Dawson's Plantation Quarry, Penshaw

[NZ 3355 5464]–[NZ 3375 5487]

Highlights

This quarry (box 5 in (Figure 3.2)) contains a superb exposure of a submarine debris flow that lies a few metres above the base of the Raisby Formation. Though generally less than a metre thick, the debris flow displays great lateral variation; it is part of an extensive, but discontinuous, thin sheet of disrupted strata that became unstable and moved east-northeastwards down the marginal slope of the Zechstein Sea. One or more earthquakes may have triggered the movement. The quarry also features many curved joints and minor movement planes, similarly possibly caused by contemporary, but slightly later earth movements.

Introduction

Dawson's Plantation Quarry, Penshaw, exposes about 7 m of limestones and dolomites of the Raisby Formation and contains a thin disturbed sequence interpreted as a submarine proximal turbidite or debris flow. The disturbed bed lies low in the face and perhaps 5–8 m above the (unexposed) base of the formation; it was first reported by Smith (Geological Survey fieldnotes for 1:10,560 Sheet NZ 35 SW, 1953) and later described more fully and interpreted as the product of a complex episode of downslope movement of partly-lithified sediment (Smith, 1970c). The deposit was re-examined in greater detail by Lee (1990), who recognized evidence of three closely-spaced pulses of downslope movement.

Description

The quarry is about 300 m long and lies along the south-east margin of Dawson's Plantation (Figure 3.25); it is cut into the north-west facing escarpment of the Raisby Formation and most beds dip regularly and gently east-northeastwards. The general sequence is given below.

	Thickness (m)
Dolomite, buff, finely crystalline, in irregular beds 0.05–0.30 m thick, gradational base	*c.* 1.0
Calcite mudstone, buff, in slightly irregular beds 0.03–0.1 m thick except in lowest 0.6 m where several more regular beds are 0.1–0.15 m thick; apparently barren	*c.* 2.5
Limestone breccio-conglomerate, grey, and associated grey wackestones, packstones and grainstones; very varied, locally shelly; base sharp and conformable up	to 0.9
Interbedded (thinly in lowest 0.4 m) buff, finely crystalline, dolomite and subordinate grey calcite–mudstone, sparingly shelly	0.9
Very thinly (0.002–0.02 m) unevenly interbedded grey calcite-mudstone and buff finely crystalline dolomite; sparingly shelly	1.6+

The breccio-conglomerate (proximal turbidite or debris flow) may be traced in the quarry face for about 250 m (Figure 3.26); it thins and becomes less pebbly south-westwards. The lithology of the deposit was investigated by Lee (1990) who identified six main rock types that are present in a roughly consistent, but laterally varied sequence:

6 (at top) Calcarenite, upwards-fining, interbedded with host calcite mudstones

5 Fine calcirudites and pebbly calcarenites, grading up into calcite- and then dolomite mudstones

4 Coarse, poorly-sorted, calcirudite, containing subspherical to tabular clasts

3 Calcirudite/calcarenite, upwards-lining

2 Slightly to severely deformed, interbedded calcite- and dolomite mudstones

1 Calcirudite, clast-supported, well-rounded calcite mudstone clasts

Lee noted penecontemporaneous erosion surfaces within the deposit, particularly below units 3 and 5, and carefully documented its lateral variability (Figure 3.27). He interpreted this variability as at least partly caused by complex channelling and reworking, the trend of the channels (and therefore the direction of sediment transport) being difficult now to determine; fresher surfaces in 1953 had previously revealed clast imbrication and deformation patterns suggestive of south-west to north-east sediment transport (Smith, 1970c, p. 7). Bioclasts, especially productoids, are much more abundant in the debris flow than in enclosing strata and, though some are deformed, are commonly unusually well preserved. Smith (1970c) has speculated that this good preservation may have resulted from rapid burial of the whole animals rather than slow accumulation of more fragile disarticulated valves and empty shells. Lee (1990) noted a good size correlation between lithoclasts and bioclasts and commented that skeletal remains are most abundant in the finer-grained calcirudites and calcarenites.

In addition, to the debris flow, the Raisby Formation in Dawson's Plantation Quarry features abundant, intersecting, curved low-angle joints and minor rotational movement planes (Smith, 1970c). Most of these are concave-upwards, with a tendency to grade downwards into bedding-plane slips; they cut all strata, including the debris flow.

Interpretation

Dawson's Plantation Quarry contains, without doubt, the best-exposed and most impressive proximal turbidite or debris flow in the Magnesian Limestone. Related disturbed strata are widespread (although not ubiquitous) at about the same stratigraphical level in north-east Durham; they vary greatly in character from place to place, ranging from graded turbidites, as at the former Downhill Quarry [NZ 348 601], to coarse breccias composed of slide-blocks up to several metres across as at the High Moorsley Quarry site (Smith, 1970c). Most of the disturbed strata are more fossiliferous than beds above and below, presumably because of rapid deposition, and almost all yield evidence of early sea-floor lithification of the carbonate muds. The rarity of disturbed strata at most other levels in the formation argues against inherent sediment instability through natural oversteepening of the deposition slope and may point to a brief phase of instability caused by contemporary local earth movements.

The low-angle curved joints and minor movement planes in the Raisby Formation at Dawson's Plantation Quarry are similar to others at many northern exposures of these strata, including the Claxheugh Rock site and sea cliffs in Sector 1 of the Trow Point to Whitburn Bay site. At these two localities the joints are truncated upwards at the base of the late Raisby Formation submarine slide sequence, suggesting that they too may have resulted from contemporary earth movements.

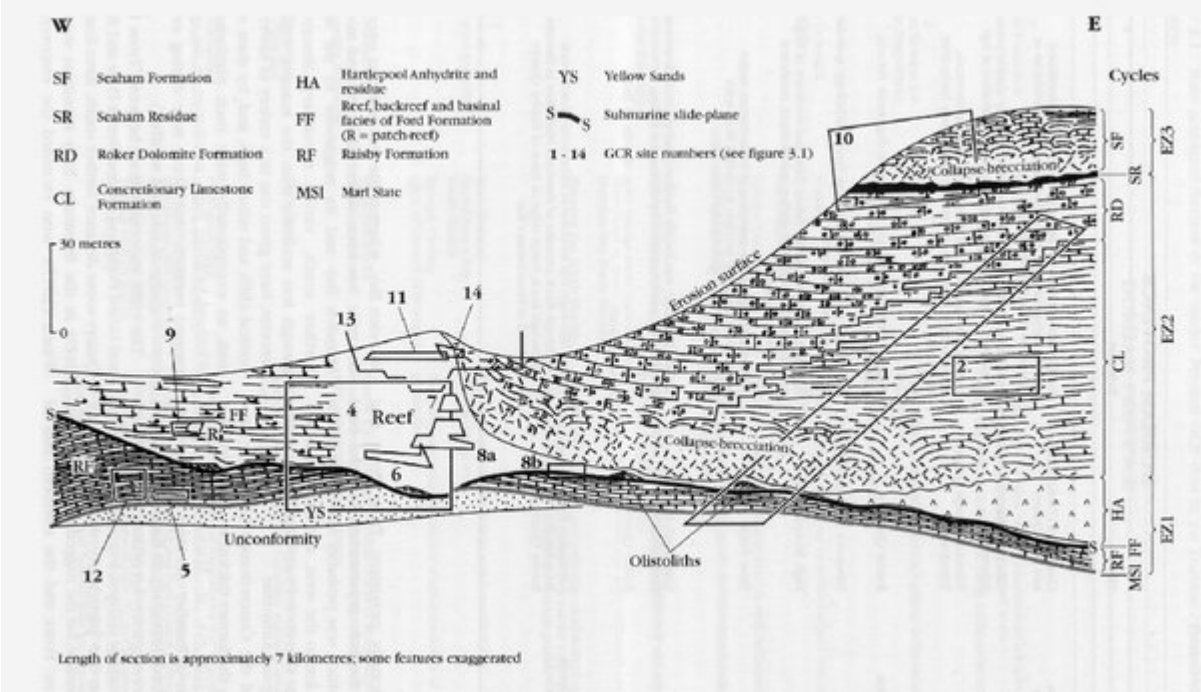
Future research

The sedimentology of the Raisby Formation has recently been investigated by Lee (1990, 1993) and there is little immediate scope for further research on this aspect of Dawson's Plantation Quarry. The transported fauna in the disturbed bed and related fall-out deposits, however, are likely more closely to represent the total contemporary benthos than the sparse, selectively-preserved fauna of undisturbed Raisby Formation strata and could repay further study.

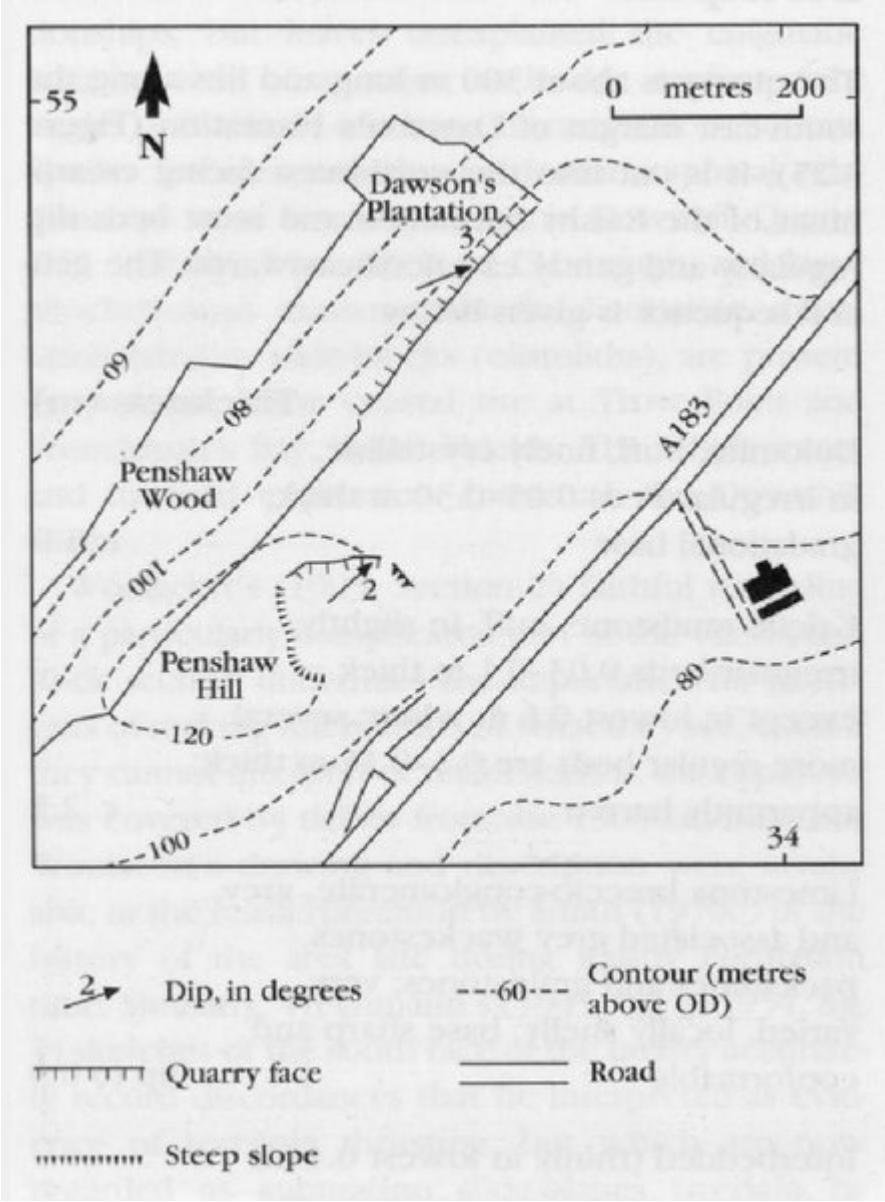
Conclusions

This site exposes the lower part of the Raisby Formation and is unique in that it is the best exposed example of a debris flow in the marine Permian of the Durham Province. The debris flow is thought to be part of a more extensive sheet of disrupted sediment that moved ENE down the depositional slope near the western margin of the Zechstein Sea. Such downslope movement of sediment may have been triggered by an earthquake. The transported sediment contains a better-preserved fauna than the strata below and above, which may be the result of rapid burial of the shelly organisms on the sea floor. The retention of this site is important for sedimentological study and for future research on the fauna of the disturbed sequence.

References

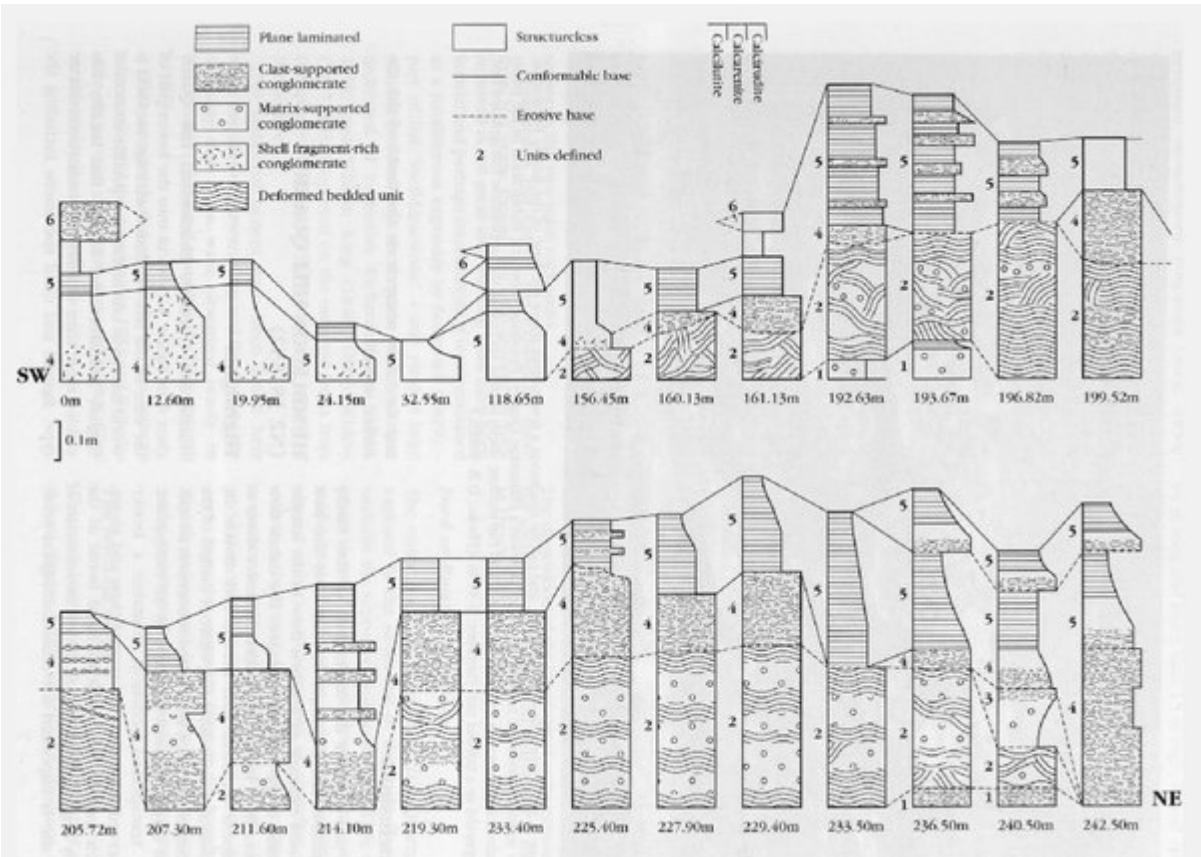


(Figure 3.2) Approximate stratigraphical position of GCR marine Permian sites in the northern part of the Durham Province of north-east England (diagrammatic). Some sites in the southern part of the Durham Province cannot be accommodated on this line of section and have been omitted. The Hartlepool Anhydrite would not normally be present so close to the present coastline but is included for the sake of completeness.



(Figure 3.25) Dawson's Plantation Quarry, Penshaw, and its environs.

(Figure 3.26) Debris flow of dolomite- and calcite mudstone a few metres above the base of the Raisby Formation. View to south-east near north-east end of Dawson's Plantation Quarry, Penshaw. Note the imbrication in the partly rounded clasts towards the top of the unit, and the mollusc shells seen in section in the uppermost fine-grained bed, interpreted as a fall-out tail. Hammer: 0.33 m. (Photo: D.B. Smith.)



(Figure 3.27) Disturbed strata in the Raisby Formation at Dawson's Plantation Quarry, showing their lateral variation. After Lee (1990, fig. 2.21).