Cusop Dingle, Herefordshire–Powys

[SO 233 421]–[SO 257 384]

Potential GCR site

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Introduction

Cusop Dingle (Figure 5.13) is a prominent deep valley that cuts into the foot-slopes of the Black Mountains, immediately south-east of Hay-on-Wye, Powys. For much of its length it forms the border between England and Wales. The stream sections exposed by the Dulas Brook and its tributaries. the Crigiau Stream and Esgryn Brook, provide approximately 215 m of vertical succession, making up one of the two most continuously exposed inland sections of late P■ídolí–early Devonian Old Red Sandstone succession in the Welsh Borderland-Black Mountains area. The Sawdde Gorge section (see GCR site report, this chapter) provides the other (Almond, 1983). The section exposes the upper part of the Raglan Mudstone Formation (late Downtonian–P■ídolí) and the lower part of the St Maughans Formation (Dittonian) (Figure 5.14), the top of the former marked by a thick pedogenic limestone (the main 'Psammosteus' (Bishop's Frome) Limestone). The lower part of the succession is dominated by red siltstones, commonly showing pedogenic characteristics, and punctuated by grey, green and red sandstone bodies. It includes the volcanogenic Townsend Tuff Bed (Allen and Williams, 1981a). The upper part of the succession is dominated by green and grey fluvial sandstones with subordinate green and red siltstones. The lithologies illustrate a facies change in the Lower Old Red Sandstone from distal (marginal marine) mudflats to fluvial-dominated alluvial plains. Descriptions of geological localities in Cusop Dingle and the adjacent areas have featured in literature and other records, but the following account presents the first comprehensive description of the succession.

Murchison (1834) provided the first geological sections and notes on the area. King (1934) summarized the geology and stratigraphy of the area, allocating the succession to lithostratigraphical zones. M'Caw (1936) gave a brief description of the geology of the Black Mountains area based on King's work, together with a rudimentary geological map. From the 1930s to the 1950s, Cusop Dingle was visited by palaeontologists, including H.A. Toombs, W.N. Croft and R.H. Denison from the British Museum (Natural History), in search of early vertebrate remains. Brief lithological descriptions of the localities collected were recorded in their field notebooks. White (1946) provided outline descriptions of two localities in Cusop Dingle, together with lists of the fauna found. Turner (1973) noted a thelodont assemblage 9 m below the 'Psammosteus' Limestone in Cusop Dingle. The geology and stratigraphical succession of Merbach Ridge and Merbach Brook, immediately east of the Black Mountains and Cusop Dingle, was described by Clarke (1955). Clarke described and named two lithologically distinct marker units within the Downtonian Red Marls, the Newton Marlstone and the Middlewood Sandstone. He also mentioned a bed of 'volcanic ash' about 95 m below the main 'Psammosteus' Limestone, later correlated by Allen and Williams (1981a) with the Townsend Tuff Bed.

The geology of the Black Mountains area to the south of Cusop Dingle is not well documented, but Turner *et al.* (1995) described the microvertebrate fauna from a section exposed at Pwll-y-Wrach, near Talgarth, first recorded by Hawley (1991). Barclay and Wilby (2003) provide a brief description of the geology of the Talgarth 1:50 000 geological map.

Description

The lower part of the succession (Figure 5.13), below the Bishop's Frome Limestone, exposes about 160 m of strata dominated by packages of siltstones (65–75%), with the remaining 25–35% consisting of two types of sandstone bodies. The siltstones are red-brown, micaceous and generally poorly sorted. They contain some primary sedimentary structures and many secondary features, including palaeosols. The most abundant primary structures are parallel bedding planes, parallel lamination, low-angle ripple cross-lamination, wrinkle marks on bedding planes, desiccation cracks and a range of trace fossils, including surface trackways, shallow horizontal burrows, vertical lobate burrows and vertical

Skolithos-type burrows. A high proportion of the siltstones contain pedogenic (vertisol) structures, including concentrations of pale subspherical carbonate (calcrete) nodules, most common in the upper part of some siltstone units, where they are locally concentrated and form horizons that are more resistant to erosion. Below horizons of carbonate nodules, or where concentrations are low or absent, many siltstones display large bowl-shaped, curved, slickensided fracture planes (pseudo-anticlines), blue-grey drab haloes, prismatic ped structures and wedge-shaped ped forms. Desiccation cracks occur in the tops of some beds with weak carbonate nodule development. The vertical profile of pedogenic features is truncated and repeated in many siltstone units.

The sandstones (Figure 5.15) are mainly green or grey, although purple varieties also occur and the finer-grained sandstones are commonly red. Many sandstones in the lowest part of the succession contain high proportions of mica, giving them a grey or silver colour, but increasing amounts of quartz in the higher sandstones result in them being dominantly green or grey. Two distinct sandstone bodies can be recognized. Coarse- to fine-grained, fining-upward sandbodies are 3 m to 5 m thick. Their basal parts consist typically of fine- to medium-grained sandstone sets with parallel bedding, low-angle cross-stratification or ripple cross-lamination, capped by a thin, bioturbated siltstone with desiccation cracks. The succeeding main sandstone unit overlies a sharp, mild erosion surface with strings of siltstone clasts or laterally impersistent lenses of poorly sorted conglomerate containing clasts of red and green siltstone, calcrete pebbles and poorly preserved fish fragments. The sandstone is coarse grained and well-sorted, and comprises tabular and/or trough cross-stratified units. The trough cross-sets are thinly laminated where there is a high mica content. At the top of the sandbodies are fine-grained, tabular, parallel-laminated or ripple-laminated, fining-upward sandstone sets, capped by thin red siltstones or truncated by a scour surface. Palaeocurrent directions are variable, but predominantly to the south-east.

Medium- to fine-grained, well-sorted, red and green interbedded sandstone bodies overlie siltstone units. They range between 0.4 m and 0.8 m in thickness, and typically have a very low-relief, undulating base or one comprising interdigitating lenses of siltstone and sandstone. The beds commonly comprise low-angle cross-stratified beds or decimetre-thick tabular sheets with alternately coloured lamination. Some of the beds are bioturbated and contain shallow cylindrical burrows and trails on the upper surfaces.

The 'Psammosteus' Limestones Group (Squirrell and Downing, 1969) includes three mature calcretes and is the correlative of the Chapel Point Calcretes Member of Pembrokeshire, where there are up to eight profiles in 50 m of mudrock. The main 'Psammosteus' Limestone of Ball and Dineley (1961) and the Bishop's Frome Limestone of Brandon (1989) is 1.5 m to 4 m thick (its base is not exposed in the Esgryn Brook), with less well-developed calcretes 11.5 m above and about 20 m below.

A fine-grained, green, splintery tuff about 1.5 m thick with a distinctive jointing/fracture pattern [SO 250 400] occurs 40 m stratigraphically below the base of the main 'Psammosteus' Limestone, at 190 m above OD, and is overlain by two thinner beds of hard, pale purple rock, both with some green mottling and separated by a thin, red, coarse-grained sandstone. The lowest bed is very fine-grained, whereas the upper one is coarser grained and contains glassy fragments. These beds are correlated with the Townsend Tuff Bed (Allen and Williams, 1981a), which crops out at similar stratigraphical levels in the Digedi Brook and River Enig to the west, and in Scotland Dingle and Merbach Brook to the east.

The upper part of the succession (above the main 'Psammosteus' Limestone) exposes about 55 m of strata correlated with the St Maughans Formation. These are dominated by green and grey, coarse- to fine-grained sandstones and conglomerates comprising 65% of the succession, with the remainder being siltstones. In addition to the stream section, exposures also occur in small outcrops and old quarries scattered across the upper slopes of the valley.

The sandstones are multi-storey bodies up to 9 m thick made up of discrete channel-fill and fining-upward units of variable thickness. The base of each unit lies on an erosion surface of varying relief, overlain by lenses and thin beds of poorly sorted conglomerate with planar or low-angle cross-stratification. A scatter or string of disc-shaped siltstone clasts is common where conglomerate is absent. The overlying sandstones are generally well-sorted and preserve an upward progression of sedimentary bed types reflected in the decrease in grain size, from planar and trough cross-stratification through low-angle cross-beds to horizontally bedded and laminated beds with parting lineation, passing up into ripple cross-lamination showing common re-activation surfaces. This sequence is rarely found in full and is commonly truncated by an erosion surface and overlain by a succession of units displaying one or more of the bed types.

Poorly preserved plant fragments commonly occur in the coarser-grained sandstones, scattered along the bases of troughs. Concentrations of more comminuted plant debris are found at the tops of laminated beds. Similarly, fish fragments occur in basal conglomerates and coarse-grained sandstones, with better-preserved specimens occurring in the laminated beds. Burrows occur in the troughs of ripples. Palaeocurrents are variable, but have a predominantly southerly drainage direction.

The sandbodies grade up into fine-grained, micaceous beds up to 4.5 m thick. These are dominated by green, very fine-grained sandstones and green siltstones with subordinate thinner beds of intercalated green and red siltstones. In thicker developments, these pass up into red siltstone beds. Strong parallel lamination is dominant, with coarser-grained layers displaying low-relief undulations or low-amplitude ripple-lamination, sporadically disturbed by bioturbation. Some thicker red siltstones contain weakly developed pedogenic features.

Interpretation

The lithologies and facies displayed in the lower part of the succession in Cusop Dingle represent the distal component of an extensive fluvial system, deposited in a semi-arid climate. The environment is interpreted as a broad, low-relief aggradational alluvial-floodplain, largely composed of silt and crossed by shallow, through-flowing, sandy river channel systems. Mica-rich sediments and distinctive suites of heavy minerals suggest that the source of sediments was the metamorphic terrane of north-west Britain (Allen, 1974c).

The two types of sandstone bodies correspond to different types of fluvial drainage across the area. The thicker sandbodies represent channels of the main distributary systems. These were high-sinuosity, laterally migrating rivers that deposited broad bar forms and low-relief dunes and were subject to highly variable discharge rates, with channels drying completely at some times. Frequent flooding caused water to spill on to low-gradient interfluve areas, resulting in shallow outbreak channels and poorly channelized or unconfined ephemeral flows from which the thinner, sheet-like sandstone bodies were deposited (e.g. Williams and Hillier, 2004). The vertical distribution of the sandstone bodies and the development of pedogenic horizons suggest regular avulsion of the main channels, over distances of several kilometres (Love and Williams, 2000).

The packages of siltstones record episodes of subaqueous deposition interspersed with significant periods of subaerial exposure and pedogenesis. Thick sequences of well-laminated siltstones indicate frequently repeated and rapid inundation of the floodplain by shallow sheets of water followed by very short intervals of subaerial exposure. In some instances the sediment remained damp enough for colonization by burrowing invertebrates, although the bioturbation density is generally low, suggesting that residence time was limited by relatively rapid sedimentation rates. Marriott and Wright (2004) suggest that burrowed laminated facies in stratigraphically equivalent beds in Pembrokeshire may indicate more prolonged periods of subaqueous deposition in semi-permanent lakes formed in depressions in the floodplain. Long interruptions to these aggradational periods are recorded by desiccation cracks and other pedogenic features, which show that sedimentation rates slowed or stopped and the floodplain frequently dried out. Variation in the maturity of the pedogenic features and calcrete palaeosols indicates non-depositional periods of the order of between 500 and 30 000 years (Retallack, 1990). The main 'Psammosteus' Limestone represents the longest hiatus in sedimentation, for which Allen (1985) proposed a maximum period of 30 000 years. He postulated that the 'Psammosteus' Limestone facies records the commencement of final uplift of the former Welsh Basin and Irish Sea Ridge, producing a change in sediment provenance and depositional style. During this time, the Anglo-Welsh Basin was sediment-starved and effectively shut down. The Townsend Tuff Bed is evidence of a Plinian-type eruption that deposited volcanic ash across the floodplain. It is widespread throughout Pembrokeshire, central south Wales and the Welsh Borderland, providing a valuable stratigraphical marker horizon across the Anglo-Welsh Basin (Allen and Williams, 1981a). Its source is not known, although Allen and Williams (1981a) suggested it might have been either to the west or east along the strike line of the developing Rheic Ocean, with dispersal by winds from one of these directions.

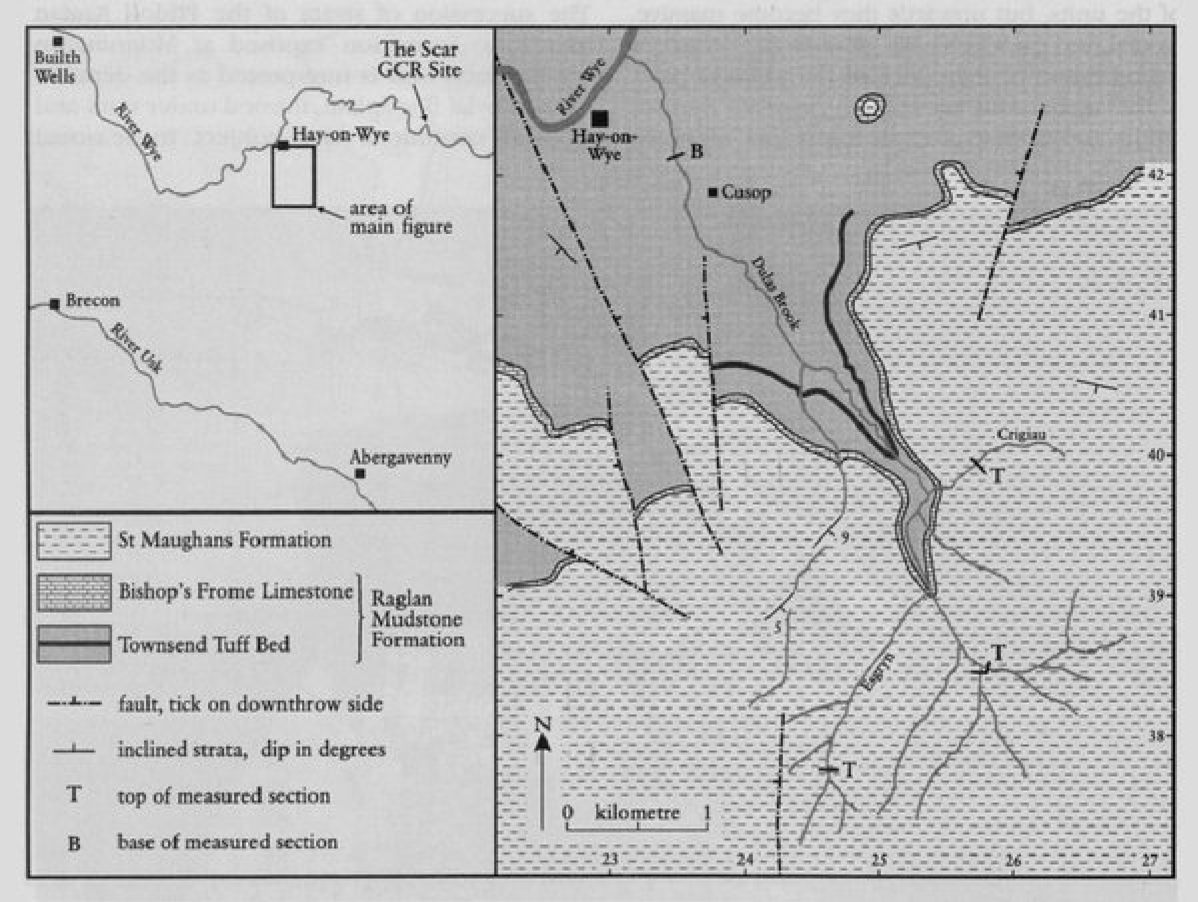
The succession above the main 'Psammosteus' Limestone shows the change in depositional style consequent on the uplift to the north-west (Allen, 1985). This resulted in the establishment of predominantly fluvial conditions on a more proximal floodplain characterized in part by laterally accreting, sinuous, meandering rivers draining southwards (cf. Williams and Hillier, 2004). The overall climate may have become wetter, the region experiencing sub-tropical monsoonal conditions.

The sandstone bodies display the fining-upward features of point-bar deposits, arranged in (incomplete) multi-storey packages with common erosion surfaces and repetition of bedsets, which would be expected from lateral, downstream meander migration during aggradation (Bridge and Diemer, 1983). The prevalence of parallel-laminated beds suggests currents of relatively large stream power. Crosscutting re-activation surfaces within ripple cross-laminated beds point to frequent fluctuations in water-levels. Individual bedsets were probably deposited during individual, major, flood events, but the rivers were perennially charged. The regularity of siltstone clasts in basal conglomerates and cross-beds and the low proportion of siltstone to sandstone indicate regular reworking of the floodplain. The increased amounts of plant material suggests more favourable conditions for plant growth, with stands of vegetation growing on the flood-plain marginal to the channels. The dominance of the green and grey colour of the lithologies suggests that the area experienced relatively high water-tables during this period.

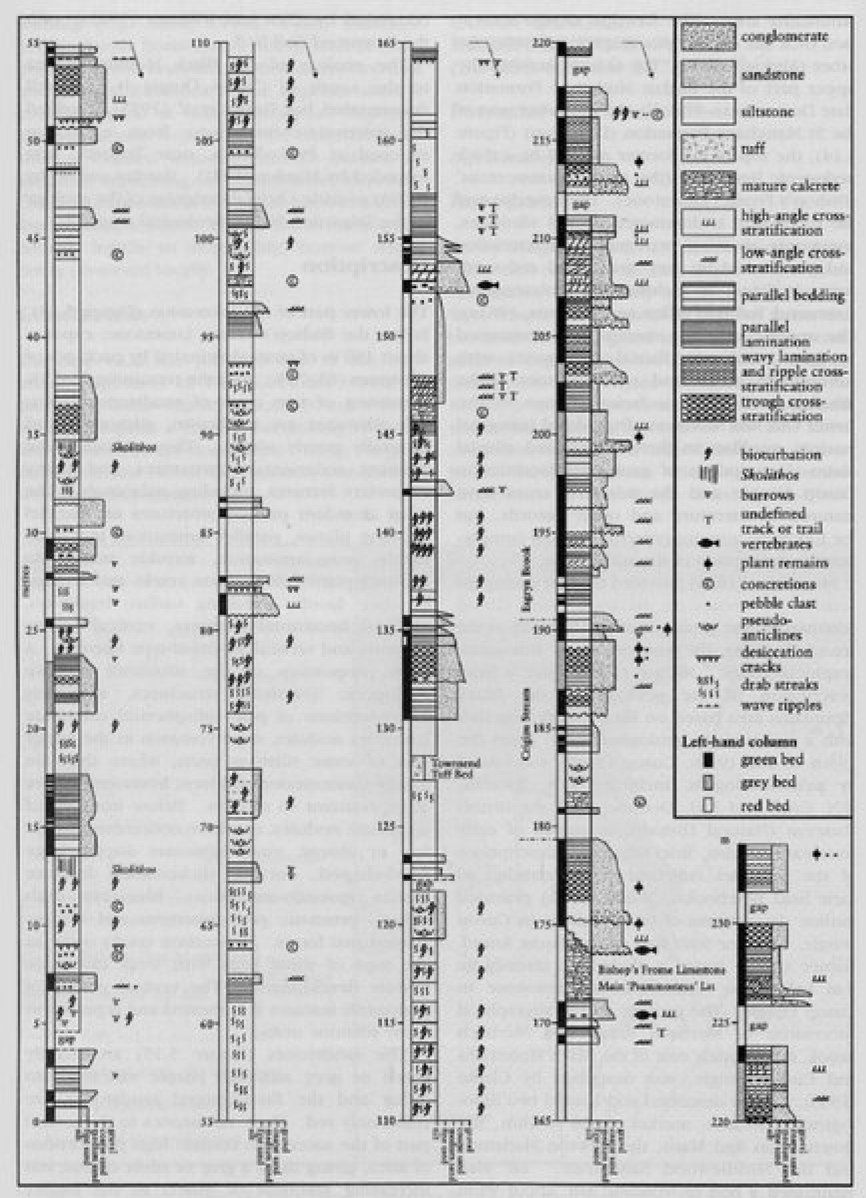
Conclusions

The stream sections in the Dulas Brook and its tributaries, the Crigiau Stream and Esgryn Brook, expose approximately 215 m of vertical succession, making up the most continuous and representative section of the late P■ídolí–early Devonian Old Red Sandstone succession in the Welsh Borderland and Black Mountains area. The sections provide evidence of the changing conditions in the Lower Old Red Sandstone Anglo-Welsh Basin, illustrating a shift in environment from low-lying mudflats created by ephemeral distributary channels at the distal end of a river system, through a hiatus in sedimentation to alluvial plains dominated by perennially charged meandering rivers. The section includes exposure of two important stratigraphical marker beds in the Lower Old Red Sandstone, the volcanic Townsend Tuff Bed and the main 'Psammosteus' Limestone, which allow correlation and comparison with other Lower Old Red Sandstone outcrops in the Anglo-Welsh Basin.

References



(Figure 5.13) Geological map of Cusop Dingle. Based on British Geological Survey 1:50 000 Sheet 214 (England and Wales), Talgarth (2004).



(Figure 5.14) Graphic log of the section in Cusop Dingle.

(Figure 5.15) Distributary channel sandstone body in the Raglan Mudstone Formation at Cusop Mill fall [SO 239 413]. Fining-upward tabular and trough-cross-stratified beds overlie a scoured surface cut in parallel-bedded fine-grained sandstones that conformably overlie siltstones. The coarser sandstones are more resistant and cap a waterfall. (Photo: D.J. Hawley.)