West Angle Bay (North), Pembrokeshire

[SM 852 034]

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Introduction

The low cliffs at West Angle Bay (North), south Pembrokeshire, expose a continuous section from the Ridgeway Conglomerate Formation at the base, through the Skrinkle Sandstones Group, up into the Lower Limestone Shale Group (Figure 5.55). The age of the Ridgeway Conglomerate is uncertain, lacking diagnostic fossils, bounded by unconformities and lying in a fault-bounded block; late Early Devonian and Mid-Devonian ages have been suggested. The formation is one of only three in south Wales to have been sourced from the south. The age of the overlying Skrinkle Sandstones Group is well constrained, extending from the Late Devonian to the lowermost Carboniferous (Tournaisian).

The section is regionally important because it demonstrates the transitional nature of the boundary between the non-marine Old Red Sandstone facies and the marine deposits of the Lower Carboniferous strata in this part of the Anglo-Welsh Basin. It is also important in providing evidence with which to correlate the local Upper Old Red Sandstone succession with international biostratigraphical schemes based on spores and conodonts, and in allowing the location of the Devonian-Carboniferous boundary. In addition, the site is the stratotype for the West Angle Formation of the Skrinkle Sandstones Group, and was the first locality at which bedload-transported pedogenic mud aggregates were recognized in the Lower Old Red Sandstone of the Anglo-Welsh Basin (Ekes, 1993).

Description

Dixon (1921) was the first person to examine and log the succession at West Angle Bay in detail, following early work by De la Beche (1846). Williams (1964), Hassan (1966) and Marshall (1977, 2000a,b) have refined the lithostratigraphy of the section and studied its sedimentology. The section is described in several field guides (Williams, 1971; Marshall, 1978; Williams *et al.,* 1982). The nature and age of the transitional boundary between the Old Red Sandstone facies and the overlying Lower Limestone Shale Group have been discussed by numerous workers (e.g. De la Beche, 1846; Marshall, 1977, 2000a,b). Early faunal studies suggested that the Devonian–Carboniferous boundary coincided with the top of the Old Red Sandstone facies (at the top of the Skrinlde Sandstones Group) (Salter, 1863; Cantrill *et al.,* 1916; Dixon, 1921; George, 1970). However, spore and conodont studies (Dolby, 1971; Bassett and Jenkins, 1977) demonstrated that the Devonian–Carboniferous boundary lies at a lower level, within the top part of the Shinlde Sandstones Group.

The faulted succession forms part of the northern limb of the Angle Syncline, a WNW-trending Variscan structure, the axis of which passes through the centre of the bay. The strata dip steeply (typically between 55° and 70°) and are repeated, but with some important litho- logical differences, on the south side of the bay (Dixon, 1921; Marshall, 2000b). The strata were deposited on the southern margin of the Wales–Brabant Massif, immediately to the south of the Ritec Fault, in the small (30 x 10 km) Tenby–Angle Basin that developed by intermittent subsidence during Devonian and Early Carboniferous times (Powell, 1987, 1989; Marshall, 2000a,b). The exposed succession is divided into three major lithostratigraphical units – Ridgeway Conglomerate Formation, Skrinkle Sandstones Group and Lower Limestone Shale Group.

The Ridgeway Conglomerate Formation consists of red-brown and purple, coarse, polymict, extraformational conglomerates 1–3 m thick, interbedded with thicker (1–25 m) red-brown siltstone-dominated units. The conglomerates contain subangular to well-rounded clasts, generally 1–5 cm in diameter, with some up to 20 cm, in a sandstone matrix.

The clasts are mainly of quartzite, vein quartz, lithic greywacke, siltstone, felsite and green phyllite. Some of the conglomerates are patchily cemented by calcite and most have sharp tops and bases, the latter resting on erosion

surfaces. Most are poorly sorted and internally massive, although some show clast imbrication and poorly developed trough cross-bedding. Some contain sandstone interbeds. The interbedded siltstone-dominated units typically comprise a series of stacked, 0.5–2 m-thick fining-up cycles, each resting on a scoured surface and commonly commencing with a thin intraformational conglomerate. Typically, basal planar laminated or low-angle cross-laminated sandstones are succeeded by trough cross-bedded or ripple cross-laminated siltstones. Many of the cycles are capped by mudstones 20–40 cm thick with abundant trace fossils, including the giant form *Beaconites antarcticus,* in their upper parts. In addition, desiccation cracks and immature nodular calcrete profiles also occur. At West Angle Bay, the Ridgeway Conglomerate Formation is 120 m thick, but thins rapidly to the south-east away from the Ritec Fault (Dixon, 1921; Williams in Owen *et al.,* 1971). Its top is marked by calcretized red-brown mudstones and by a distinctive, 1.25 m-thick, grey-green, medium-grained, cross-bedded sandstone. Palaeocurrent data indicate that the formation was derived from the south (Williams, 1964; 1971; in Owen *et al.,* 1971).

The overlying Skrinkle Sandstones Group is of Late Devonian (Upper Old Red Sandstone) age, established by the presence of *Holoptychius* sp. (Dixon, 1921). The group is lithologically very variable and is divided into the Gupton and West Angle formations (Marshall, 1977). At West Angle Bay, the Gupton Formation is represented only by the Stackpole Sandstone Member (Figure 5.56). The West Angle Formation is subdivided into the Conglomerate and Red-Grey members. The Gupton Formation is 6 m thick and its base is sharp, slightly uneven and marked by a re-entrant in the cliff face [SM 8503 0380]. The basal 1.25 m are dull red, silty mudstones and very finely laminated sandstone interbeds, arranged in centimetre- to decimetre-scale packages with abundant *Skolithos*-like and *Chondrites*-like burrows at some horizons. Decimetre-thick, hard, pink, quartzose sandstones form 90% of the upper part of the formation. These form horizontally bedded and low-angle cross-laminated lenticular sheets, or trough cross-bedded, channelized bodies, commonly with pebbly layers, resting on erosion surfaces. Palaeocurrents indicate southerly flow away from the Ritec Fault.

The Conglomerate Member of the West Angle Formation is 63 m thick and comprises a stacked succession of fining-upward cycles in which red and locally grey or green, conglomerate- and sandstone-based beds up to 2.5 m thick are capped by thicker beds of siltstone. The base of the member is a cross-bedded conglomerate about 1 m thick, with a sharp, scalloped base. Three beds preserve excellent examples of lateral accretion sets (e.g. [SM 8502 0379], [SM 8498 0373]). The conglomerates are cross-bedded and contain a varied clast suite, including vein quartz, acid igneous rocks, mylonite, purple quartzite and intraformational fragments. They are generally of pebble grade and moderately well-rounded to subangular. The bases of the conglomerates and sandstones are sharp, but not obviously erosion surfaces. Most of the siltstones are red and structureless, and several contain immature, nodular calcrete horizons. Disturbed, dark grey mudstone laminae are preserved in a grey-green siltstone approximately 20 m above the base [SM 8498 0373]. Palaeoflow data indicate south-westerly sediment dispersal.

The base of the overlying Red-Grey Member (Heterolithic Member of Marshall, 2000a) of the West Angle Formation coincides with a malachitic horizon [SM 8494 0375] first noted by Dixon (1921). The member is 59 m thick and dominated by red, mauve and green-grey, decimetre-scale beds of quartzitic sandstone and silty mudstone, commonly in fining-upward units capped by mottled mudstones and nodular calcretes. The sandstones are fine- to coarse-grained, commonly cross-bedded and sharp based. Some rest on erosion surfaces, particularly those towards the top of the member, where their bases are defined by thin (6–7 cm) basal intraformational granule layers.

The most characteristic feature of the Red-Grey Member are five so-called 'marine' beds (Dixon, 1921). These consist of grey mudstone, limestone or calcareous sandstone and contain bivalves, ostracods, plant debris, root traces and, at one level, a thin coal. Two of the 'marine' beds are particularly distinctive. The lower one lies above a 0.4 m-thick nodular calcrete, approximately 33 m above the base of the member and is most easily examined on a large southward-facing bedding plane [SM 8494 0370]. Its base consists of 15 cm of grey mudstone that has yielded bivalves, plant debris (Dixon, 1921) and abundant fish teeth. Above is a burrowed, grey sandstone that fines upwards over 0.4 m into grey mudstone, then red-grey mottled mudstone and then red beds again. A few metres to the south the higher 'marine' bed Is exposed in a crevice in the cliff. At its base is a 0.45 m-thick, green-grey, fining-upward. cross-bedded quartzitic sandstone with calcretes. This is overlain by 0.3 m of grey, ferruginous interbedded mudstone and sandstone with abundant *Planolites* burrows, overlain in turn by 0.5 m of calcareous, brown and grey, trough cross-bedded sandstone. This is capped by a 10 cm-thick, rubbly, bioclastic limestone.

The top of the Red-Grey Member is best exposed on the foreshore *c.* [SM 8492 0369]. Here, the characteristic red-grey interbedding is replaced about 7 m beneath the top of the member by the abrupt appearance of interbedded grey shales and thin (generally less than 15 cm), yellow-weathering, dolomitic sandstones. Dixon (1921) recorded fish fragments, bivalves (*Modiola lata*), crinoid ossicles and brachiopods (*Lingula* sp.) from these beds and an orthocone nautiloid (*Orthoceras* sp.) from the red siltstone immediately beneath. These beds are succeeded by about 3 m of cross-bedded sandstone containing bryozoa and ooliths, which mark the top of the SkrinIde Sandstones Group. At West Angle Bay the total thickness of the Skrinkle Sandstones Group is 130 m, but it thickens dramatically to the south (Marshall, 1977). It is succeeded by grey mudstones and calcareous sandstones of the Lower Limestone Shale Group, which contains abundant sedimentary slump folds near its base [SM 8491 0362] (Kelling and Williams, 1966).

Interpretation

During Early and Late Devonian times, sedimentation in south Pembrokeshire was strongly influenced by a series of southerly dipping, NW-trending growth faults that controlled the formation of a series of small, fault-bounded basins, each with its own distinct lithostratigraphy (Allen and Williams, 1978; Powell, 1989). The rocks exposed along the foreshore of West Angle Bay were deposited in the southernmost of these basins. The succession is confined immediately to the north of the GCR site by the Ritec Fault, and to the south by a series of major faults on the northern margin of the former so-called 'Bristol Channel Landmass' (Dunne, 1983; Tunbridge, 1986; Brooks *et al.,* 1988). Syndepositional movement on the faults resulted in considerable lateral facies and thickness variations in the succession across the basin (Powell, 1989).

The succession is dominated by continental deposits. The Ridgeway Conglomerate Formation has been interpreted as a proximal alluvial-fan with braided stream deposits (Williams, 1971; Williams *et al.,* 1982; Cope and Bassett, 1987). Braided stream deposition is suggested by the upward-fining cyclothems at West Angle Bay, as well as the presence of *Beaconites antarcticus,* which is believed to be the trace of an animal that inhabited the banks of active river channels (Allen and Williams, 1981b). At least some of the siltstones may have been transported as pedogenic aggregates of mud pellets and deposited from stream bedload (Ekes, 1993). Based on palaeocurrent trends, structural data and the predominance of exotic Lower Palaeozoic sedimentary/metasedimentary clasts, the Ridgeway Conglomerate Formation is widely believed to have been sourced from the 'Bristol Channel Landmass' to the south (Dixon, 1921; Williams, 1964; Williams *et al.,* 1982; Tunbridge, 1986; Cope and Bassett, 1987). This is consistent with the northwards decrease in the average particle size of the unit and with its dramatic thickening towards the Ritec Fault. Lacking diagnostic fossils and bounded by unconformities, the age of the Ridgeway Conglomerate is uncertain. It has generally been assigned to the late Early Devonian (Lower Old Red Sandstone) (Dixon, 1921; Thomas, 1978; Williams, 1978; Allen, 1979; Powell, 1987, 1989; Ekes, 1993) on tectonic (post-Acadian deformation) and lithological grounds, although it may extend into the Mid-Devonian (Middle Old Red Sandstone) (Williams, 1964, 1971; Allen, 1965b, 1977; Allen *et al.,* 1967; Tunbridge, 1986).

The Skrinkle Sandstones Group was deposited following major tectonic inversion in Mid-Devonian times. This event completely changed the palaeogeography of the region (Allen, 1974a) and switched the sediment source of the Tenby–Angle Basin from the south to the north (Allen, 1965b). Continued movement on the basin-bounding faults during Late Devonian time (Powell, 1989) imparted a southerly tilt on the basin and a reversal in the sense of thickening of the sequence. Allen (1965b, 1974a) interpreted the Skrinkle Sandstones Group as a large-scale, fining-upward system comprising lower braided stream deposits and upper heterolithic coastline barrier deposits. Allen (1986) suggested that the Gupton Formation may be of shallow marine origin. More recently, however, Marshall (1977, 2000a,b) interpreted the lower, laminated part of the Stackpole Sandstone Member of the Gupton Formation as the lacustrine deposits of a lake that may have drained to the south or east, and the overlying quartzose sandstones as high-energy, sandy braidplain ephemeral stream and sheet-flood deposits.

SE-directed palaeocurrents and the textural maturity of the Gupton Formation indicate axial basin-fill, parallel to the bounding faults (Marshall 2000a,b). In contrast, the succeeding Conglomerate Member of the West Angle Formation records the influx of immature, locally derived fluvial sediments sourced from the north-east, across the Ritec Fault (Marshall, 1978). Once established, this sediment transport path persisted throughout the deposition of the remainder of

the West Angle Formation. The varied suite of clasts in the conglomerates, which is very different to those in the Ridgeway Conglomerate Formation, suggests a source in Carmarthen or north Pembrokeshire (Marshall, 1977) and confirms the presence of a major depositional break between the Ridgeway Conglomerate Formation and Skrinkle Sandstones Group.

The overlying Red-Grey Member of the West Angle Formation is interpreted as the deposits of a coastal barrier/lagoon complex (Allen, 1965b; Marshall, 1978; 2000a,b). Marshall (2000b) recognized a complex of tidal-flat, lagoonal and washover fan deposits, culminating in the topmost barrier sandstone. The Red-Grey Member is laterally equivalent to the Shirehampton Beds of the Bristol district (see Portishead GCR site report, this chapter). Both record the start of the northward marine transgression of the Lower Carboniferous sea on to the Wales-Brabant Massif ('St George's Land'), culminating in deposition of the fully marine Lower Limestone Shale Group. Spore and conodont data from West Angle Bay indicate that the Devonian-Carboniferous boundary is located 8–15 m below the top of the Skrinkle Sandstones Group (Dolby, 1971; Bassett and Jenkins, 1977).

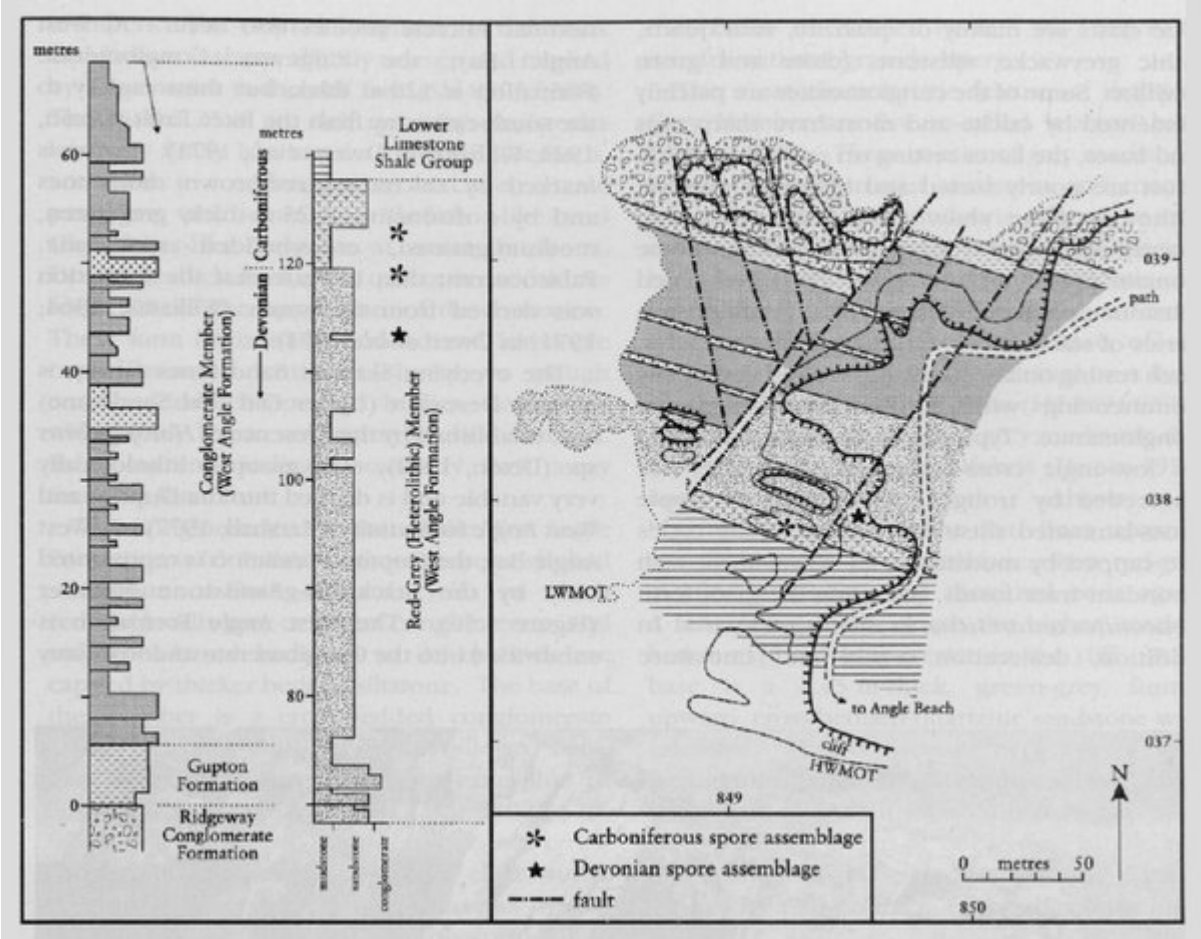
Conclusions

The low cliffs at West Angle Bay (North) expose a continuous section encompassing the Ridgeway Conglomerate Formation of possible Mid-Devonian age, the Late Devonian to Early Carboniferous Skrinkle Sandstones Group, and the succeeding Lower Limestone Shale Group. The section exhibits a wide range of lithologies, representing depositional environments in a small, fault-bounded basin.

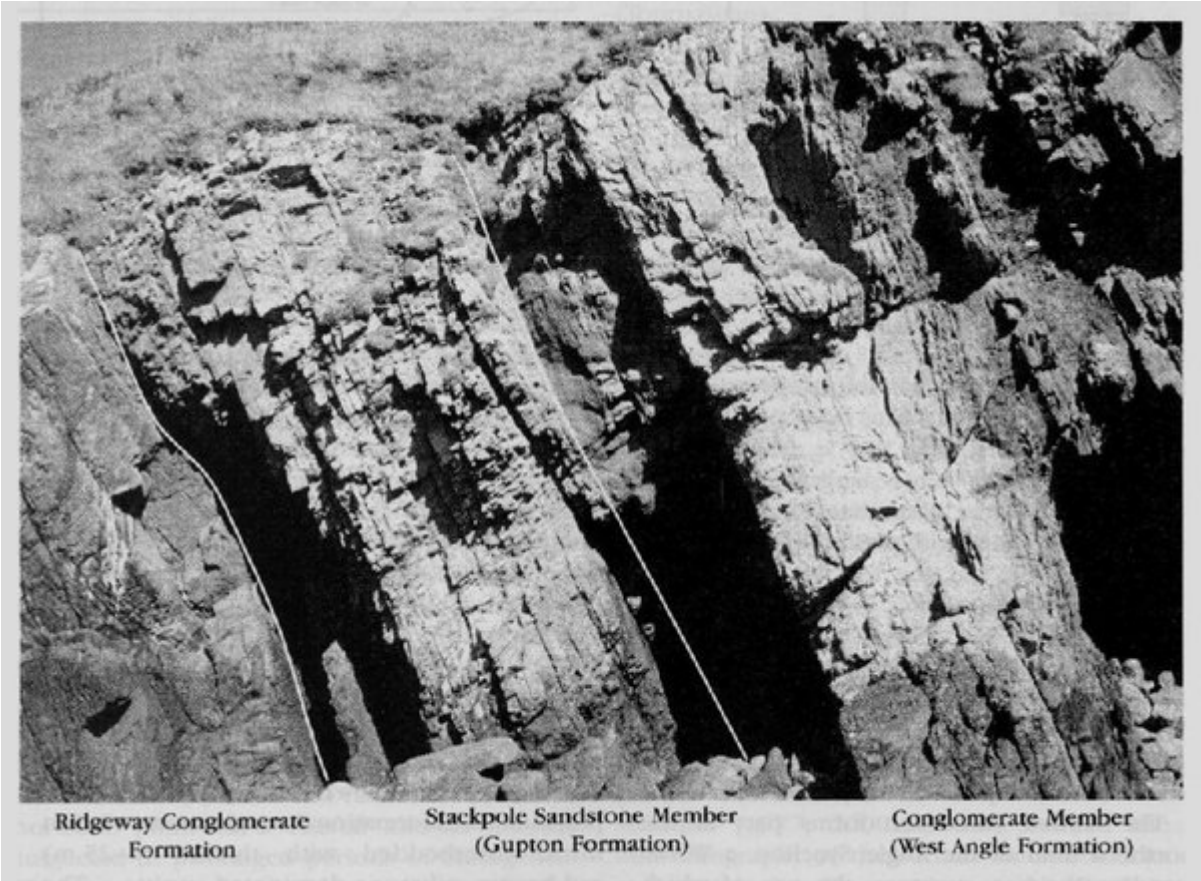
The site is important because:

- it shows the transition from the non-marine Upper Old Red Sandstone facies, through a number of marginal marine grey beds at the top of the Skrinkle Sandstones Group, to the fully marine Lower Limestone Shale Group.
- microfossil evidence indicates that the Devonian-Carboniferous boundary lies within Old Red Sandstone facies, 8–15 m below the top of the Skrinkle Sandstones Group.
- it provides evidence to show that deposition during Devonian times in this region was tectonically controlled and confined to fault-bounded sub-basins. Correlation between these sub-basins is difficult, but detailed spore analysis at West Angle Bay has enabled the Upper Old Red Sandstone lithostratigraphy of the Tenby-Angle area to be correlated with an international biostratigraphical scheme based principally on marine sequences.
- in addition to being the stratotype for the West Angle Formation, the locality is critical to the understanding of the palaeoenvironmental setting of the Skrinkle Sandstones Group. The site offers continued opportunities to collect Late Devonian fish material.

References



(Figure 5.55) Geological sketch map of the north side of West Angle Bay and log of the Skrinkle Sandstones Group. After Williams et al. (1982).



(Figure 5.56) Strata in West Angle Bay; view looking east [SM 8503 0380]. The beds dip steeply and young southwards (left to right). The Ridgeway Conglomerate Formation is succeeded by the Stackpole Sandstone Member of the Gupton

Formation, which in turn is overlain by the basal beds of the Conglomerate Member of the West Angle Formation. (Photo: P.R. Wilby.)