# Sawdde Gorge, Powys

[SN 729 245]–[SN 733 237]

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## Introduction

The section described here lies in the Mon Sawdde gorge in Powys, south-central Wales, and is an extension to the 2 km-long section of strata of Llandovery to Ludlow age described in the companion GCR volume on Silurian stratigraphy (Aldridge *et al.,* 2000). It commences at Pont-ar-llechau bridge [SN 7285 2448] and extends for approximately 1 km upstream (Figure 5.16). Almost complete exposure in the bed and banks of the Mon Sawdde provides one of the most continuous sections in Wales and the Welsh Borderland through the upper part of the Ludlow Series, all of the P■ídolí Series and the basal part of the lower Devonian (Lochkovian) succession. Crucially, it includes a complete section through the early P■ídolí Tilestones Formation (the Long Quarry (Sandstone) Formation of Potter and Price, 1965), a probable lateral equivalent of the Downton Castle Sandstone Formation of the Welsh Borderland. The southern boundary of the original GCR site extended 150 m upstream of Pont-ar-llechau bridge, but it is recommended that it should be extended southwards to beyond Turkey Cottage [SN 7331 2365] to include the basal part of the St Maughans (Llanddeusant) Formation. It is a key section in the study of the nature and the timing of the late Silurian marine to terrestrial transition. In addition, it is important for the interpretation of the depositional environments of the rocks exposed. It also provides one of the few inland exposures of the stratigraphically important Townsend Tuff Bed (Allen and Williams, 1981a), as well as the younger Pickard Bay Tuff Bed and a number of other lesser tuffs.

Since Murchison's (1839) visit, the section has been included in several regional studies (Strahan *et al.,* 1907; King, 1934; Potter and Price, 1965; Squirrell and White, 1978; Bassett *et al.,* 1982). The sedimentology and palaeontology of the Ludlow sequence are well known (e.g. Stamp, 1923; Potter and Price, 1965; Richardson and Lister, 1969; Burgess and Richardson, 1995; David Siveter, 2000) and have been summarized in field guides by Simpson (1971), Bassett (1982a), Siveter *et al.* (1989) and Almond *et al.* (1993). The site played a key role in the previous definition of the Silurian–Devonian boundary and of the base of the Old Red Sandstone in central Wales (see Potter and Price, 1965, fig. 2 for a summary of the most important views). The section formed a major component of Almond's (1983) PhD study of depositional environments (Almond *et al.,* 1993; (Figure 5.17)). Almond (1983) retained the name 'Tilestones' for the Long Quarry (Sandstone) Formation, named the mid- to late P■ídolí rocks the 'Gwynfe Formation', and the early Devonian rocks the 'Llanddeusant Formation'. The name 'Tilestones Formation' is used by the British Geological Survey (BGS) in this area and in this account. The other names used by the BGS (Raglan Marl Group (now Raglan Mudstone Formation) and St Maughans Formation respectively; Squirrel and White, 1978) have found more general acceptance (Siveter *et al.,* 1989; David Siveter, 2000; Lane, 2000b) and are used in this account. (Figure 5.16) shows these and the names erected by Almond. Most recently, Jenkins (1998) examined the uppermost part of the section in an attempt to establish the extent of marine influence on Old Red Sandstone deposition around the Silurian-Devonian boundary in the Anglo-Welsh Basin.

## Description

The strata in the gorge dip steeply (up to 70°) towards the SSE. The base of the Old Red Sandstone (and of the Tilestones Formation) is exposed in the river bed 4 m downstream (north) of Pont-ar-llechau bridge, and in a cutting behind the former Three Horse Shoes Inn ([SN 7283 2447]; (Figure 5.18)). It is marked by a sharp change in colour and lithology, but with no angular discordance in bedding. Blue-grey, calcareous mudstones and siltstones (Lower Roman Camp Formation) are overlain by yellowish grey and green, micaceous sandstones and siltstones (Tilestones Formation). A regional unconformity has been postulated at the base of the latter (e.g. Potter and Price, 1965). About 14 km to the north-east of the gorge, the Tilestones Formation is said to rest unconformably on the late Ludfordian Upper Roman Camp Formation (e.g. Lane, 2000b), with the latest Ludfordian (Whitcliffe Formation) absent. In the Sawdde gorge, the

Tilestones Formation rests on strata assigned by Potter and Price (1965) to the Lower Roman Camp Formation (e.g. David Siveter, 2000), both the Upper Roman Camp Formation and the Whitcliffe Formation apparently being cut out.

The upper part of the Lower Roman Camp Formation consists of hard, blue-grey, calcareous mudstones with abundant hummocky siltstone and sandstone interbeds 5–20 cm thick. It contains a restricted, but abundant, marine fauna, much of which is concentrated in shelly lags within the coarser units (Potter and Price, 1965; Siveter *et al.,* 1989). The biostratigraphically important ostracod *Neobeyrichia lauerzsis* appears in the lower part of the formation, suggesting correlation with the Upper Leintwardine Formation (early Ludfordian) of the Ludlow Anticline (Potter and Price, 1965; David Siveter, 2000).

The Tilestones Formation is 18.5 m thick and consists predominantly of yellowish or green-grey, mica-rich, flaggy siltstones and fine- to medium-grained sandstones. A 0.5 m-thick mudstone occurs near the base. Bedding is conspicuously thicker (0.15–0.5 m) than that in the Lower Roman Camp Formation. A limited faunal assemblage includes brachiopods (e.g. *Lingula minima, Protochonetes ludloviensis* and *Microsphaeridiorhynchus nucula*) (Potter and Price, 1965; Almond, 1983), bivalves (e.g. *Modiolopsis complanata*), gastropods (e.g. *Turbochelius helicites, Loxonema gregaria*), crinoid ossicles, nautiloids (*Orthoceras* sp.), carbonaceous plant fragments and an assemblage of kloedinine beyrichiacean ostracods (Siveter *et al.,* 1989; David Siveter, 2000). Most of the sandstones are planar laminated or low-angle cross-laminated, some have bases resting on erosion surfaces. Many contain concentrations of shell fragments, green intraformational mudstone clasts (up to 3 cm) and faecal pellets; rare acid igneous clasts also occur. Locally, particularly near the top of the formation, communities of bivalves are preserved in life position and, in some of the thinner beds, burrowing (*Skolithos* sp.) destroyed all of the original sedimentary structures.

To the south-west of the Mon Sawdde, the Tilestones Formation is overstepped by the 'Green Beds' (the Capel Berach Beds of Potter and Price, 1965), the local basal unit of the overlying Raglan Mudstone Formation (Squirrel and White, 1978). In the Mon Sawdde, approximately 7 m upstream (south) of Pont-ar-llechau bridge, the formation is conformably overlain by the Raglan Mudstone Formation (Figure 5.17). The basal 26 m (the Pont-ar-llechau Member of Almond, 1983) are distinguished by very fine- to medium-grained, highly quartzitic sandstones with thin green siltstones and mudstones. The lowest 5 m of these comprise an upward-coarsening sequence of stacked, grey and green-grey, micaceous sandstones, which preserve horizontal to low-angle cross-lamination where not homogenized by bioturbation. *Skolithos* burrows are preserved locally and a bedding plane near the top exposes large *Fucusopsis*-type burrows. Some of the sandstones are composite bodies. Many of them rest on erosion surfaces, their bases containing scattered quartz granules, intraformational mudstone clasts and/or shell fragments; one shows excellent soft-sediment deformation structures. Interbedded with the sandstones are dull green and yellowish green lenticular siltstones and mudstones.

Above are 15 m of red, micaceous, ripple cross-laminated and wavy bedded, very fine-grained sandstones and homogeneous siltstones and mudstones, some arranged in fining-upward packages. Bioturbation is widespread and the beds have yielded a poor, low-diversity, nearshore, shallow marine fauna, including the brachiopod *Lingula cornea,* the gastropod *Cymbularia carina,* the ostracod *Leperditia* sp., and a range of forms also present in the Tilestones Formation (e.g. *Modiolopsis complata, Turbochelius helicites, Lingula minima*)and older strata (*Loxonema conicum*)(Potter and Price, 1965). Almond (1983) recovered a cornua of *Cyathaspis banksi,* an ostracoderm known from the Downton Castle Sandstone Formation (Bassett *et al.,* 1982).

The topmost 6 m of Almond's Pont-ar-llechau Member consists of dull red, massive mudstones and very fine-grained, ripple cross-laminated sandstones interbedded with wavy, flaser and lenticular bedded siltstones. Some of the sandstones are gritty and pebbly and all of the lithologies are commonly intensely bioturbated, with modiolopsids and lingulids seen in life position.

The succeeding 750 m of strata (the 'Middle division' and 'Upper division' of Almond's Gwynfe Formation) are typical of much of the Raglan Mudstone Formation in south and central Wales and the Welsh Borderland. They consist predominantly of massive, bright red, silty mudstones/siltstones with moderately well-developed calcrete profiles, and minor purple, grey and pink, fine- to medium-grained, lithic sandstones. The sandstones are typically 1 m to 3 m thick, locally pebbly, and have sharp bases resting on erosion surfaces. Internally, they generally show a fining-upward trend, with planar cross-bedding at the base passing up into horizontal lamination and ripple cross-lamination with lenticles of

siltstone and mudstone at the top. Desiccation cracks and Skolithoform burrows are common at their tops, and some sandstones pass up into thin units of ripple cross-laminated silty mudstone.

Except for trace fossils, particularly *Beaconites antarcticus,* the 'Middle division' and 'Upper division' of the Raglan Mudstone Formation are poorly fossiliferous and have yielded only a few specimens *of Modiolopsis* sp., *Pachytheca* sp. and disseminated plant debris. Airfall tuffs are common (Almond, 1983; Almond *et al.,* 1993), the thickest of nine recorded being the Townsend Tuff Bed (2.9 m). As at Little Castle Head (see GCR site report, this chapter; Lane, 2000c), and at most localities in south-central Wales (Allen and Williams, 1981a), the Townsend Tuff Bed comprises three closely spaced airfall tuffs (A, B and C), which are sheared here. Fall A (0.25 m) is a muddy dust tuff with its upper surface characteristically strewn with faecal pellets. Fall B comprises fine-grained, cream, purple and yellow, crystal- and crystal-lithic tuff passing up into a siliceous dust tuff. It is truncated by an erosion surface overlain by Fall C, which consists of coarse- to medium-grained crystal-lithic tuff grading up into dull red and green mottled dust tuff. A tuff 23 m above is correlated by Almond (1983) with the Pickard Bay Tuff Bed of south Pembrokeshire. It is 0.75 m thick and consists of two superimposed tuffs, the lower fine-grained and crystal-lithic, the upper a muddy dust tuff. Both the Townsend and Pickard Bay Tuff beds outcrop in weathered recesses on the west bank of the river *c.* [SN 7325 2385] and the outcrop of the Townsend Tuff Bed can be traced in the adjacent field in a waterlogged gully.

Although still dominated by mudstones, the overlying 100 m of strata (the 'Upper division' of Almond, 1983) show a general coarsening-upward trend, through an increase in the thickness and the frequency of the sandstones, until the base of the St Maughans Formation is reached about 20 m south of Turkey Cottage. Almond (1983) and Jenkins (1998) identified two types of cyclic facies sequences in these beds. The first (5–8 m thick) comprises sandstones above a basal erosion surface, fining upwards through trough- and low-angle cross-bedded, fine- to medium-grained sandstones into micaceous, planar-laminated siltstones (up to 1.5 m thick) and then blocky siltstone with calcrete nodules. The second (4.4–8.7 m thick) is characterized by a coarsening- and then fining-upward trend. Typically, it consists of ripple cross-laminated siltstone (0.3–1 m thick) overlain by low-angle and trough cross-bedded sandstones (2.5–3 m thick) that fine upwards into thin (up to 1 m), planar-laminated and ripple cross-laminated siltstones. These are in turn overlain by a micaceous, blocky siltstone unit (up to 4.6 m thick), commonly containing calcrete nodules.

There are numerous moderately mature calcrete horizons in the uppermost beds of the Raglan Mudstone Formation, although the thick limestone development of the Psammosteus (Bishop's Frome) Limestone as seen elsewhere is absent. A 10.2 m-thick horizon of siltstone with calcrete nodules (Stage I–II calcrete of Machette, 1985) 10–20 m south of Turkey Cottage [SN 733 238] marks the top of the formation (Jenkins, 1998).

The basal 36 m of the St Maughans (Llanddeusant) Formation consists of interbedded sandstones and siltstones with minor conglomerates arranged in three fining-upward sequences (Jenkins, 1998). The sandstones include some laterally accreted units. The conglomerates rest on erosion surfaces and are intraformational, except for four thin (2–7 cm) extraformational beds near the base of the formation, which have small (up to 5 mm) quartz pebbles in addition to intrabasinal mudstone and siltstone clasts (Jenkins, 1998).

## Interpretation

The period between the late Ludlow and late P■ídolí was one of dramatic palaeogeographical and environmental change within the Welsh Basin (Woodcock, 2000b). The differentiation between basin and shelf that had existed throughout Ordovician and Silurian times (Holland and Lawson, 1963; Cherns, 1988) broke down as Avalonia finally docked with Laurentia, initiating basin inversion (Allen, 1985; Woodcock and Gibbons, 1988). The Sawdde Gorge is situated on the south-east flank of the Tywi Anticline, a major Caledonian lineament which formed part of a fault system that defined the southern margin of the basinal area (Woodcock and Gibbons, 1988). To the south of the fault system, the strata of the Ludlow Series formed mainly in shallow shelf and nearshore marine environments and show an overall shallowing trend that culminated in a regional hiatus at the base of the P■ídolí Series (Bassett, 1982a; David Siveter, 2000).

This unconformity (Straw, 1930; Walmsley, 1962; Squirrel and White, 1978; Bassett *et al.,* 1982) is placed at the base of the Tilestones Formation in the Sawdde Gorge (Potter and Price, 1965; David Siveter, 2000), although there is no angular discordance and no basal lag deposit, as reported elsewhere at this level.

The Tilestones Formation is interpreted as the product of shallow marine deposition, probably sourced in part from volcanic rocks to the south-west (Allen, 1985; cf. Almond, 1983). Sedimentation occurred in a range of nearshore to marginal marine and lagoonal settings against the NW–SE-trending shore of the 'Pretannia' landmass to the south (Potter and Price, 1965; Squirrell and White, 1978; Cope and Bassett, 1987). Almond (1983) interpreted the basal 3 m (the Capel Horeb Member) as the deposits of a brackish-water lagoon or protected shallow marine embayment, the sandstones representing washover storm events.

The upward increase in grain size and frequency of higher-energy bedforms were interpreted by Almond (1983) to be caused by increased wave action, or by encroachment of a tidal-flat complex into the area. Above is a transgressive sequence of lower to middle shore-face sediments (the Long Quarry Member of Almond, 1983) that were deposited on a high-energy coastline periodically affected by storm waves. The shelly sandstones were possibly the deposits of tidal channels.

Almond (1983) interpreted much of the Raglan Mudstone Formation as the deposits of the lower reaches of a muddy, low-lying coastal plain (cf. Allen, 1985). However, the basal 5 m (of the Pont-ar-llechau Member) are interpreted by her as the infilling of a shallow lagoon by washover sheet sands. The succeeding 15 m-thick, hetero-lithic sequence is interpreted as the deposits of small tidal channels. The uppermost 6 m of the Pont-ar-llechau Member are interpreted as a stacked, generally regressive sequence of sub-tidal to supratidal deposits, the latter containing evidence of pedogenesis in the form of small calcrete nodules.

The sandstones in the succeeding mudrock-dominated, calcrete-prone 'Middle division' and 'Upper division' are interpreted by Almond (1983) as the deposits of low- to moderately sinuous river channels, perhaps subjected to tidal influence. The calcretes point to carbonate soil formation on the alluvial floodplain. Jenkins (1998) distinguished fining- and coarsening-upward sequences in the uppermost 100 m of the Raglan Mudstone Formation, emphasizing the importance of rapid run-off, variable discharge and the flashy nature of sedimentation in the Old Red Sandstone. The fining-upward sequences are interpreted as the bars and fills of wide, shallow channels prone to overtopping, the overlying sediments probably being deposited during one discharge event. Siltstone-based, coarsening-upward sequences may have been the products of flood events, with initial deposition of silt from dense hyper-concentrated sediment- and soil-rich flood waters followed by sand deposition from streams derived from the upper catchment.

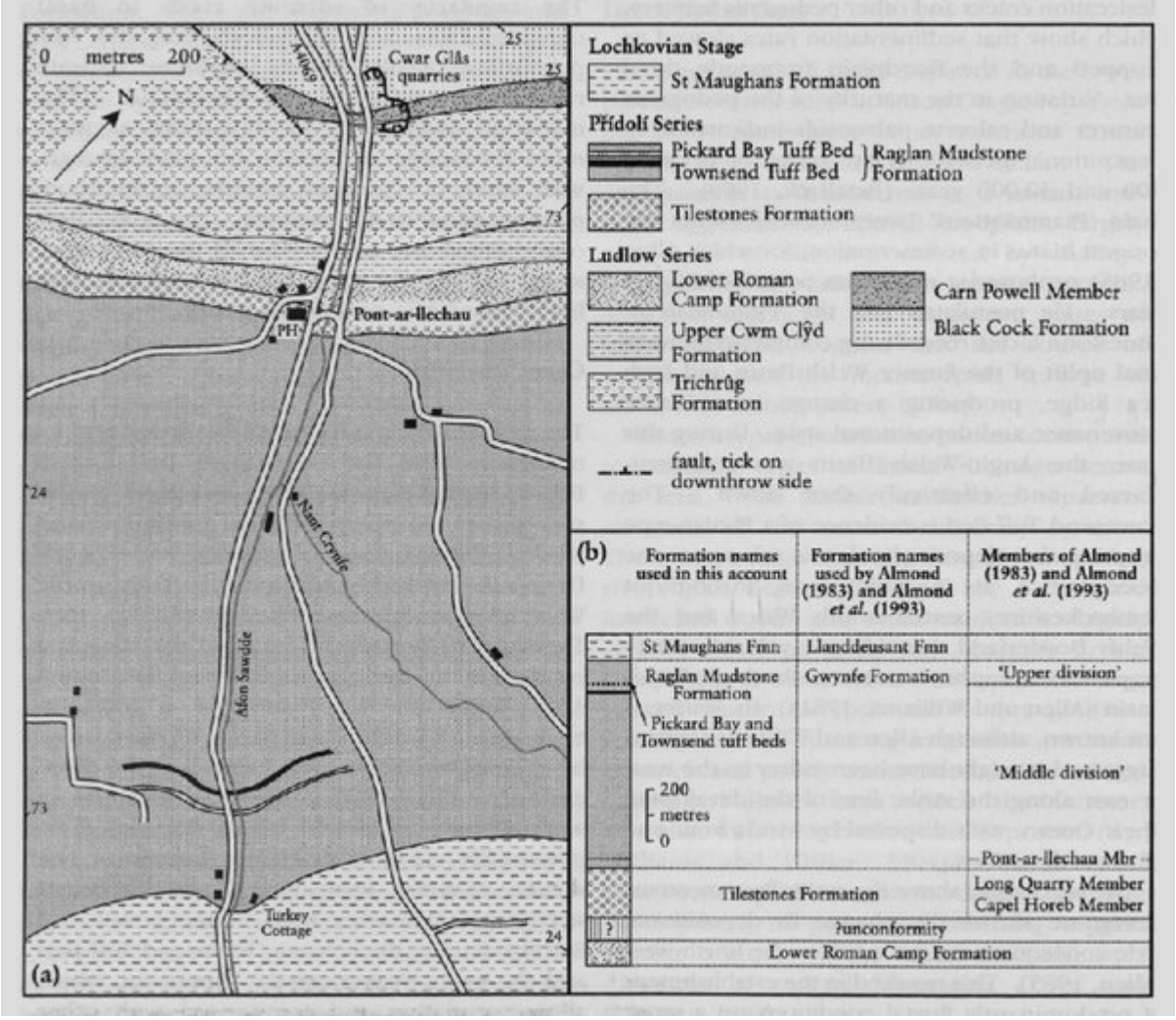
The absence of a thick, mature calcrete at the top of the Raglan Mudstone Formation equivalent to the Psammosteus Limestone was ascribed by Almond *et al.* (1993) to more continuous subsidence and sedimentation in this area, perhaps controlled by movement on the nearby Carreg Cennen Disturbance (Cope, 1979).

The St Maughans Formation represents a range of fluvial channel, overbank and floodplain facies similar to those at the top of the Raglan Mudstone Formation, but with channelized sandstones becoming thicker and more common at the expense of both finer-grained overbank and sheet-flood sandstones and argillaceous calcretized floodplain mudrocks. A thin, siltstone-based, coarsening-upward unit at the base of the formation may have been the deposit of a two-peak, single discharge event similar to those in the Raglan Mudstone Formation.

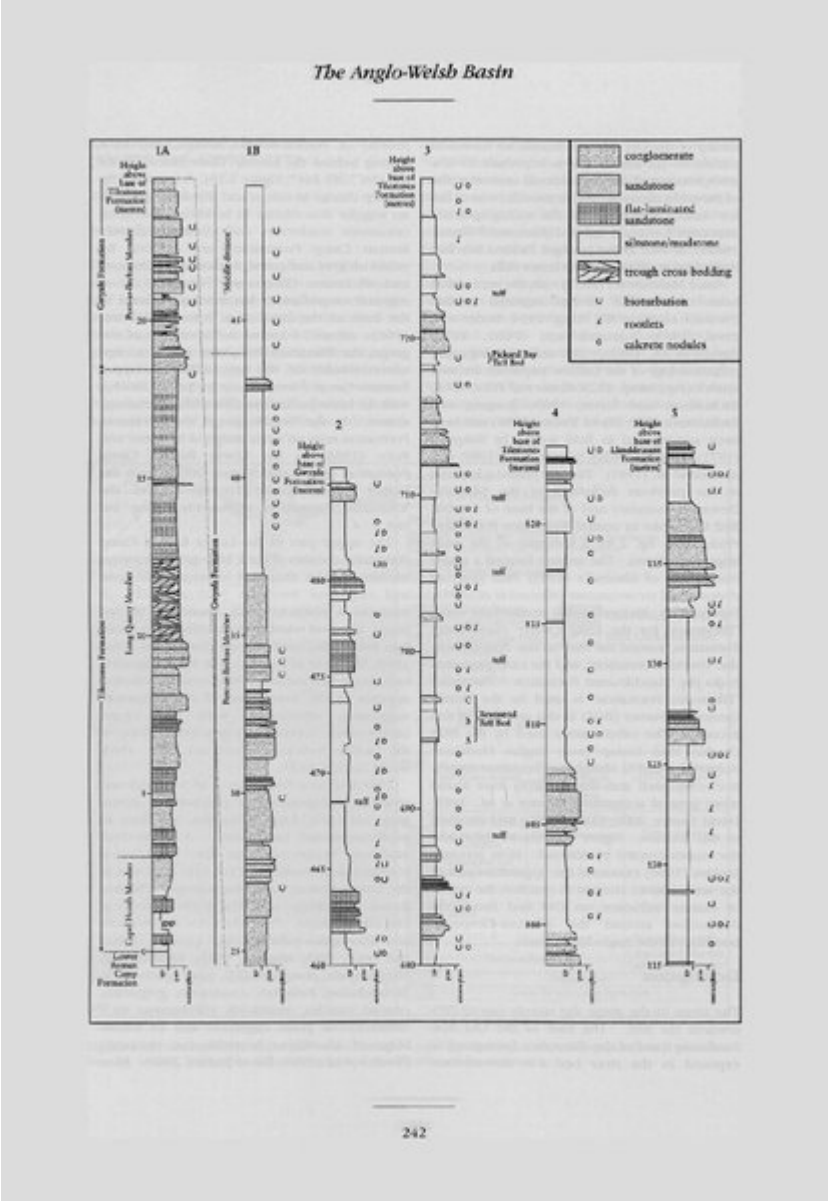
## Conclusions

The Sawdde Gorge site provides a unique transect through the Silurian and Early Devonian rocks of south-central Wales. Together with the sections through earlier Silurian rocks described in the GCR volume on Silurian stratigraphy (Aldridge *et al.,* 2000), the site and recommended extension present one of the most complete successions through the Silurian strata of the Welsh Basin and succeeding Old Red Sandstone of the Anglo-Welsh Basin. The part described here is a key section in the understanding of the transition from late Silurian offshore marine to littoral and terrestrial environments. The nature of the junction between the rocks representing the offshore and littoral environments warrants further examination. The site is one of only a handful of inland exposures of the stratigraphically important Townsend Tuff Bed. The recommended extension to the GCR site provides a complete section through the late Silurian (P■ídolí Series) Raglan Mudstone Formation into the early Devonian St Maughans Formation, and provides an opportunity for further investigation of the Silurian–Devonian boundary.

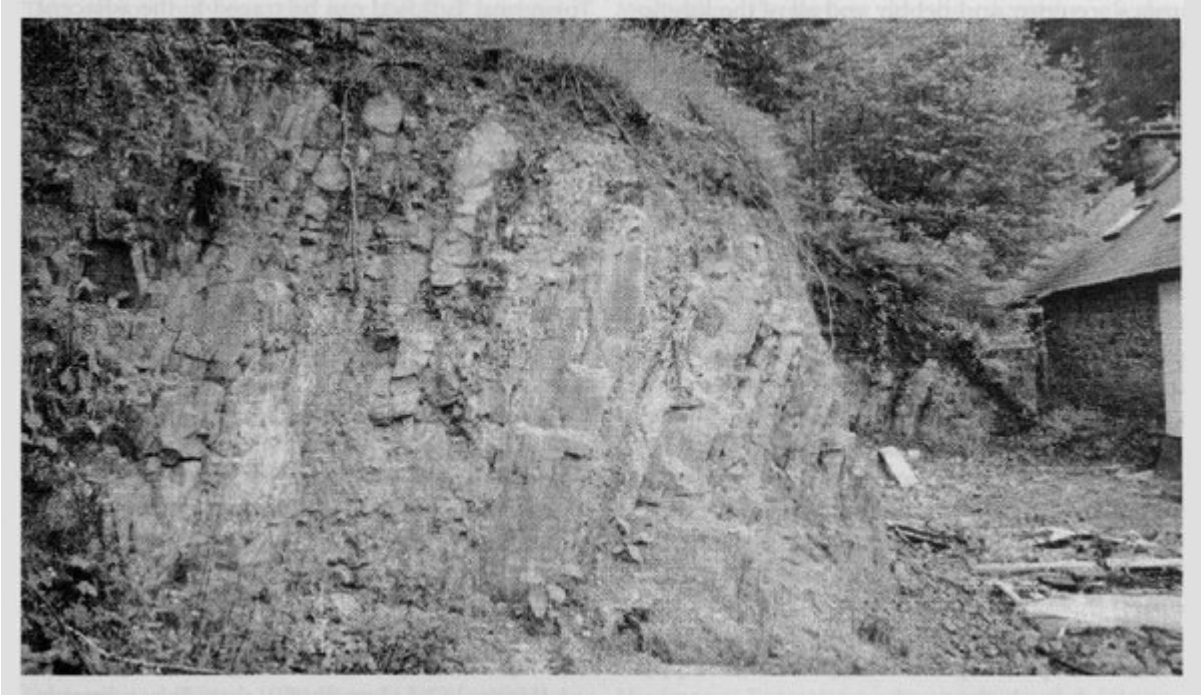
**References**




*(Figure 5.16) Geology of the upper part of the Sawdde Gorge: (a) — geological sketch map (north-west part after Derek J. Siveter, 2000); (b) — lithostratigraphical classification of the succession.*




*(Figure 5.17) Graphic logs of parts of the Old Red Sandstone succession in the Mon Sawdde. 1A,1B — continuous section of the Tilestones Formation and basal part (Pont-ar-llechau Member) of the Gwynfe (Raglan Mudstone) Formation [SN 7282 2452]–[SN 7286 2449]; 2 — part of the 'Middle Division'of the Raglan Mudstone Formation [SN 7308 2400]; 3 — part of the 'Middle Division' containing the Townsend Tuff Bed and Pickard Bay Tuff Bed [SN 7325 2385]; 4 — section typical of the 'Upper Division' of the Raglan Mudstone Formation [SN 7330 2381]–[SN 7332 2372]; 5 — section typical of the St Maughans Formation [SN 7340 2364]. After Almond et al. (1993). Note that the logs have different scales.*



*(Figure 5.18) Section behind the former Three Horse Shoes Inn [SN 7283 2447] exposing the junction of the basal beds (Capel Horeb Member of Almond et al., 1993) of the Tilestones Formation and the underlying topmost beds of the Lower Roman Camp Formation. The hammer marks the junction. (Photo: R.A. Waters.)*