Tynemouth to Seaton Sluice

Highlights

Tynemouth to Seaton Sluice provides the best exposure of Duckmantian in Northern England, and the best continuous succession through much of that stage anywhere in Britain. It can be demonstrated here that the depositional environment was different from that present in the Pennine Basin to the south, being subjected to periodic high-energy conditions. The site has also several important fossil localities, including the famous Whitley Bay non-marine bivalve site.

Introduction

These are coastal exposures [NZ 373 693]–[NZ 345 760] extending for about 9 km NNW of the mouth of the River Tyne, Tyne and Wear and Northumberland. They are some the finest natural exposures of Westphalian strata in Britain (Figure 11.4). It shows a continuous succession of Duckmantian strata, folded into a periclinal struc ture known as the Whitley Dome. It was the subject of the pioneering sedimentological work by Sorby (1852), and more recently by Haszeldine and Anderton (1980) and Haszeldine (1981, 1983a, 1983b, 1984a). The general field geology has been described by Absalom and Hopkins (1926), Jones (1967) and Land (1974).

Description

Lithostratigraphy

A succession of about 145 m thick is represented here (Figure 11.5). The exposures are at least partly along strike, thus providing some evidence of lateral variation of the strata. The lowest beds seen are massive, cross-bedded sandstones, known as the St Mary's Island Sandstone. The base of this unit is not seen here, but from nearby boreholes and shafts it has been shown to be about 6 m thick (Land, 1974). It is part of an elongate sandstone body, 2–4 km wide, that extends north-west from St Mary's Island.

There follows 39 m of coal-bearing strata, which include the Hutton, Northumberland Low Main and Durham Low Main coal seams. Between the St Mary's Island Sandstone and the Bottom Hutton are lacustrine mudstones marking the position of the Plessey Seam. Further north in Northumberland, the Plessey seam is one of the most important coals and has been worked over 7 km out to sea. As is shown by Land (1974, fig. 35), however, it rapidly thins to the south and in this particular section has completely disappeared. The Hutton Seam, in contrast, has its main development to the south, and was commercially exploited near Newcastle-upon-Tyne and South Shields, but at their locality it has thinned to less than 0.4 m thick. There are also two thin seams a short distance above the Hutton referred to by Jones (1967) as the Middle and Top Hutton. According to Land (1974), these are very localized deposits, only known here. However, the shales between the Hutton and Middle Hutton seams are of interest as they contain ironstone nodules, and are at the same level as the famous fossiliferous ironstone deposits found near Crawcrook. Finally, there is a 12 cm thick coal some 5 m above the Northumberland Low Main coal, known as the Whitley Seam. Although this coal is of no commercial significance, its roof is an ironstone (the Whitley Ironstone) which was worked in the neighbourhood in the 18th century. The roof also contains well-preserved bivalve fossils, and hence is sometimes referred to as the Low Main Shell Bed.

The two 'Low Main' seams are more fully developed near Tynemouth; the Northumberland Low Main Seam is 1.7 m thick, and the Durham Low Main Seam 1.2 m thick. Both have been extensively worked in this area and, although their exposure on the coast is rather poor, Jones (1967) claimed that they could be uncovered by digging along the foreshore. The nomenclature of these seams has caused considerable problems, the 'Low Main' coals mined in Northumberland and Durham were traditionally regarded as the same seam, but Armstrong and Price (1954) showed that the Durham coal is stratigraphically higher and equated with the Five Quarter Seam of the Northumberland sequence (Jones, 1967 still persisted with the old nomenclature). To further complicate matters, in the Newcastle-upon-Tyne area the name Five Quarters Seam has been used for what is now called the Northumberland Low Main. These nomenclatural difficulties have been largely resolved by Land (1974).

The sedimentology of the interval between the Northumberland Low Main and Durham Low Main as exposed here have been described in detail by Haszeldine (1981, 1984a). He interpreted it in terms of three facies associations.

1. Lacustrine association. This refers to coarsening-upwards successions, representing the progressive in-fill of a lake. In the lower part are black mudstones with ironstone bands that pass up into alternating dark and pale grey, slightly coarser-grained mudstones. These are in turn overlain by coarsening-upwards rippled siltstones and fine sandstones.
2. Flood-plain association. This consists mainly of coals, seat earths, and epsilon cross-bedded siltstones. They represent emergent conditions that developed when the lake had silted-up.
3. Deltaic association. This includes various types of sandstone, representing bar and channel-fills of the deltas that supplied sediment and water into the lake. Such small-scale deltas may also be referred to as crevasse channel and splay deposits.

Haszeldine's model has been slightly modified following subsequent work by Fielding (1984a, 1984b, 1986), based mainly on artificial exposures that allowed more three-dimensional observations to be made. Nevertheless, the essence of the model remains intact as a means of interpreting much of the British middle Westphalian coal-bearing deposits, in terms of the infill of lakes formed in floodbasins by small-scale deltas or crevasse-splays.

The laminated lacustrine shales that immediately overlie the Northumberland Low Main seam are lateral equivalents of the well-known cannely shales found at Newsham, and which contain numerous vertebrate fossils (Andrews *in* Land, 1974; Boyd, 1984).

Above this interval of coal-bearing strata is a 20 m thick sandstone unit known as the Table Rocks Sandstone. The lower part of the formation is conglomeratic, and the base is erosive; in the northern part of the site it lies some 6.5 m above the Durham Low Main, while in the more southerly exposures near Table Rocks it has almost cut down as low as the Northumberland Low Main. Another distinctive feature of this unit is that the underlying strata are disturbed, which Lebour and Smythe (1906) interpreted as the result of thrusting. Land (1974) instead argued that the sandstone was a washout and that the underlying beds had suffered contemporaneous disturbance during or just before its deposition. However, it is not a localized channel washout, having been identified over large areas of the Northumberland–Durham Coalfield (Land, 1974, fig. 45).

There have been nomenclatural problems with the Table Rocks Sandstone, due at least in part to its diachronous base. Jones (1967) referred to the outcrops near Hartley Bay as the Lower Crag Point Sandstone, but Land (1974) has shown that they are in fact the same as the Table Rocks Sandstone. The Upper Crag Point Sandstone is in fact the Seaton Sluice Sandstone, and will be discussed below.

In much of the site, the Table Rocks Sandstone are overlain by 8.6 m of mudstones, thin sandstones and the 0.6 m thick Bensham coal. This is another economically important coal seam worked extensively in this area (Land, 1974, fig. 47), whereas further north it splits into two leaves.

The interval containing the Bensham Seam is in turn overlain by 12–14 m of sandstone (in the northernmost part of the site the sandstone cuts down through this coal and lies directly on top of the Table Rocks Sandstone). Jones (1967) variously called this the Brown's Point Sandstone, the Upper Crag Point Sandstone and the Seaton Sluice Sandstone, depending on where it outcropped. However, Land (1974) argued that it was all part of the same diachronous unit, which he referred to as the Seaton Sluice Sandstone. The sedimentology of this sandstone has been studied in detail by Haszeldine and Anderton (1980) and Haszeldine (1981, 1983a, 1983b, 1984a), who demonstrated that it was probably the remains of laterally migrating medial bars deposited in a low-sinuosity, braided river system.

Above the Seaton Sluice Sandstone sees another return to coal-bearing strata, which is best seen in the northern part of the site near Seaton Sluice. The sequence is described in detail by Jones (1967) and Land (1974). The former noted that the evidence for the traditional naming of the seams in this section was far from conclusive, and they were revised later by Land. To clarify the apparent discrepancy between the stratigraphical logs provided in these two descriptions, the two schemes of seam nomenclature are correlated as follows:

Coal Seam Names (Jones, 1967)	**Coal Seam Names (Land, 1974)**
—	Middle Thin
Bottom Yard	Upper Thin
Top Yard	Yard
Bottom Grey (or Stone)	Bentick
Top Grey (or Metal)	Five Quarters
High Main	Metal

The general consensus now seems to be that Land's identifications are the correct ones, and that the High Main Seam, one of the most important in the coalfield, does not crop out here. Of the seams that do occur, only two are economically important, the Yard and Metal seams (0.8 and 1.2 m thick respectively).

The stratigraphically highest Carboniferous strata exposed here are about 22 m of mainly purple-stained sandstones. They are named the Charley's Garden Sandstone, after the prominent stack of that name between Collywell Bay and Seaton Sluice (Figure 11.6). The formation is conglomeratic at the base, including mud- and coal-clasts, reflecting its erosive base that scoured into the coal-bearing strata. Cross-bedding suggests sediment transport was in a broadly southerly direction. The colouring of the sandstone is thought to be due to staining from the overlying Permian beds (Anderson and Dunham, 1953).

Biostratigraphy

Non-marine bivalves

The lowest biostratigraphical evidence here comes from a thin band of ironstone overlying the level thought to equate with the Plessey Seam, and known as the Plessey Mussel Band. Jones (1967) mentions that they are not seriously compressed, but he does not give a species list, nor does Hopkins (1929, 1930) or Land (1974). However, from other localities in the vicinity, Land lists taxa of the *Anthracosia ovum* Subzone, indicating the basal Duckmantian.

The next highest bivalves comes from the so-called Low Main Shell Bed, which in fact is the roof of the Whitley Seam. Historically, the most important exposure of this band is in Whitley Bay, where it yields *Anthracosia beaniana* King, *A. phrygiana* (Wright) and *A.* cf. *ovum* Trueman and Weir; it will almost certainly be the provenance of the historical specimens found in many museums labelled as 'Whitley Bay'. Most significantly, it is the type locality for *A. beaniana,* which in turn is the type species of *Anthracosia,* one of the most important genera of non-marine bivalves from the middle Westphalian of northern Europe.

The same Low Main Shell Bed also occurs near Crag Point. Here, it does not yield *A. beaniana,* but includes the remainder of the species found at Whitley Bay, together with *Anthraconaia salteri* (Leitch), *Anthracosphaerium* aff. *radiatum* (Wright), *A.* aff. *turgidum* (Brown), *A.* cf. *propinquum* (Melville) and *Naiadites quadratus* (Sowerby). From the assemblages described from both of these localities, the Low Main Shell Bed would seem to belong to the *A. phrygiana* Subzone, in the topmost part of the *A. modiolaris* Zone.

Land (1974) lists a fauna from about 4.5 m above the Low Main Shell Bed at Crag Point. It contains a very similar *A. phrygiana* assemblage, particularly with respect to the *Anthracosia* species (except *A. beaniana* is absent).

In an offshore borehole, Land (1974) reports the roof of the Bensham Seam to contain bivalves of the *Anthracosia caledonica* Subzone, thus marking the lowest part of the 'Lower *similis–pulchra*'Zone. However, the stratigraphically lowest horizon in these coastal exposures to yield this subzone is above the Seaton Sluice Sandstone, in a thin cannel above the Middle Thin Seam; Land reports from here *Anthraconaia pulchella* Broadhurst, *Anthracosia faba* (Wright), *A. simulans* Trueman and Weir, *A.* cf. *caledonica* Trueman and Weir and *Naiadites productus* (Brown).

The highest level to yield bivalves is just above the Bentick Seam, from where Land (1974) records *Anthraconaia* cf. *pumila* (Salter), *Anthracosia aquilinioides* (Tchernyshev), *A. caledonica?* Trueman and Weir, *A. simulans* Trueman and

Weir, *A.* cf. *planitumida* (Trueman), *Anthracosphaerium turgidum* (Brown) and *Naiadites productus* (Brown). This again almost certainly belongs to the *A. caledonica* Subzone.

Arthropods

From the mudstones above the Hutton Seam have been found fragments of a crustacean that has been variously named *Pygocephalus* and *Anthrapalaemon* (Rhodes and Wilson, 1957; Jones, 1967; Land, 1974). It has been found at two separate points in the site, near Brierdene and at Cullercoats. Also, Jones states that the same crustacean occurs in the Phoenix Brickworks at Crawcrook, which is also just above the Hutton coal.

In addition to this crustacean, estheriid arthropods have been found in the Low Main Shell Bed and in the cannel above the Middle Thin Seam.

Plant macrofossils

From the same horizon that yielded the crustacean remains mentioned above, Jones (1967) mentions plant 'species' *Pecopteris, Neuropteris, Alethopteris, Sphenopteris, Annularia* and *Calamites.* This assemblage has not been documented in detail, but is probably similar to that listed from the Phoenix Brickworks at Crawcrook by Kidston (1922). From its lower Duckmantian position, it would be expected to belong to the '*Neuropteris*' *hollandica* Subzone of the *Lonchopteris rugosa* Zone.

Interpretation

This is one of the finest exposures of Westphalian strata in Britain, showing much of the Duckmantian. Most exposures of these beds tend to be inland and thus usually of limited extent. This restricts their value, especially for sedimentological studies, which thus have to rely on temporary, man-made exposures which do not allow repeat observations to be made. The only other extensive coastal exposures are in Pembrokeshire, but these are mainly lower Westphalian. The only well-exposed Duckmantian strata in Pembrokeshire is at Amroth Coast, which is limited to the basal part of the stage (see Chapter 4). Also, the Pembrokeshire sequences suffer from more severe tectonic deformation, distorting both sedimentological structures and the fossils, as well as causing difficulties in establishing a continuous stratigraphical succession.

The type of sedimentological work such coastal exposures allow is exemplified by the studies of Haszeldine and Anderton (1980) and Haszeldine (1981, 1983a, 1983b, 1984a) on the Seaton Sluice Sandstone. They have argued that this is one of a number of distinctive sandstone bodies found in the Northumberland–Durham Coalfield, and thought to represent the deposits of relatively short-lived, braided rivers. According to their model, these braided river systems were the result of intervals of tectonic uplift and erosion of the sedimentary source areas (mainly the Southern Uplands and North Sea High) causing a sudden dis charge of sediment into the delta. They contrast with the rather lower energy, meandering river systems that characterize the Pennine Basin further south. Haszeldine and Anderton (1980) suggest that this may reflect the more proximal, slightly elevated position of the Northern England area relative to the Pennine Basin, an idea which seems to be supported by the evidence from the marine bands (Calver, 1968).

The site is also of considerable palaeontological interest. It is the best surface outcrop for yielding non-marine bivalves of the upper *A. modiolaris* and lower 'Lower *similis–pulchra*'zones, many of which are preserved three-dimensionally in ironstone. In particular, the historically important 'Whitley Bay' site (Low Main Shell Bed) is here, from where much material was collected in the 19th century, including the types of the stratigraphically significant genus *Anthracosia* King.

From the list of form-genera mentioned by Jones (1967), there is also considerable palaeobotanical potential here; if the assemblage from above the Hutton Seam is as diverse as it suggests, it will be the best lower Duckmantian palaeoflora known (at least from surface outcrop) from anywhere in Britain.

The ironstones from above the Hutton Seam also have much potential for palaeozoological work. They have already yielded crustacean remains. As it is the same stratigraphical level as the famous palaeontological deposits at the Phoenix

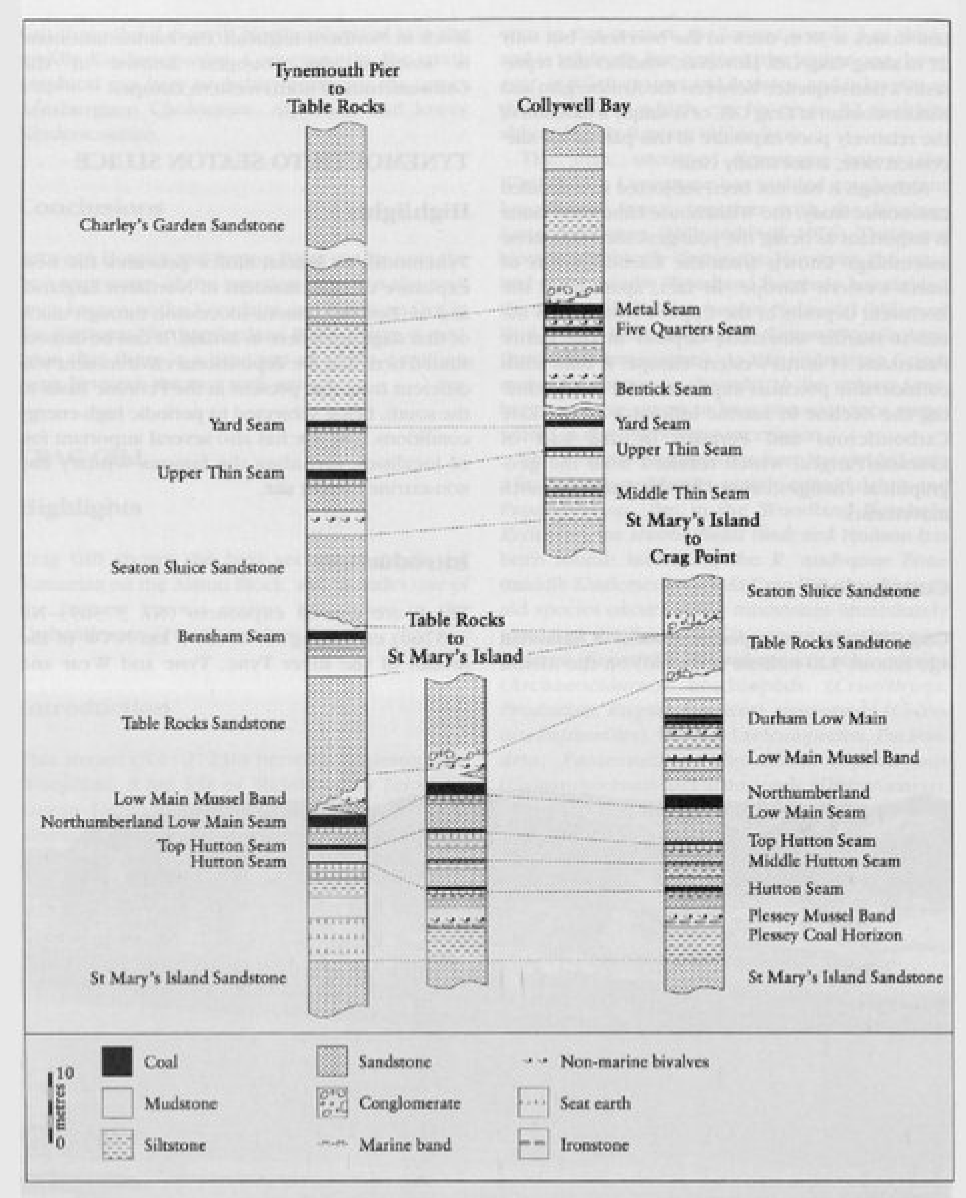
Brickworks, Crawcrook, Ryton, it would not be unreasonable to anticipate further faunal discoveries.

Conclusions

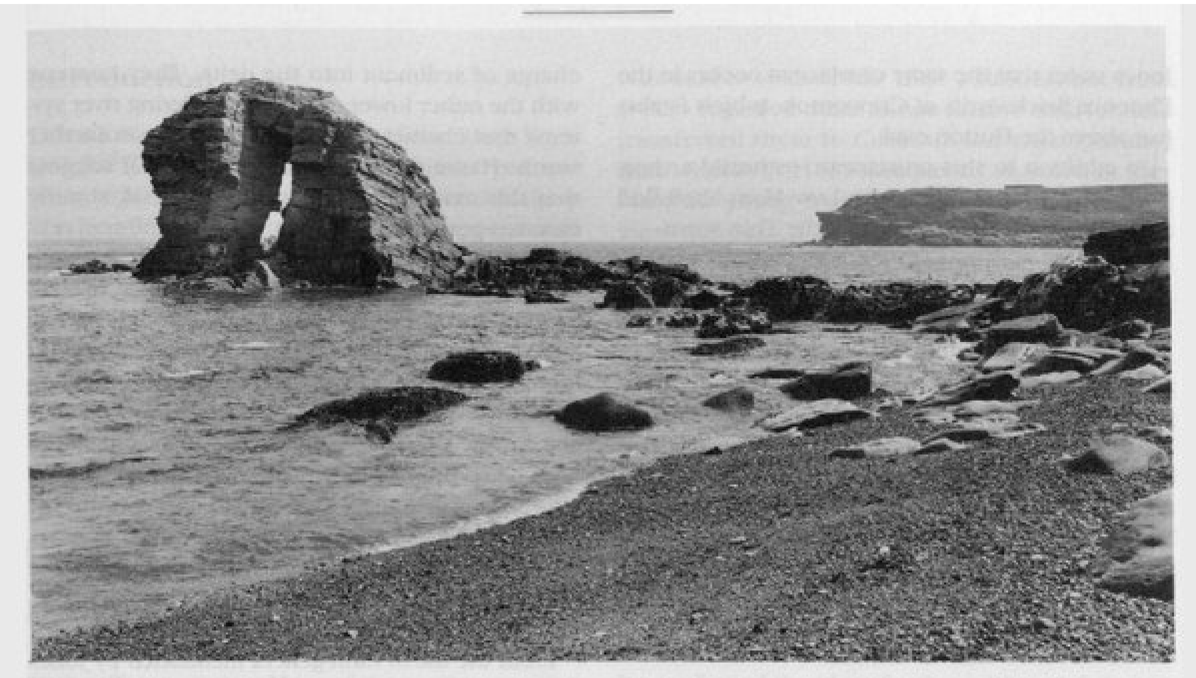
Tynemouth to Seaton Sluice is the most extensive exposure of rocks of Duckmantian age (about 313 million years old) in north-western Europe. It is possible to study here in great detail the depositional environments represented by these rocks. There are also several important fossil localities here, including the famous Whitley Bay non-marine bivalve site.

References

(Figure 11.4) Typical exposures of the Productive Coal Formation exposed at Hartley Cliff, 160 m S of Crag Point, Tynemouth to Seaton Sluice GCR site. Reproduced by permission of the Director, British Geological Survey: NERC copyright reserved (L630).



(Figure 11.5) Sequence of Duckmantian strata seen along the coast between Tynemouth and Seaton Sluice. Reconstructed from information given in Jones (1967).



(Figure 11.6) Charley's Garden, Tynemouth to Seaton Sluice GCR site. Reproduced by permission of the Director, British Geological Survey: NERC copyright reserved (L637).