Wern Ddu

Highlights

Wern Ddu shows the only continuous sequence from the lower Langsettian to upper Bolsovian in the eastern part of the South Wales Coalfield. It is also the only extant site in the coalfield from which palynomorphs have been obtained, and which thus allows an approximate identification of palynological zones.

Introduction

This is a disused claypit 1.5 km south-east of Caerphilly, Mid-Glamorgan, Wales [ST 168 857]. The site has provided an extensive exposure of Productive Coal Formation on the east crop of the coalfield (Figure 4.28). The claypit has not been worked for many years and exposure is now poor, but there is considerable potential for re-excavation. Details of the field geology, as originally exposed, are given by Moore (1945) and Squirrell and Downing (1969), while Sullivan (1962) has described the palynology of some of the coals.

Description

Lithostratigraphy

The sequence exposed here in the 1940s and described by Moore (1945) was 185 m thick. Although Moore provided a detailed stratigraphical log (summarized in (Figure 4.27)), his interpretation of the sequence needs to be modified in the light of the work by Squirrell and Downing (1969). Moore used local names for the coals and the following table shows their equivalents in the standard classification of Squirrel and Downing (the latter names $_{w}$ill be used through the rest of this report).

Moore	Squirrell and Downing
Big Rock Vein	No. 2 Rhondda Coal
Bodwr Fach Coal	No. 3 Rhondda Coal
Bodwr Fawr Coal	Hafod Coal
Limog Fach Coal	Abergorky Coal
Limog Fawr Coal	Pentre Rider Coal
	Pentre Coal
Yard Coal	Lower Pentre Coal
	Eighteen Inch Coal
Big Vein Group	Big Coal
Black Vein	Nine Feet Coal
Fork Vein	Bute Coal
Brass Vein	Seven Feet Coal
Hard Vein	Five Feet-Gellideg Coal

At the base of the sequence are flaggy sandstones which seem to represent the upper part of the Farewell Rock Formation. This is overlain by a 7 cm thick coal, which is probably the Garw Coal (Squirrell and Downing, 1969). The roof of this coal consists of shales containing fish fragments, and is thus similar to the roof of the Garw Coal as seen at Brynmawr Road Cutting.

The succeeding 6 m are shales, mudstones and clayband ironstones. Similar deposits, albeit rather thicker, occur in most of the South Wales Coalfield at this level (for instance, the interval between the Cnapiog and Grey coals at Cwm Gwrelych–Nant Llyn Fach), and seem to represent an interval of lacustrine conditions that prefaced the onset of more typically fluvio-deltaic conditions represented by the Productive Coal Formation.

More typical Productive Coal Formation deposits start with the Five Feet–Gellideg Coal. In more central parts of the basin, the Five Feet and Gellideg coals can be individually recognized, and in some places the Five Feet further splits to form a group of closely spaced seams (e.g. near Pontypridd — Woodland and Evans, 1964). At Wern Ddu, however, they have coalesced to form a 75 cm thick coal with thin dirt bands.

About 3 m above this is another compound coal with thin dirt partings called the Seven Feet Coal. The local name, Brass Vein, reflects the high pyrite content of both the coal and the partings. A little way to the west, the partings become thicker, and three discrete seams become recognizable, known as the Seven Feet, Yard and Amman Rider coals (or the Seven Feet Group).

This in turn is overlain by 3 m of shales containing marine fossils, which is thought to be the Vanderbeckei Marine Band (see below). There then follows 50 m of non-marine deposits, consisting mainly of mudstones, seat earths and subsidiary sandstones. It is typical of the Productive Coal Formation in this part of the coalfield, as it includes a relatively high proportion of ironstone-bands, at least compared with the more central parts of the coalfield. Three major coals occur here: the Bute, Nine Feet, and Big coals. They are all compound coals, consisting of leaves of coal separated by dirt bands or seat earths, and which further west split into several discrete seams.

The top leaf of the Big Coal (known locally as the Red Vein) is overlain by an impersistent conglomerate, and then a thin 'paper shale' containing marine fossils, assumed to be the Haughton Marine Band (see below). The latter marks the base of the interval where marine intercalations become more common. Above the Haughton Marine Band are about 6 m of shales and ironstones, followed by 6.5 m of more arenaceous deposits, the latter probably being equivalent to the Cockshot Rock. This is overlain by 15 cm of black shales which, from its position relative to the Cockshot Rock, is probably the Aegiranum Marine Band.

There follows 6 m of unfossiliferous, non-marine shales with ironstones, overlying which are about 3 m of sandy shales and seat earths. Moore (1945) interpreted this emergent interval as the probable position of the 'Yard Seam' (a local name for the Eighteen Inch Coal), but Squirrell and Downing (1969) argued that it could be equated with all the seams between the Eighteen Inch and Pentre Rider coals, inclusive. However, Moore located the position of another coal about 12 m above what he called the Yard Coal, and in its roof shales found *Lingula.* If, as is argued by Squirrell and Downing, the roof shales are the Edmondia Marine Band, then this second coal is likely to be the Pentre Rider Coal. It seems more likely, therefore, that Moore's Yard Coal is a combination of only the Eighteen Inch, Lower Pentre and Pentre coals.

Overlying the Pentre Rider are 9 m of sandstones and some shales and seat earths. One 30 cm thick shale in this interval has a bright red colour, perhaps reflecting a slight lowering of the water-table, and offering a foretaste of the reddening of the strata seen in the Pennant Formation of the east crop (Downing and Squirrell, 1965). The next coal is generally referred to as the Abergorky Coal and, as elsewhere in the coalfield, is overlain by black, 'papery' shales of the Shafton (or Lower Cwm Gorse) Marine Band.

Above the Shafton Marine Band, sandstones become less common than in the Pentre–Abergorky interval; the succeeding 7 m includes only just over 1 m of sandstone. This interval is relatively characterless, other than for the presence of a thin coal, which Squirrell and Downing (1969) claim is known nowhere else in this part of the coalfield. It is overlain by another, but this time more widely occurring coal — the Hafod Coal. The roof of this coal is mudstones containing marine fossils, and represents the highest marine band in the coalfield — the Cambriense (or Upper Cwm Gorse) Marine Band.

In the central part of the coalfield, the Cambriense Marine Band is almost immediately overlain by coarse sandstones of the Pennant Formation. On the east crop, however, the Productive Coal Formation extends well above the Cambriense Marine Band. This is particularly well demonstrated at Wem Ddu where there are some 23 m of mudstones, ironstones, seat earths and coals, with only a few thin sandstones. Coals recognizable in this part of the sequence include the Blackband Coal (represented here by what Moore calls 'Coaly "rashings" and dark shale'), the 30 cm thick No. 3 Rhondda Coal, a 5 cm thick smut which is probably the Taldwyn Coal, and the 40 cm thick Gilfach Coal.

The roof of the Gilfach Coal is a 12–15 m thick sandstone, which in this part of the coalfield marks the base of the Pennant Formation. A total of 25 m of Pennant Formation was reported here by Moore (1945), consisting mainly of coarse sandstones and conglomerates, although there was also a 40 cm thick coal and its seat earth — the No. 2 Rhondda Coal. Squirrell and Downing (1969) identify the conglomerate and sandstone which overlie the No. 2 Rhondda Coal and which marks the top of the sequence exposed at Wern Ddu, as the Saron Sandstone.

Biostratigraphy

Marine bands

As already stated, six mudstone or shale bands in the Wern Ddu sequence have been identified as marine bands. They yield assemblages of only very limited diversity, restricted mainly to inarticulate brachiopods, *Dunbarella* and '*Productus*'. However, they are thought to be the Vanderbeckei, Haughton, Aegiranum, Edmondia, Shafton and Cambriense marine bands, based on their position relative to widespread coals and sandstones in the section.

A seventh mudstone, immediately overlying the Garw Coal near the base of the sequence, was reported by Moore (1945) to yield fish fragments. It is uncertain whether it is a marine band, but it is interesting to note the presence of an identical bed above the Garw Coal at Brynmawr Road Cutting, some distance to the north.

Non-marine bivalves

Moore (1945) reported a single specimen of 'Naiadites flexuosa' (*auct., non* Dix and Trueman) from an ironstone 2.3 m above the Garw Coal (see account of the Brynmawr Road Cutting for comments on the affinities of these bivalves). Although an isolated example, it provides an interesting comparison with shells found above the Garw Coal at Brynmawr.

From the Five Feet–Gellideg Coal, Moore reported *Anthraconauta minima auct.,* which is now normally referred to as *Curvirimula belgica* (Hind) following proposals made by Trueman and Weir (1960). This is a long ranging species, having been reported from the Viséan to Bolsovian.

More diagnostic assemblages were reported by Moore from between the Bute and Nine Feet coals. They included *Anthraconaia williamsoni* (Brown) and *A. robertsoni* (Brown), and thus belong to the *A. modiolaris* Zone, probably the *A. phrygiana* Subzone. This indicates the middle Duckmantian.

A number of other horizons were reported by Moore to yield bivalves at Wern Ddu, but they were isolated specimens and/or poorly preserved. They include *Anthracosia* cf. *acutella* (Wright) from above the Nine Feet Coal (? Lower *Similis-Pulchra* Zone), a single *Anthracosia* sp. shell from the roof of the Abergorky Coal, a poorly preserved assemblage from above the Hafod Coal which Trueman *in* Moore (1945) claimed belonged to the *Similis-Pulchra* Zone, and poorly preserved examples of '*Anthracomya*'sp. (*?Anthraconaia* sp.) from above the No. 3 Rhondda Coal.

Plant fossils

Three significant assemblages were found by Moore at Wem Ddu. There are no available illustrations of the fossils, and some of the identifications are suspect. It is possible to interpret at least parts of the lists in terms of modem taxonomy and to draw some biostratigraphical conclusions. However, it will be necessary to re-investigate these assemblages, preferably with new collections, before their full biostratigraphical significance can be established.

The lowest includes '*Neuropteris grangeri*' (probably *N. beterophylla* Brongniart), *N. obliqua* (Brongniart) Zeiller, *Renaultia gracilis* (Brongniart) Zeiller, *Sphenophyllum cuneifolium* Sternberg, *Annularia radiata* (Brongniart) Sternberg and *Asterophyllites charaeformis* (Sternberg) Unger. Although containing a range of taxa, the assemblage is not particularly diagnostic, indicating only a position somewhere between the upper *Lepidophloios hoeninghausii* Zone to upper *L. rugosa* Zone (upper Langsettian to upper Duckmantian).

The second assemblage was found in shales 5 m below the Nine Feet Coal. It includes '*Neuropteris gigantea*'(probably *Paripteris pseudogigantea* (Potonié) Gothan), '*N. heterophylla*' (probably *Laveineopteris loshii* (Brongniart) Cleal *et al.*) *N.*

cf. *obliqua, Alethopteris decurrens* (Artis) Zeiller, *Lonchopteris rugosa* Brongniart, *Mariopteris muricata* (Brongniart) Zeiller, *Bertrandia avoldensis* (Stur) Danzé, *Sphenophyllum cuneifolium* and *Annularia radiata.* Such an assemblage probably belongs to the *L. rugosa* (or possibly lowest *P. linguaefolia*) Zone, indicating the Duckmantian Stage. Determining the true identity of Moore's *N.* cf. *obliqua* would provide a more accurate biostratigraphical control on the assemblage, particularly if it could be fitted into the phylogenetic model outlined by Josten (1962).

About 8 m above the Abergorky Coal, Moore found *Laveineopteris tenuifolia* (Sternberg) Cleal *et al., Paripteris pseudogigantea, Macroneuropteris scheuchzeri* (Hoffmann) Cleal *et al., Eusphenopteris obtusiloba* (Brongniart) Novik, *Renaultia chaerophylloides* (Brongniart) Zeiller, *R. rotundifolia* (Andrä) Zeiller and *Sphenophyllum majus* (Bronn) Bronn. This almost certainly belongs to the *P. linguaefolia* Zone, indicating the Bolsovian or uppermost Duckmantian.

Palynology

The palynology of this site was described by Sullivan (1962). Other than an unpublished thesis by Williams (1956), the results of which were summarized by Butterworth and Millott (1960), this is the only account of Upper Carboniferous palynomorphs from the South Wales Coalfield. Sullivan's work was also important in that he demonstrated that the non-marine shales yielded assemblages of similar composition to the coals; previous studies on Upper Carboniferous palynology had been based only on the coals, and there had been some debate as to whether the shales would yield similar palynomorphs. This is not the place to provide a detailed biostratigraphical analysis of Sullivan's study; there appear to be differences in the taxonomy used in his paper compared with later biostratigraphical reviews, such as by Smith and Butterworth (1967) and Owens (1984). The following is thus a brief resume of his conclusions.

That part of the section below the Seven Feet Coal was included in the *Cirratriradites aligerens* Zone of Butterworth and Millott (1960) (the *Radiizonates aligerens* Zone of Smith and Butterworth, 1967). This is a well defined zone in the upper Langsettian of much of western Europe (Owens, 1984).

Smith and Butterworth (1967) assigned the very topmost Langsettian of South Wales to the *Schulzospora rara* Zone, but Sullivan found no evidence of it at Wern Ddu. His next highest assemblages, other than those from the Vanderbeckei Marine Band, originated from the Bute Coal. The samples from here up to the Aegiranum Marine Band were assigned to the *Dictyotriletes bireticulatus* Zone. This seems to correspond to the *M. nobilis — F. junior* Zone of Owens (1984), which is known in the Duckmantian and topmost Langsettian in western Europe.

Assemblages from just above the Aegiranum Marine Band up to just below the Hafod Coal were assigned by Sullivan to the *Novisporites magnus* Zone of Butterworth and Millott (1960). It marks a significant change in the palynomorph assemblages, with the incoming of taxa such as *Vestispora magna* (Butterworth and Williams) Smith and Butterworth, *Microreticulatisporites nobilis* (Wicher) Knox and *Triquitrites sculptilis* Balme. However, the change appears to be a relatively local affair, and is not recognized in the classification outlined by Owens (1984).

The Hafod Coal was reported to yield the first rare occurrences of *Torispora securis* Balme, and was taken by Sullivan to mark the base of the zone of that name. This is a major palynological event, which can be identified throughout much of Europe (Owens, 1984). However, the exact level can vary between basins: in South Wales it occurs at about the middle Bolsovian, whereas in the Lorraine (France) and Donetz (Ukraine) it is near the base of the Bolsovian. This in part explains the discrepancies between the zonation of Smith and Butterworth (1967), in which the base of the *T. securis* Zone is placed at the Cambriense Marine Band, and that of Owens (1984), in which it is placed in the lower Bolsovian.

Interpretation

This is the only site in the eastern part of the South Wales basin to show a continuous sequence from the lower Langsettian to the upper Bolsovian. Moore (1945) and Squirrell and Downing (1969) describe similar strata from a number of other places in this part of the coalfield, but they either show only small parts of the sequence, or were underground workings. Although exposure at Wern Ddu is now poor, there is still the potential to open up a continuous sequence through the Productive Coal Formation here. When combined with Brynmawr Road-Cutting and Coed-y-Darren, it will be possible to examine most of the Coal Measures in the eastern part of the basin.

The Productive Coal Formation is significantly condensed compared with sequences to the west. For instance, at Wern Ddu the Duckmantian is only 75 m thick, whereas near Pontypridd it is 180 m (Woodland and Evans, 1964) and near Ammanford it is 235 m (Archer, 1968). Also, significantly more of the sequence consists of seat earths, and the coals are compound seams which further west split into a number of separate seams. This all combines to indicate significantly lower rates of subsidence in this part of the coalfield, which is symptomatic of its position near the margins of the depositional basin.

Another feature of the Wern Ddu sequence is that the Pennant Formation facies occurs significantly higher than in the central part of the coalfield. The junction between this and the underlying Productive Coal Formation is gradational here, with some sandstones occurring just above the Pentre Coal. However, the lowest really massive and conglomeratic sandstones typical of the Pennant appear between the No. 3 and No. 2 Rhondda coals. In contrast, in the middle part of the north crop, such as at Cwm Gwrelych–Nant Llyn Fach, the Pennant Formation appears immediately above the Cambriense Marine Band. According to Kelling (1988), the Pennant Formation reflects the generation of new nappes near the Variscan Front to the south, which increased both basin subsidence and sediment supply into the South Wales basin. The delay in the introduction of Pennant-type lithologies into this marginal part of the basin may reflect the stabilizing effect of the Usk Axis to the east, which may have been able to resist the nappe-loading, at least for a time.

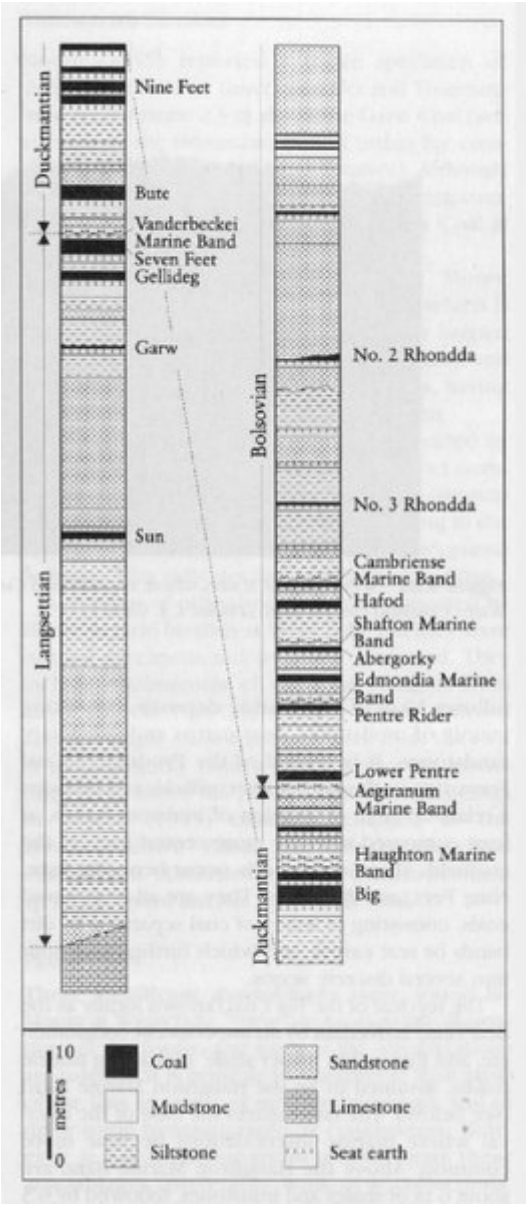
Biostratigraphically, Wern Ddu is important because it is one of the few places in South Wales to have yielded palynological evidence. South Wales provides good biostratigraphical evidence for the other groups, such as plant macrofossils, non-marine bivalves and marine fossils. However, the rank of the coals is normally too high for the preservation of palynomorphs (Smith and Butterworth, 1967); only in the eastern part of the coalfield, such as at Wern Ddu, is the rank sufficiently low for them to be preserved. There is a problem in relating the evidence from these marginal areas to the main part of the coalfield, as the sequence is condensed and detailed comparisons of the coals are difficult. Sullivan's (1962) discovery that the non-marine mudstones here yielded essentially similar palynomorphs to the coals offers a potential solution to this problem; palynomorphs in shales are less vulnerable to the destructive effects of coalification, and thus might still be preserved in the more central parts of the coalfield. However, although 30 years have now lapsed since Sullivan's discovery, there have been no reported attempts to investigate the palynomorphs from shales in the main part of the coalfield, and thus to provide a more detailed palynostratigraphical analysis of the South Wales sequence.

Conclusions

Wern Ddu shows the only continuous sequence of rocks ranging in age from the early Langsettian to late Bolsovian (300–315 million years old) in the eastern part of the South Wales Coalfield. It is also the only site in the coalfield from where the fossilized remains of plant pollen and spores can still be obtained, which is important for establishing correlations of the strata with sequences in other parts of Europe. This is also helped by a range of other types of fossils, including the remains of various marine and non-marine animals.

References

(Figure 4.28) Wern Ddu GCR site, where a condensed Coal Measures sequence on the eastern margins of the South Wales Coalfield can be seen. (Photo: C.J. Cleat.)



(Figure 4.27) Log of sequence exposed at Wern Ddu. Based on Moore (1945).