Penstrowed Quarry

[SO 068 910]

Introduction

Penstrowed Quarry is located in Powys about 4 km west of Newtown. Detailed work on the Silurian of this area of mid-Wales stems essentially from that of Cummins (1957, 1959a, 1959b, 1963, 1969), who described the petrography, sedimentology and provenance of the Wenlock and Ludlow turbidites ('greywackes) of this central part of the Welsh Basin — the Montgomery Trough — and the country stretching northwards towards Denbigh in north Wales. Cummins' sedimentological work followed on from the numerous analogous investigations of Boswell (1949 and references therein) in the Denbigh Trough, the sediments and faunas of which were later scrutinized by Warren *et al.* (1984). Dimberline (1987), Dimberline and Woodcock (1987) and Dimberline *et al.* (1990) have, most recently, given fresh insights into the nature of the Wenlock turbidite system in mid-Wales.

Up until the 1970s, the lower Wenlock turbidites that make up Penstrowed Quarry were referred to the Denbigh Grits. This lithostratigraphical term was for many years applied to rocks of this general type and age throughout their outcrop — an almost continuous belt of strata from Conway in north Wales to near Llandrindod Wells in central Wales (see Cummins, 1957). The term 'Denbigh(shire) Grits' was apparently (Warren *et al.,* 1984) first used by Murchison (1859), though Sedgwick had slightly earlier (1843a) recognized such a unit under a different name ('Denbighshire Sandstones'). Ramsay (1881), in the second edition of the Geological Survey Memoir on north Wales, refers to the Denbighshire flags, grits and shales of Sedgwick. Boswell (1949 and previous papers) used the terms 'Denbigh Grits' or 'Denbigh Grits Series', and Cummins (1957) used 'Denbigh Grits'. Warren *et al.* (1984) differentiated a 'Denbigh Grits Group' for these rocks in their type area.

Subsequently, mapping by the British Geological Survey (1972) at Newtown led to a revision of the lithostratigraphy for the lower Wenlock turbidites (and other Silurian strata) of this area, the BGS naming them the Penstrowed Grits Formation. This formational name has since appeared on the Montgomery map (British Geological Survey, 1994) and has also been applied to rocks in the Rhayader area to the south (British Geological Survey, 1993; Davies *et al.,* 1997). Synonyms of the formation are the Castle Vale Formation of the Llanbister area 15 km to the south of Newtown (Dimberline and Woodcock, 1987) and the Fynyddog Grits (Wood, 1906) of the Tarannon outlier 8 km to the east (Dimberline and Woodcock, 1993).

In the Llanbister area the outcrop of Wenlock turbidites is affected by folds and faults of the Towy Lineament, this line also marking the south-eastern limit of strong cleavage; to the south-east of there the turbidite system abuts against the north-west flank of the Pontesford Lineament (Woodcock, 1984; Dimberline and Woodcock, 1993).

Penstrowed Quarry gives its name to the Penstrowed Grits Formation. The site superbly exposes the turbidites and associated sedimentary structures of this unit — features that are typical of the basin during the Wenlock. The Penstrowed Grits probably span at most the *riccartonensis* and *rigidus* biozones of the Sheinwoodian, with their age span (and thickness) decreasing to the south-east towards the basin margin, where they are probably confined to the *riccartonensis* Biozone (Dimberline, 1987).

Description

The faces of this quarry, which ceased working in 1994, were constantly changing during its active life. About 90 m of the Penstrowed Grits Formation are exposed, the beds dipping at about 50° to the north-west and having a steep NW-dipping cleavage. In their reviews of the deep water realm, Pickering *et al.* (1986, 1989) recognized a total of 7 facies classes (A-G). Five of these (B, C, D, E and G) are present in Penstrowed Quarry, which has been described by Dimberline (1987) and Dimberline and Woodcock (1993), after earlier, brief comments on certain sedimentary structures there by Cummins (1957).

Facies B comprises medium to thick beds (10 cm to > 100 cm) of granule to medium sand grade. Some beds do not have any internal organization, but typically they show an inversely graded granule to medium sand base, then a structureless coarse to medium sand division, followed by parallel- then cross-laminated medium to fine sandstones. Thick-bedded sandstones of this facies are well displayed in the quarry. Single event sandstones up to granule grain size and 50 cm in thickness are present; amalgamation of sandstones is common. Beds of Facies B represent deposition from a high density, then weakening to a low density, turbidity current. This facies forms, overall, a minor component of the Wenlock turbidites.

Facies C is characterized by medium-bedded (3–30 cm) sand–mud couplets, the beds usually showing graded bedding. They show the typical Bouma sequence (Figure 3.40) from structureless graded sand (Ta), through parallel-laminated sand (Tb), cross- and convolute-laminated sand (Tc), parallel-laminated fine sand and mud (Td), to structureless mud (Te). Some of these divisions may be missing. Beds of this facies were produced by traction sedimentation from a low density turbidity current, preceded for coarser beds by suspension sedimentation from a high density turbidity current. In the quarry, flute marks (corkscrew and nested types) and other sole structures can be seen on blocks of Facies C sandstones (Figure 4.52), this facies type being the most dominant of the Wenlock turbidite system.

Facies D is made up of thinly to thickly laminated (1–10 mm), graded silt–muds having, variously, parallel-, cross-, and convolute-lamination. These beds are the products of low-concentration, slow-moving, fine-grained turbidity currents.

Facies E comprises very thin to thin beds (1–10 cm) of graded mud, a very thin silt lamina often occurring at the base of a bed. Such beds received their sediment from muddy turbidity currents.

Facies G mainly consists of very thinly laminated siltstone, with silt laminae alternating with organic carbon-rich laminae, three to four of these couplets being present per millimetre. Graptolites occur on lamination surfaces, and bioturbation is sometimes in evidence. This facies is interpreted as hemipelagic fallout, with each couplet possibly representing a near-annual cycle of phytoplankton blooms alternating with intensified silt input into the basin. Bottom waters were generally anoxic, though brief intervals when more oxic conditions prevailed are indicated by the bioturbated hemipelagites (Dimberline and Woodcock, 1987; Dimberline *et al.,* 1990).

Interpretation

During the time the Penstrowed Grits and the Denbigh Grits were laid down, the Montgomery Trough and the Denbigh Trough were the two main basins of deposition within the deepest parts of the Welsh Basin ((Figure 4.53); see also Hurst *et al.,* 1978 and Holland, 1992). The grits of the Castle Vale Formation and the Fynyddog Grits were probably deposited in continuity with the Penstrowed Grits of the type area, though original continuity of the Penstrowed Grits with the approximately coeval Denbigh Grits Group of north Wales is less certain (Dimberline and Woodcock, 1993).

In the Montgomery Trough, four sediment distribution systems were in operation (Dimberline and Woodcock, 1987, 1993; (Figure 4.54)): sand-bearing turbidity currents, muddy turbidity currents, hemipelagic fallout and submarine slumping. The sand-bearing turbidity currents received supplies from the south-western end of the basin, flow direction, as indicated by sole structures, being to the NNE as far as Newtown, thereafter swinging more towards the north. The palaeoslope to the south-east, which was underlain and controlled by the Welsh Borderland Fault System, constrained the turbidity currents on this flank. The muddy turbidity currents probably received more local supplies, from the adjacent platform and slope. These muddy currents were more frequent and of less volume than the sand-bearing currents. Mean repeat times of 120 years have been estimated for those of the Penstrowed Grits Formation, this timespan being compatible with the mobilization of sediment during strong storms. Hemipelagic fallout (pelagic organisms, their faecal pellets, terrigenous silt) was the typical background sedimentation throughout the basin. Submarine slumping, probably induced by fault/seismic activity, took material down-slope.

In the Denbigh Trough, the dominant direction of sediment transport was towards the east (Figure 4.53).

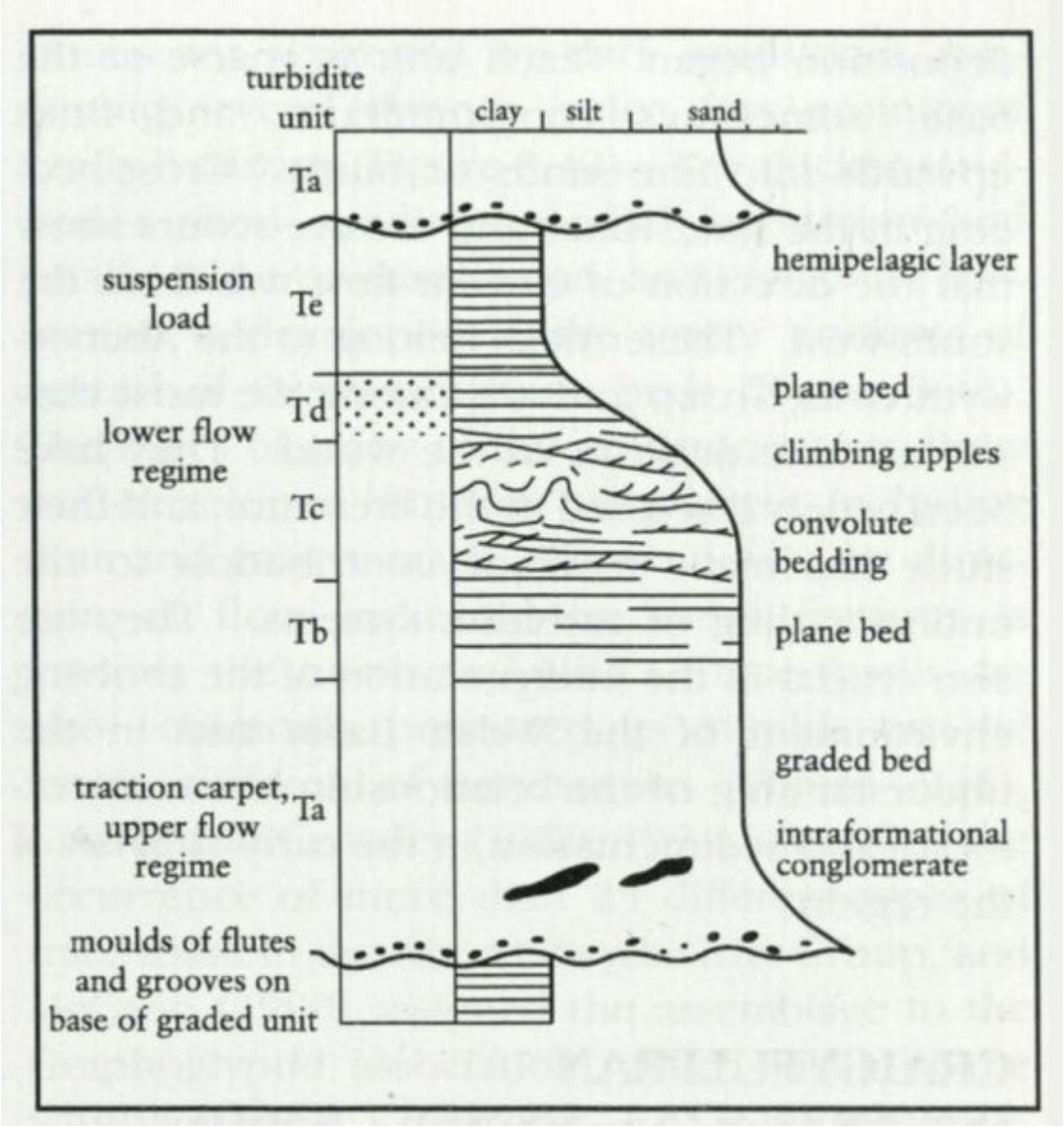
Penstrowed Quarry is linked most closely to the Ty Mawr site on the Denbigh Moors, where younger Wenlock (Homerian) basinal sediments of the Lower Nantglyn Flags Group occur. The latter are turbidites, but deposited overall

under less turbulent conditions.

Conclusions

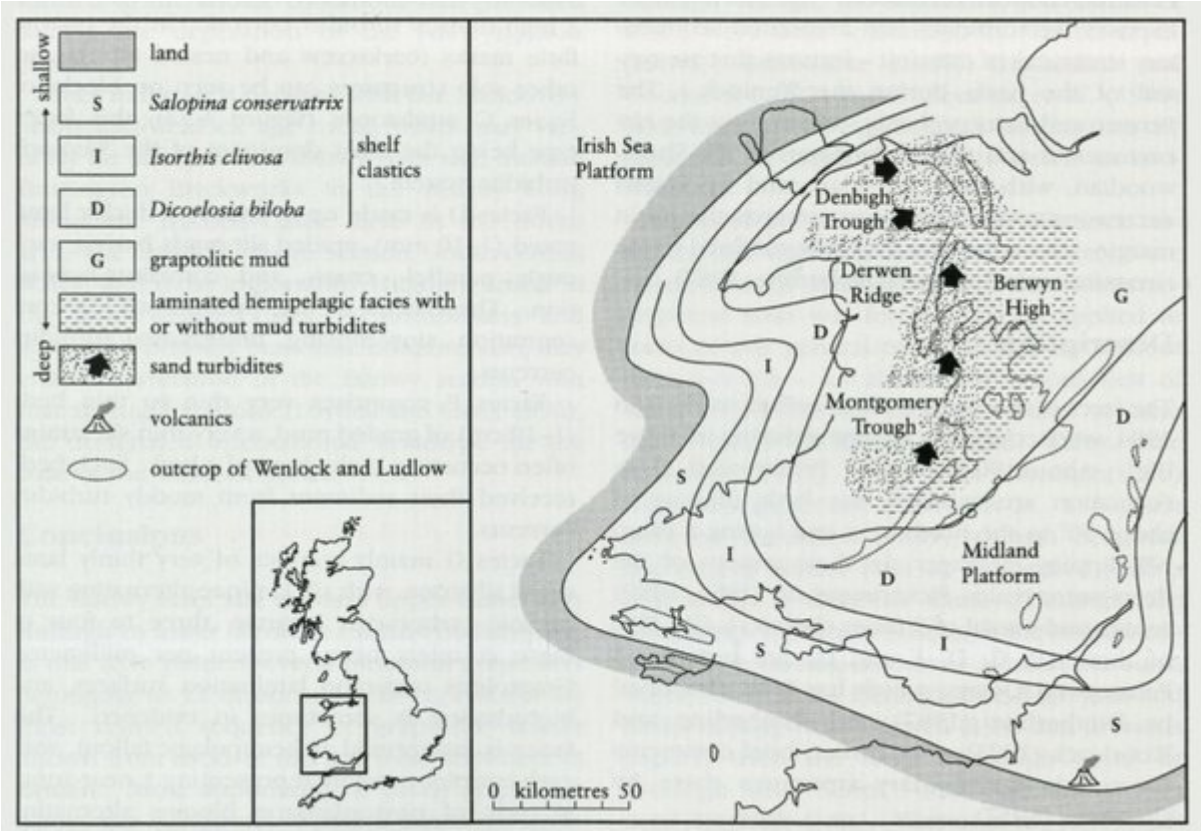
Penstrowed Quarry is an important site for demonstrating the sedimentology of the deep-water part of the Welsh Basin during early Wenlock times. It stands as the type locality for the Penstrowed Grit Formation, a lower Wenlock turbidite unit the sediments of which were deposited offshore, in the Montgomery Trough. Many of the facies and sedimentary structures classically associated with turbidity current derived sediments are displayed, together with horizons formed by the background hemipelagic fallout.

References

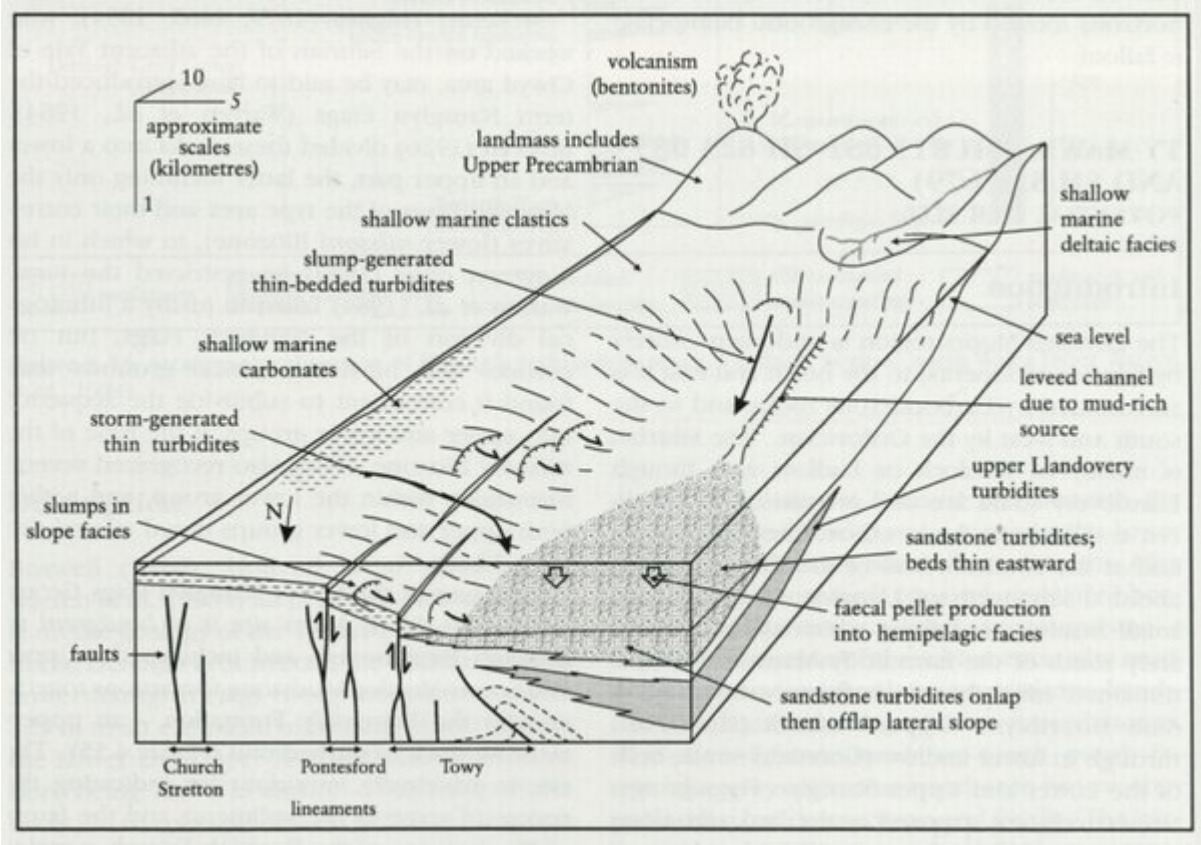


(Figure 3.40) Idealized graphic log of the full Tabcde Bouma turbidite cycle (modified from Selley, 1978, after Bouma, 1962).

(Figure 4.52) Penstrowed Quarry, Newtown, Powys. Flute casts on the base of a sandstone bed within a tur-biclite sequence. (Photo: Derek j. Siveter.)



(Figure 4.53) Map of Wales showing outcrop of Wenlock and Ludlow rocks, selected palaeogeographical features and depth-related faunal communities for rigidus Biozone time. Facies boundaries are conjectural away from outcrop control (after Dimberline et al., 1990).



(Figure 4.54) Reconstruction of the Wenlock turbidite system in relation to the contemporary tectonic setting of the Welsh Basin (after Dimberline and Woodcock, 1987).