, cut and fill structures, etc.) that are suggestive of shallow-water accumulation. Some beds are graded, perhaps through being reworked during storms. Most beds are sparingly shelly but some are highly fossiliferous. Only two genera of bivalves — *Liebea* and *Schizodus* — are generally present, together with the 1 × 10 mm stick-like tubular remains of the supposed alga *Calcinema*. These remains, which occur locally in rock-forming proportions, commonly form aligned swarms on bedding planes. Salinity may have been slightly above normal and energy was generally low to moderate.

Limestone of the upper part of the Brotherton Formation was formerly widely worked in and around Brotherton, Ferrybridge and Knottingley but although quarrying has now almost ceased, hundreds of local walls and buildings testify to the vast amount of rock extracted and provide readily accessible examples of most of the rock-types present. The effects of differential subsidence caused by Tertiary or later dissolution of evaporites in the underlying Edlington Formation is seen in most of the quarry faces around Brotherton in the form of gentle sags, folds and minor faults.

There are many quarry faces of limestone of the Brotherton Formation east of the A1 . For those with time to spare, or those travelling southwards, excellent exposures are to be found at Brotherton [SE 481 267] and Knottingley [SE 498 239].

Locality 7 [SE 446 324], Micklefield Quarry S.S.S.I. (40 mins)

Park in the quarry, behind the houses. *No hammering please; hard hats recommended*. An important section that exposes the Hampole Beds and adjoining parts of the Wetherby and Sprotbrough members of the Cadeby Formation (EZ I Ca) (see (Table 14.2)).

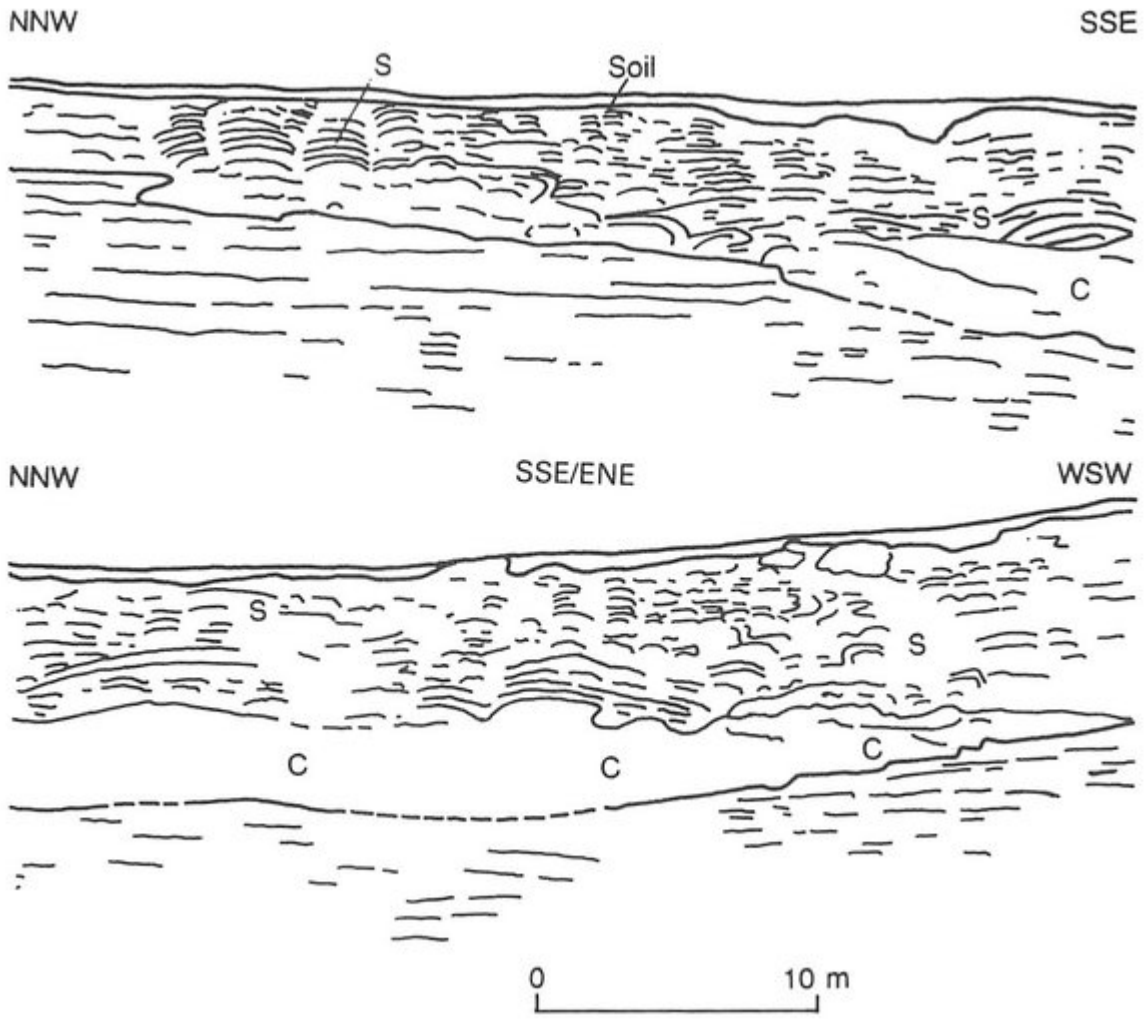
The Hampole Beds record a phase when the sea level fell by a few metres and subsequently rapidly recovered. The sea level fall led to subaerial exposure and the cutting of the Hampole Discontinuity, an erosion surface that can be traced from Ripon to Nottingham, and the return of the sea caused the shoreline to retreat westwards. The area then became part of a north–south offshore belt of large white submarine sand waves composed of ooliths. The sediment below the sea floor at this time was able to support a variety of burrowing organisms but the current-swept sea floor itself was an inhospitable and dangerous place and few invertebrates survived to be preserved as fossils. The 'fenestral fabric' in the lower part of the Hampole Beds is thought to have been caused by the expansion of trapped methane bubbles given off by decaying organic (microbial) films ('algal mats') in the laminated intertidal sediment. The 0.8 m bed in which it is present is an excellent and readily recognizable building stone and features in most of the stone-built houses and walls in New Micklefield.

A notice board gives additional information and interpretation.

Bibliography

	Modern names	*Old names*		*Thickness (m)*
Permian	Brotherton Formation	(Upper Magnesian Limestone)		13–18
	Edlington Formation	(Middle Marls)		7–21
	Cadeby Formation	(Lower Magnesian Limestone)	Sprotbrough Member	18–35
			Wetherby Member	15–25
	Basal Permian (Yellow) Sands, patchy			0–6
	unconformity			
Upper Carboniferous Coal Measures				

(Table 14.1) The Permian sequence in the excursion area.



(Figure 14.2) The bryozoan-stromatolite reef at South Elmsall.

	Thickness (m)	
Pale cream finely oolitic dolomite with large-scale wedge-bedding; many burrows in places.	c.7.00+	Sprotbrough Mbr
Pale cream finely oolitic dolomite, medium-bedded at top, flaggy below.	c.0.65	
Hampole Beds Two thin beds of plastic grey-green dolomitic clay separated by 0.10–0.15 m of pale cream finely oolitic dolomite. In recess.	c.0.17	
Pale cream-buff unevenly microbially-layered oolitic dolomite with dense layers ("crusts"), rip-up **clasts** and a strong fenestral fabric. A single bed, clearly distinguishable from a distance.	c.0.80	Wetherby Mbr
Pale cream-buff oolitic dolomite, slightly unevenly thick-bedded, with some cross-bedding and cut and fill structures; scattered poor casts of bivalves and gastropods. Formerly seen to 4 m but now . . .	0.60+	

(Table 14.2) The sequence at Micklefield Quarry.