Portishead, North Somerset

[ST 461 770]

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Introduction

The Portishead GCR site exposes Lower and Upper Old Red Sandstone beds and provides the best exposure on the southern side of the Bristol Channel of the Lower–Upper Devonian boundary as preserved in continental red-bed facies. It also exposes the biostratigraphically important Woodhill Bay Fish Bed. The site has played an important role in identifying the provenance of the Old Red Sandstone in southern Britain, and in demonstrating its thickening southwards across the Anglo-Welsh Basin. The importance of the site also lies in its unique fish fauna, for which it is described separately in the fossil fishes GCR volume (Dineley and Metcalf, 1999).

The low cliffs of Woodhill Bay, Kilkenny Bay and Black Nore Point to the south of Portishead (Figure 5.73) expose a continuous, 354 m-thick section through the upper part of the Black Nore Sandstone Formation and the lower part of the overlying Portishead Formation. The latter includes the lithostratigraphically important Woodhill Bay Conglomerate at its base and, 27 m higher, the Woodhill Bay Fish Bed. The Black Nore Sandstone Formation is unfossiliferous (Kellaway and Welch, 1955), but is correlated with the Lower Devonian Brownstones Formation of south Wales (Kellaway and Welch, 1955; Green, 1992). The Portishead Formation is correlated with the Quartz Conglomerate and Tintern Sandstone formations of the Forest of Dean (Kellaway and Welch, 1955). It is mainly of Late Devonian age, but probably extends into the earliest Carboniferous (Neves and Dolby, 1967; Utting and Neves, 1970).

Description

The site is located on the southern limb of an ENE-trending anticline that forms a prominent ridge that extends from Portishead 5 km southwestwards to Clevedon. The anticline plunges WSW at its south-western end and ENE around Portishead. Consequently, the lowest part of the sequence is exposed at the southern end of the section between Kilkenny Bay and Black Nore Point. The rocks dip at a moderate angle (typically 20°) to the south-east and are cut by a number of NW-trending faults, many of which show post-Triassic movement (Wallis, 1927; Pick, 1964b). Most of the faults are minor, with throws of the order of 10 m to the south-west. At various points along the section, the Old Red Sandstone is blanketed by a discontinuous cover of dolomitic conglomerate, a marginal facies of the Triassic Mercia Mudstone Group.

The sedimentology and stratigraphy of the Old Red Sandstone at Portishead was described by Reynolds and Greenly (1923), Wallis (1927, 1928), Kellaway and Welch (1948, 1955, 1993), Butler *et al.* (1972) and Dodd (1986). The site is included in two field guides (Reynolds, 1921; Williams and Hancock, 1977). Wallis (1927) investigated the provenance of the sediments and discussed their depositional environment. The most detailed study was by Pick (1964a,b). He subdivided the Portishead Formation into nine formations (A to I) and the Black Nore Sandstone Formation into three (J1 to J3). However, only the Woodhill Bay Conglomerate and Woodhill Bay Fish Bed (Pick's formations I and F respectively) justify separate names, the remaining units representing laterally impersistent facies variations that are not mappable over a significant distance (Williams and Hancock, 1977). Also, Dodd (1986) suggested that formations A to C, which crop out south of the GCR site near Clevedon, may, in fact, be the same beds that are exposed at Portishead, repeated by faulting, with Pick's formations C and G being the same unit. The structural setting of the region was described by Reynolds and Greenly (1924). The diverse fish fauna from the Woodhill Bay Fish Bed, which is unique in southern Britain and includes the only British record of the placoderm *Groenlandaspis,* is described in the fossil fishes GCR volume (Dineley, 1999g).

The succession (Figure 5.74) is most easily examined in descending stratigraphical order by traversing the section from north-east to southwest. For convenience, it is described using Pick's (1964a,b) 'formations'. The highest unit ('formation'

D), which forms part of the Portishead Formation, crops out near the top of the cliff adjacent to the seawall at the southern end of Woodhill Bay. It is approximately 3 m thick and consists of centimetre- to decimetre-scale beds of soft, red and green, cross-laminated, sandy siltstones and interbedded fine-grained sandstones that are harder, red, micaceous and parallel-laminated. Some of the sandstones rest on erosion surfaces, fill minor channels and contain thin, discontinuous intraformational mud-flake conglomerates (Williams and Hancock, 1977). Some are bioturbated, some preserve desiccation cracks and some contain fish fragments (Wallis, 1928). Beneath this unit are 7.5–17 m of mauve-red and green-grey, trough cross-bedded, fine- to medium-grained, metre-scale beds of sandstone (Pick's 'formation' E). The lowermost sandstones contain dispersed vein quartz pebbles (averaging 1.3 cm in length), mudstone rip-up clasts and rare eurypterid remains (Simpson, 1951). The base of this unit is marked just to the northeast of an indentation in the cliff [ST 4602 7695] by an erosion surface above which lies a conglomerate and channelized, cross-bedded sandstone, each about 1 m thick. Together, 'formations' E and D form a fining-upward sequence that fills a large channel.

The underlying Woodhill Bay Fish Bed ('formation' F of Pick, 1964a,b; beds 5–10 of Wallis, 1927, 1928) is seen best in the lower two thirds of the cliff just to the south-west of the indentation. At Woodhill Bay it is 10 m thick, but it is not laterally extensive, being cut out north-eastwards by an erosion surface. It consists predominantly of red, micaceous siltstones and sandy siltstones, but also contains some decimetre-scale beds of green and red, fine-grained sandstone and green siltstone (Pick, 1964a; Williams and Hancock, 1977). Most of the siltstone beds are 1–5 cm thick and contain small, simple horizontal and vertical burrows (Dodd, 1986). The sandstones increase in abundance in the middle and upper part of the unit and four prominent beds (up to 1 m thick) can be traced across the outcrop. They are parallel-laminated, planar cross-bedded or trough cross-bedded, and contain rare pebbles and abundant intraclasts. Some bedding surfaces are rippled or display primary current lineation, and the base of the thickest sandstone preserves load casts. The important ichthofauna, which is dominated by abundant disarticulated scales and teeth of the crossopterygian fish *Holoptychius* and *Glyptopomus,* is concentrated in the thickest sandstones (beds 7, 8 and 10 of Wallis). It indicates a Late Devonian (mid-Famennian) age for the bed (Kellaway and Welch, 1993) and includes the only British record of the otherwise widespread form *Groenlandaspis* (Ritchie, 1975; Dineley, 1999g). In addition, fragmentary carbonized plant debris occurs locally and Wallis (1927) recorded a single, poorly preserved brachiopod.

The base of the Woodhill Bay Fish Bed is sharp and defined by a gently scoured, pebble-strewn surface. Beneath is a 14 m-thick, pale green sandstone unit (Pick's 'formation' G), the upper part of which is particularly distinctive and of probable aeolian origin (Dodd, 1986). It is fine grained, moderately well- to very well-sorted, and contains large-scale planar and trough cross-sets. In contrast to the units above and below, intraclasts and quartz pebbles are absent, and the cross-bedding indicates transport predominantly from the south-east.

'Formation' H consists of 13.5 m of red and green-grey, cross-laminated and cross-bedded, metre-scale beds of fine- to coarse-grained sandstone and pebbly sandstone with subordinate thin siltstones (up to 1.2 m thick) and minor (15–25 cm thick) conglomerates. Many of the sandstones are channelized, an excellent example of which occurs just above the base of the unit at the bottom of the cliff [ST 4585 7688].

Underlying these beds is the Woodhill Bay Conglomerate (Pick's 'formation' I), designated as the lowest unit of the Portishead Formation. Although thin (4 4.5 m), the bed is laterally extensive (Kellaway and Welch, 1955). It consists of well-rounded pebbles (averaging 2 cm) and cobbles (up to 15 cm), predominantlyof vein quartz and dark red-brown quartzite, set in a coarse-grained sandstone matrix cemented by quartz and calcite. In addition to quartz and quartzite, Wallis (1927) recorded exotic clasts of chert, jasper, lithic sandstone, quartz schist, mica schist and spilite. The conglomerate is generally unsorted, although in places the largest clasts are concentrated near the base of the unit and there is locally a preferred orientation of the pebbles parallel to bedding. Rare lenses up to 30 cm thick of yellow, coarse-grained, cross-bedded sandstone also occur. Palaeocurrents throughout the Portishead Formation are consistently from the north and north-west, except for most of those in the upper part of 'formation' G, which are from the south-east.

The junction between the Woodhill Bay Conglomerate and the underlying Black Nore Sandstone Formation is seen best in the cliff [ST 4585 7686] and near some steps [ST 4576 7681]. It is a sharp, irregular surface with scouring up to 1 m depth and a locally well-developed calcrete. A pipe-like carbonate body [ST 4579 7681], 2.5 m wide at its base and 2.5 m

high, extends from the Black Nore Sandstone Formation up into the Woodhill Bay Conglomerate (Figure 5.75). This is an unusual calcrete, apparently controlled in part by a joint in the conglomerate, and unrelated to any contemporaneous pedogenesis at the top surface of the Black Nore Sandstone Formation.

The underlying Black Nore Sandstone Formation consists predominantly of stacked, commonly lenticular (decimetre- to metre-thick) beds of red and pale greenish grey, fine- to medium-grained, quartzitic sandstones. There are 292 m of beds at Portishead, the base of the formation not being seen. Some sandstones have a carbonate cement and some contain beds rich in muscovite. Almost all of the sandstones rest on erosion surfaces, their bases commonly marked by intraformational conglomerates containing angular mudstone clasts and rounded calcrete pebbles. Nodular calcretes are common, particularly in the uppermost part of the formation (Williams and Hancock, 1977). There are also a few extraformational conglomerates with quartz pebbles and a very few siltstone inter-beds. The sandstones are either planar bedded or cross-bedded and indicate sediment transport from the north-west. Pick (1964a) subdivided the formation into three 'formations' (J1, J2 and J3), J2 being distinguished on the high concentration of calcrete clasts in its intraformational conglomerates. Thickness variations of the three units suggested to Pick that they wedge out laterally.

Interpretation

The section at Portishead is the stratotype for the Old Red Sandstone in the Bristol and Mendip Hills region (Kellaway and Welch, 1948, 1955, 1993; Green, 1992). The succession is characterized by a scarcity of fossils and a patchy outcrop distribution, making it difficult to correlate with adjacent areas. Lithologically, the Black Nore Sandstone Formation resembles the Lower Devonian Brownstones Formation of south Wales and the Welsh Borderland (Kellaway and Welch, 1955; Green, 1992). North of Bristol, the Upper Devonian strata are correlated with the Quartz Conglomerate and Tintem Sandstone formations of the Forest of Dean (Kellaway and Welch, 1993). However, these two formations cannot be separately identified at Portishead and are grouped together as the Portishead Formation, the numerous conglomerates and pebbly beds of the Portishead Formation being the distal correlatives of the Quartz Conglomerate.

The Black Nore Sandstone Formation and the Portishead Formation were deposited during two periods of sedimentation separated by a major (Mid-Devonian) orogenic phase. Most workers (e.g. Kellaway and Welch, 1955, 1993; Pick, 1964a; Allen, 1965b) placed the break at the base of the Woodhill Bay Conglomerate, although there is no angular discordance. Tunbridge (1986) suggested that the conglomerate may be of late Early or early Mid-Devonian age. Williams and Hancock (1977) questioned the significance of the Woodhill Bay Conglomerate–Black Nore Sandstone Formation junction, suggesting that the main unconformity may lie a few metres higher, at the top of the Woodhill Bay Conglomerate.

The Black Nore Sandstone Formation consists predominantly of alluvial channel-fill facies (Pick, 1964a; Williams and Hancock, 1977). Aeolian sandstones have been reported at Clevedon (Dodd, 1986), just to the south of the GCR site, the only occurrence of such facies at this level in the Anglo-Welsh Basin. The formation was one of the first in which the limestones of the Old Red Sandstone were interpreted as calcretes, and their significance in terms of understanding the palaeoclimatic and depositional setting of the Old Red Sandstone was recognized (Pick, 1964a).

The succeeding Portishead Formation is also mainly fluvial, but includes important interfluvial lacustrine or mudflat deposits (Pick, 1964a; Allen, 1965b). Dodd (1986) interpreted the upper part of 'formation' G as aeolian, probably deposited as relatively small barchan or barchanoid dunes. He tentatively linked the development of the dune field to deflation of the underlying sandflats in response to a eustatic regression.

The fish fauna of the Portishead Formation is unique in southern Britain and of considerable biostratigraphical and palaeoecological significance (Dineley, 1999g). In particular, the presence of *Groenlandaspis,* the only British record of this widely dispersed genus, suggests that freshwater migration routes were probably open between this region and other parts of Laurasia and Gondwana at that time. In addition, the occurrence of *Coccosteus* in the Woodhill Bay Fish Bed suggests that the Portishead Formation may pass laterally into the Pickwell Down Sandstone of north Devon and west Somerset (Kellaway and Welch, 1993).

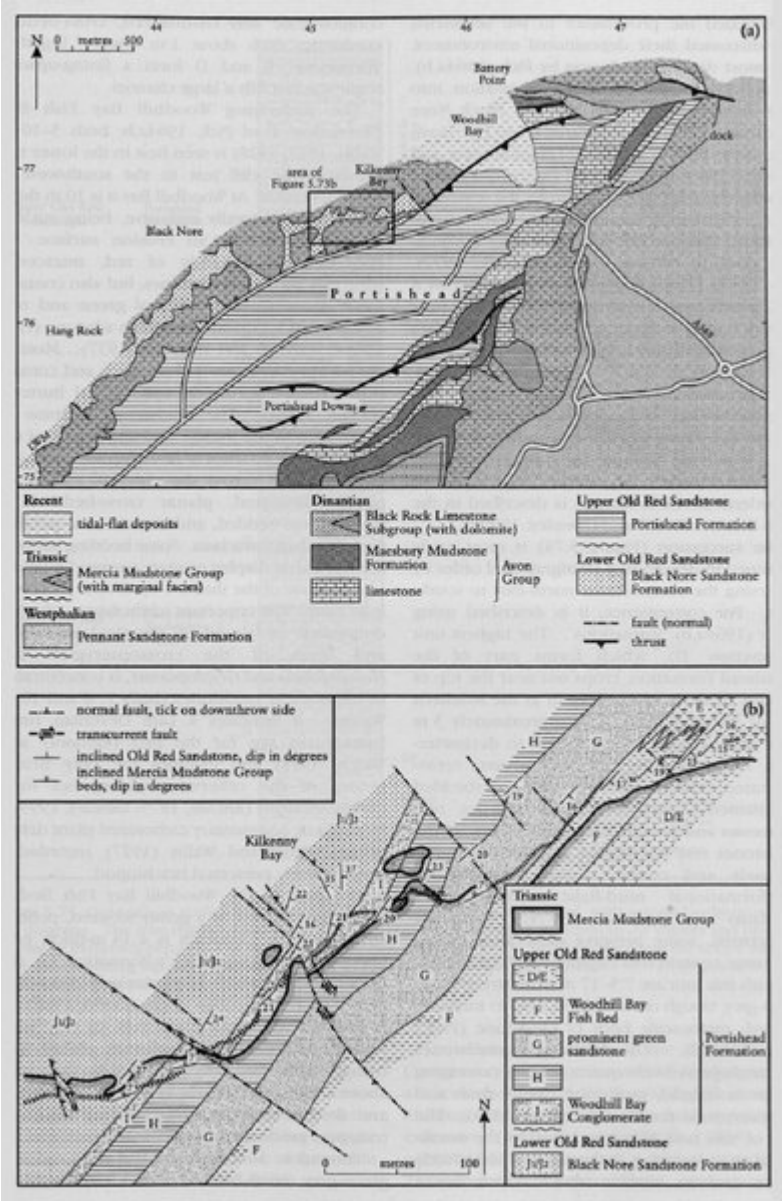
The probable source area for the sediment of the Portishead Formation can be suggested from its petrology (Reynolds and Greenly, 1924; Wallis, 1927; Allen, 1965b) and palaeocurrent data (Wallis, 1927; Pick, 1964a; Allen, 1965b). Most workers (e.g. Reynolds and Greenly, 1924; Wallis, 1927; Allen, 1965b) concluded that the source was a Precambrian massif lying to the north-west, with a similar composition to the green schists of the Gwna Melange in the Mona Complex of Anglesey. However, based on tectonic criteria and on the regional distribution of similar conglomerates, Tunbridge (1986) and Cope and Bassett (1987) suggested that the Woodhill Bay Conglomerate may have been sourced from a periodically exposed landmass to the west in the area of the present Bristol Channel.

In the Bristol area, the continental Portishead Formation passes up through a transitional sequence into fully marine Carboniferous rocks. At Portishead, the transitional sequence (the Shirehampton Formation) is concealed beneath Recent tidal-flat sediments. It was logged nearby by Reynolds and Greenly (1923) at Portishead Pier station, and by Butler *et al.* (1972) in a temporary exposure at Woodhill [ST 4689 7733]. At these localities it consists of intercalated red fluvial sandstones and mudstones, and grey, marine limestones and mudstones (Butler *et al.,* 1972; Kellaway and Welch, 1993) with a 'mixed' Devonian-Carboniferous fauna. Traditionally, the Devonian-Carboniferous boundary was placed at the base of the Shirehampton Formation in this region (see Kellaway and Welch, 1955). However, palynological evidence suggests that the boundary may lie in the upper part of the Portishead Formation (Neves and Dolby, 1967; Utting and Neves, 1970).

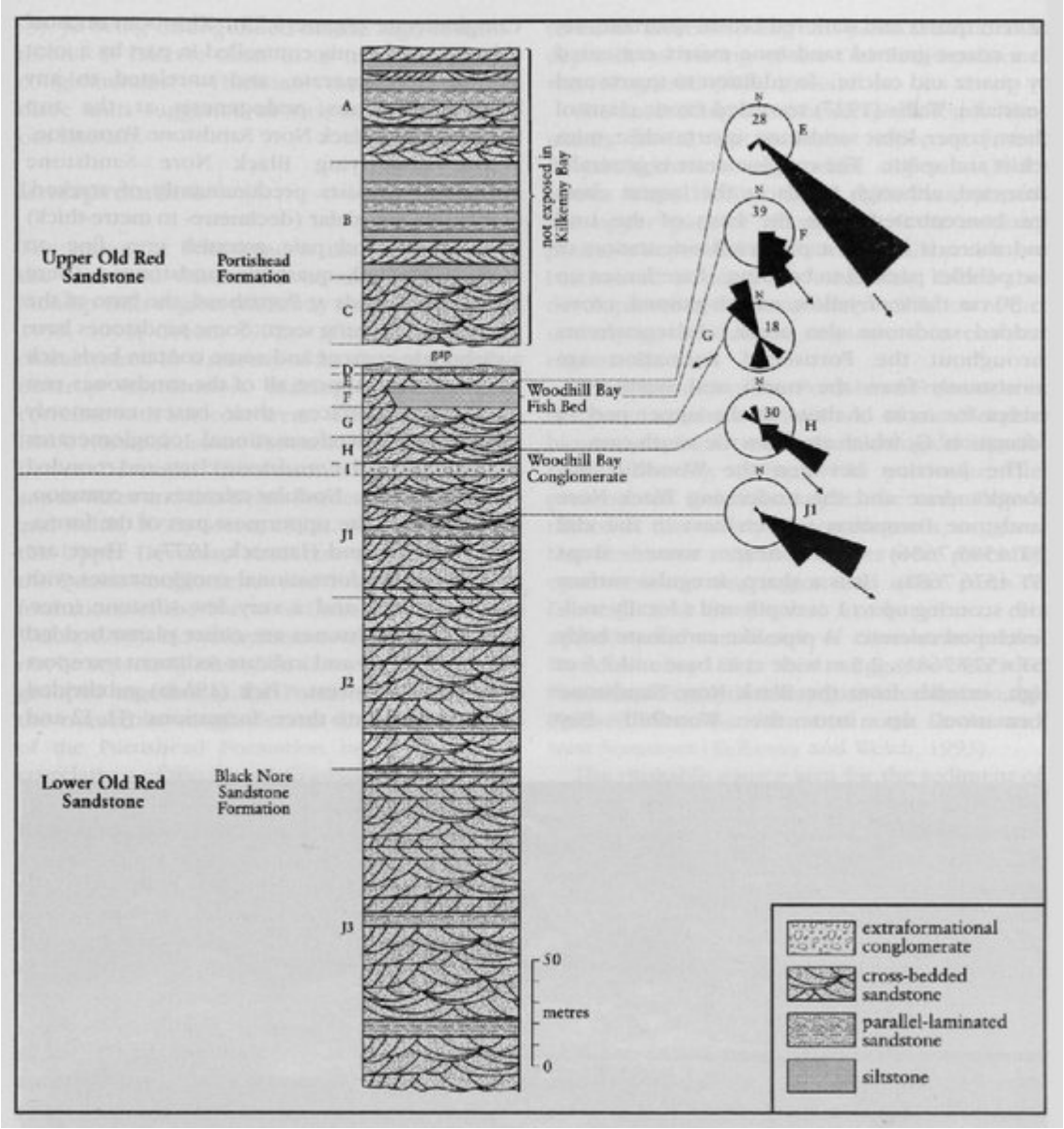
Conclusions

The cliffs to the south of Portishead between Woodhill Bay and Black Nore Point are the type locality for the Lower Devonian Black Nore Sandstone Formation and the overlying Upper Devonian to Lower Carboniferous Portishead Formation. The Portishead Formation includes important stratigraphical marker beds — the Woodhill Bay Conglomerate and the Woodhill Bay Fish Bed, the latter containing a diverse fauna that is unique in southern Britain and which provides a valuable insight into the palaeoecology of Devonian fish and their migration routes across the Old Red Sandstone continent. The site has been the subject of sustained research. It is regularly visited by undergraduate parties, and its eurypterid fauna is currently being studied. The nature of the Lower-Upper Old Red Sandstone junction, in particular the unusual calcrete development, requires detailed study to resolve conflicting interpretations. Aeolian sandstones reported in both the Black Nore Sandstone Formation and Portishead Formation also require further investigation, those in the former being unknown elsewhere in the Anglo-Welsh Basin at that stratigraphical level.

References



(Figure 5.73) Location and geology of the Portishead GCR site. (a) Geological map (after British Geological Survey 1:50 000 Sheet 264 (England and Wales), Bristol (2003)); (b) detailed map of section in southern Kilkenny Bay (based on Pick (1964a) and Williams and Hancock (1977)). Letters in (b) are 'formations' of Pick (1964a).



(Figure 5.74) Generalized vertical section of the Old Red Sandstone at Portishead, with selected palaeocurrent rose diagrams. The rose diagrams show preferred palaeocurrent directions grouped in 20° classes and plotted as number frequency percent. The circles mark the 20% frequency level. Small arrows show the vector means of the cross-bedding dip azimuths. Based on Pick (1964a) and Williams and Hancock (1977). Letters A, B, etc. are 'formations' of Pick (1964a).

(Figure 5.75) Conglomerates of the Woodhill Bay Conglomerate above sandstones of the Black Nore Sandstone Formation, Kilkenny Bay [ST 4579 7681]. A pipe-like carbonate body extends across the junction and carbonate nodules occur in the Black Nore Sandstone Formation. (Photo: BGS No. A10737, reproduced with the permission of the Director, British Geological Survey, © NERC.)