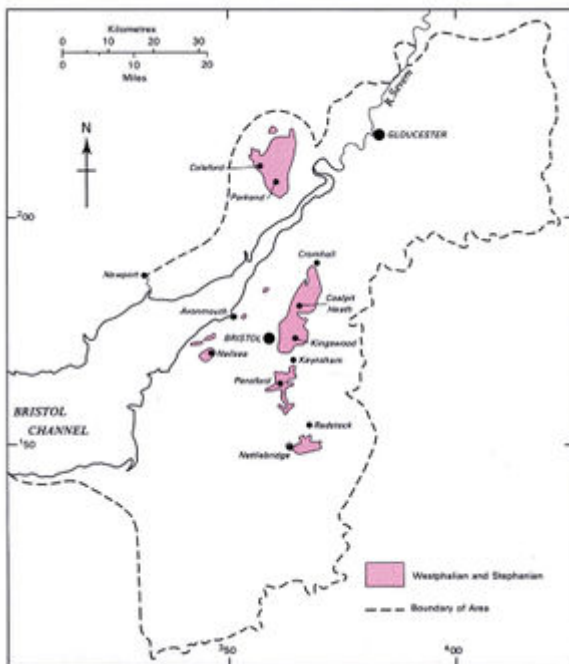


Upper Carboniferous (Westphalian and Stephanian) and its classification, Bristol and Gloucester region

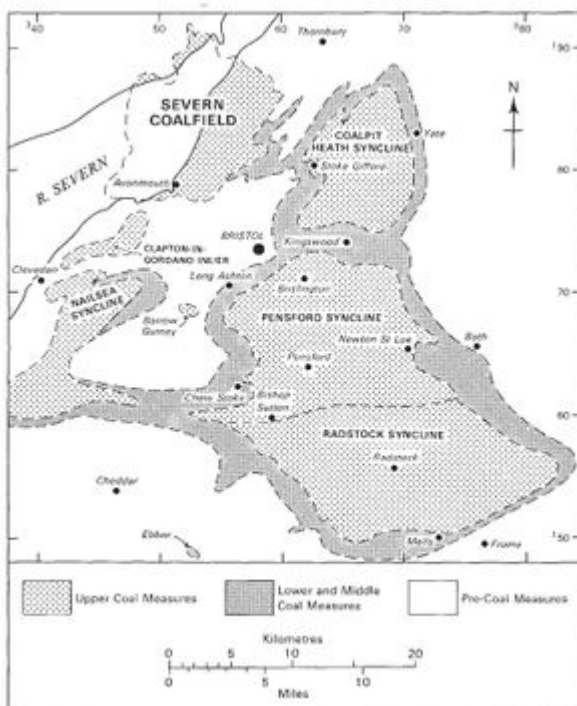
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Green, G W. 1992. British regional geology: Bristol and Gloucester region (Third edition). (London: HMSO for the British Geological Survey.)



Outcrop of the Westphalian and Stephanian rocks in the region. (P948965)



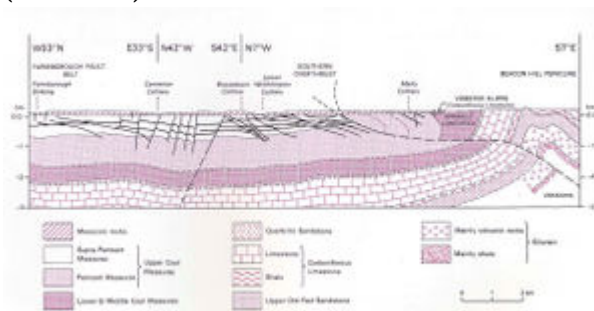
Distribution of Coal Measures (outcrop and

subsurface) in Avon and Somerset, showing coal 'basins'. (P948967)

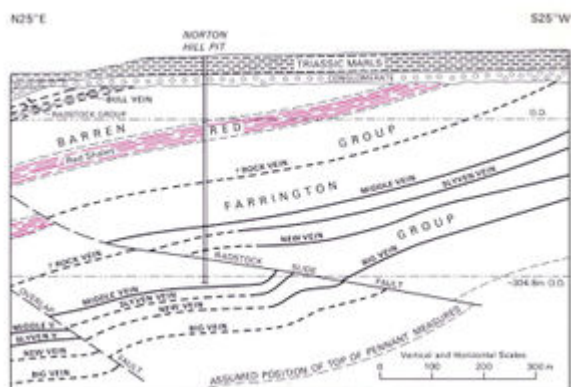
Stages	Marine bands	Nonmarine bivalves		Spores	Divisions on Geological Survey maps
		Zones	Faunal belts		
Stephanian					
Cantabrian					
Westphalian D		<i>A. iris</i>		<i>Thymospora obscura</i> (xi)	Upper Coal Measures
Westphalian C (Upper) [Bobovian]	Carbelesse*	<i>A. philippii</i>		<i>Terrispora scuris</i> (x)	
Westphalian C (Lower) [Bobovian]	Angiranium*	Upper similipulchra	<i>adams-hindi</i> * <i>atra</i> * <i>caldonica</i> * <i>pharygia</i> <i>ovum</i> * <i>regularis</i>	<i>Westipora magna</i> (ix)	Middle Coal Measures
Westphalian B [Duckmantian]	Vanderbeckei*	Lower similipulchra		<i>Dictyotrites birticalatus</i> (viii)	
Westphalian A [Langsettian]		<i>A. nodularis</i>	<i>crispigelli</i> <i>pseudonobusta</i> *	<i>Schulzospira rana</i> (vii)	Lower Coal Measures
		<i>C. communis</i>	<i>hipensis</i> <i>feras</i> <i>proxima</i> <i>extremata</i> * <i>julii-protes</i>	<i>Radizosales algerus</i> (vi)	
	Listeri? Subcresatum*	<i>C. lenticulata</i>		<i>Densosperites molatus</i> (v)	

*Marine bands and nonmarine bivalve faunal belts recognised in the Bristol and Somerset coalfields

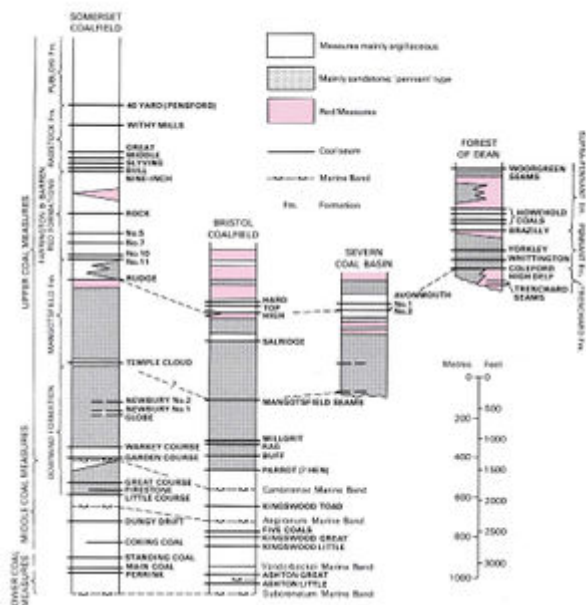
Classification of the Coal Measures (after Ramsbottom et al., 1973^[1]). The spore zones are after Smith and Butterworth (1967)^[2]. (P948994)



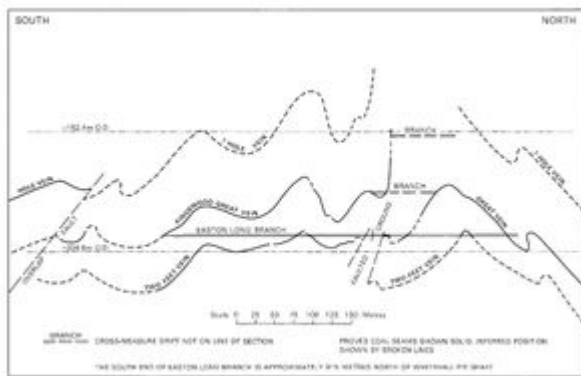
Horizontal section across the Radstock Coal Basin. The structure at depth remains unproved because no workings penetrate to the Pennant Measures north of the Southern Overthrust. (P948972)



Overthrust faulting. The 'Radstock Slide' at Norton Hill Colliery, Avon. (P948973)



Comparative vertical sections of the Coal Measures in the Somerset, Bristol, Severn and Forest of Dean coalfields. (P948968)



Section through part of the Middle Coal Measures at the western end of the Kingswood Anticline, Easton Colliery, Bristol (after E H Staples). (P948974)



Section across the southern end of the Forest of Dean Coalfield. (P948969)

The Coal Measures in the district span the Westphalian and lowermost Stephanian series. Apart from the western edge of the concealed Oxfordshire Coalfield, which is just within the eastern limits of the district, the Coal Measures occur in the exposed Forest of Dean Coalfield to the west of the River Severn, and in the Bristol and Somerset coalfields to the east of the Severn ([P948965](#)). The latter are largely (73 per cent) concealed by Mesozoic rocks.

Post-Westphalian earth movements have led to the separation of the Bristol and Somerset coalfields into a number of structurally distinct areas previously referred to as basins ([P948967](#)). The Radstock and Pensford synclines, to the south, are jointly referred to as the Somerset Coalfield, and the

Kingswood Anticline and Coalpit Heath Syncline, to the north, as the Bristol Coalfield. The Coal Measures of the Nailsea Syncline, though forming a structurally distinct domain, are in geological continuity beneath the Mesozoic cover with the Somerset Coalfield to the south and south-east. The Severn Coalfield, and the Clapton-in-Gordano and tiny Barrow Gurney inliers, which lie to the west of Bristol, are structurally separated from the main coalfield. The Coal Measures known to occur on the south side of the Mendips and in the Westbury (Wiltshire) Borehole are also presumed to be structural outliers of the main coalfield. The maximum preserved thickness of Coal Measures occurs in the Somerset Coalfield where it is between 2500 m and 2600 m.

Classification

Buckland and Conybeare (1824)^[3] were the first to divide the Coal Measures of the district into three major lithological groupings, namely the 'lower' and 'upper coal shales', separated by a thick division of grey sandstone termed the 'Pennant Grit'. Subsequent classifications of the Coal Measures built on this scheme mainly by further subdividing the upper and lower divisions on the basis of their contained coals. Subdivision of the Coal Measures has also been accomplished by using zonal schemes based on plants, nonmarine bivalves and miospores, but the basic classification depends on the recognition of marine horizons within the otherwise nonmarine sequences. The development and systematic application of such fossil-based schemes of classification, for example to correlation, depend for their success on geological examination of the strata as exploration proceeds. This only became standard practice following nationalisation of the coal industry in 1945, by which time the heyday of coal mining was past and new exploration work considerably reduced. Nevertheless, by the time the last pit closed in 1971, the accumulated data enabled application of the standard British chronostratigraphical classification of the Coal Measures to the greater part of the district ([P948994](#)).

This was systematised by the Upper Carboniferous Working Group of the Geological Society of London (Ramsbottom et al., 1973^[1]). Their recognition of the fourfold division of the Westphalian into stages labelled A, B, C and D has been formalised by Owens et al., (1985)^[4] who introduced the names Langsettian, Duckmantian and Bolsovian respectively for Westphalian A, B and C. A stratotype for the Westphalian D division has yet to be designated. The florally defined Westphalian E has now been abandoned and redefined as part of the Stephanian Series, and an intermediate stage, the Cantabrian, has been recognised between Westphalian D and the former Westphalian E. It is now thought that the highest beds of the Forest of Dean Coalfield are probably Cantabrian in age and they are, therefore, the youngest Coal Measures strata in the district (Ramsbottom et al., 1978)^[1].

The major stage boundaries are, with the exception of that taken between Westphalian C (Bolsovian) and D, drawn at the bases of marine bands. Until the stratotype for the Westphalian D division has been designated, its base is taken at the incoming of the nonmarine bivalve *Anthraconauta tenuis* and miospores characteristic of the *Thymnospora obscura* (xi) miospore zone. Marine bands over the years have been given different names in different coalfields, but those included in [P948994](#), which are based on the principal diagnostic goniatites, are applicable throughout Britain (Ramsbottom et al., 1973, p.45)^[1]. In the Bristol and Somerset coalfields the Subcrenatum, Vanderbeckei, Aegiranum and Cambriense marine bands have been known as the Ashton Vale, Harry Stoke, Crofts End and Winterbourne marine bands respectively.

The term 'Pennant', which has been used in many different ways in the past, was restricted by Ramsbottom et al. (1973)^[1] to the Forest of Dean Coalfield where, the 'Pennant' facies is now designated the Pennant Formation and the overlying beds the Supra-Pennant Formation. On the most recent Geological Survey maps of the Bristol-Somerset coalfields, the 'Pennant' facies is

designated Pennant Measures and subdivided where possible into the Downend and Mangotsfield formations, whilst the overlying coal measure formations are grouped together as Supra-Pennant Measures.

Radstock syncline

The north-north-west-trending Radstock Syncline, lying to the south of the Farmborough Fault Belt, is much broken by east-west thrusts or reverse faults ([P948972](#)), of which the well-known 'Radstock Slide' is an example ([P948973](#)). Dips are moderate towards the axis, which passes through Radstock and Timsbury. A small area of the Upper Coal Measures is exposed in the Farrington-Clutton-Timsbury area, and a considerable tract of the Lower and Middle Coal Measures occurs in the Nettlebridge Valley, but for the most part the productive measures are concealed by Mesozoic strata.

Several roughly north-south-trending faults, of which the '100 Fathom' or 'Clandown' Fault is the main one, are later than the east-west thrusts. Against the ridge of the Mendips at the south end of the syncline the inclination of the strata increases when traced eastwards from the old Moorewood Colliery, near Blacker's Hill, until, west of Barlake, the measures become vertical or overturned, a condition that is maintained through Newbury, Vobster and Mells. The incompetent argillaceous Lower and Middle Coal Measures hereabouts display very complex contortions.

The time relationships of the Radstock Syncline strata were not properly understood until the discovery of the Aegiranum and Cambriense marine bands during the dismantling of the New Rock Colliery in 1968. This proved that the base of the Pennant Measures here is at a lower stratigraphical level than farther north ([P948968](#)). Only in the southern part of the Radstock Syncline have the coals of the Lower and Middle Coal Measures been worked, mainly at the Newbury and Vobster collieries in the south-east and in the New Rock and Moorewood pits to the south-west. Owing to the intense faulting and the almost complete abandonment of the workings, identification and correlation of the seams between the two areas is uncertain. In the Newbury and Vobster district some twelve seams varying from 0.75 to 1.9 m in thickness were extensively worked. Some of the thick seams, such as the Dungy Drift and Coking Coals, appear to split and thin out westwards so that in the New Rock-Moorewood area only eight seams proved workable. In both regions the Perrink (Blackstone), Main Coal (Callows), Great Course and Garden Course seams have been extensively mined — the last two are in the Pennant Measures, above and below the Cambriense Marine Band respectively.

Palaeontological knowledge of the Lower and Middle Coal Measures is very limited. The mudstones above the Perrink contain abundant large *Carbonicola* of *pseudorobusta* type, thus identifying the faunal belt of the same name ([P948994](#)). Marine beds in contorted strata around the position of the Coking Coal, may represent the Vanderbeckei Marine Band.

The Lower and Middle Coal Measures are about 580 m in thickness, of which the top 150 m are placed in the Pennant Measures, which total about 1100 m in thickness. None of the coal seams above the Warkey Course in the Pennant Measures has been recognised in all parts of the syncline, although a few higher seams have been locally worked. These include the Newbury No.1 seam ([P948968](#)), which contains *Anthraconauta phillipsii* in the roof. The remainder of the succession is not known in detail. The uppermost 400 m of the Pennant Measures crop out in the Clutton-Temple Cloud area, where they contain a few unworkable coals, the lower of which have very tentatively been equated with the Mangotsfield Seams of Bristol (Kellaway, 1970), thus allowing correlation with the Downend and Mangotsfield formations of the Bristol area.

The Supra-Pennant Measures, totalling some 900 m in thickness, occupy the central part of the

Radstock syncline and are divided into the Farrington, Barren Red, Radstock and Publow formations whose boundaries are defined by coal seams. The coal seams in the Farrington Formation are thin, including the Rudge Vein at the base; only three of the five coals worked exceed 0.6 m in thickness. The Barren Red Formation, which has no workable coals, contains red beds, 90 m or so thick, in the middle of the formation in the southern and central areas; it thins northwards. The Radstock Formation includes six main seams, rarely exceeding 0.7 m thick, of which four were worked over most of the area. Little is known of the Publow Formation; up to about 130 m of grey measures with a number of very thin unworkable coals are present in the centre of the syncline. When traced northwards there is a tendency for all the seams in the Supra-Pennant Measures to split and deteriorate in quality, so that the coals in the Pensford area to the north, believed to be the equivalents of those at Radstock, are thinner and dirtier.

All the Supra-Pennant Measures contain typical Westphalian D floras. The Radstock Formation contains, in addition to an abundant flora, the bivalves originally used to define the *Anthraconaia prolifera* Biozone. However, owing to its erratic occurrence, it is now proposed that usage of the zone be discontinued (Ramsbottom et al., 1978); thus the whole of the Supra-Pennant Measures here belongs to the tenuis Biozone.

Pensford Syncline

This part of the Somerset Coalfield lies north of the [Farmborough Fault Belt](#) and passes northwards into the Kingswood Anticline. Lower and Middle Coal Measures are known predominantly from scattered boreholes. The only outcrops of strata beneath the Supra-Pennant Measures are in the Newton St Loe area west of Bath where the Pennant Measures have a small outcrop and five seams of probable Middle and Upper Coal Measures age were worked from the Globe Pit in the 19th century. Elsewhere, only Upper Coal Measures rocks are exposed. On the northern edge of the syncline, the lowest Supra-Pennant Measures, presumed to be part of the Farrington Formation, are exposed in the Brislington area and were mined in the 18th and 19th centuries. On the west side of the syncline, four seams, also thought to belong to the Farrington Formation, were mined at Bishop Sutton until 1926.

The succession generally is imperfectly known except in the region around the Pensford and Bromley collieries. Here, above thick Pennant Measures two coal groups, the Bromley below and the Pensford above, are separated by barren measures including red beds; they are overlain by thick barren measures known as the Publow Formation, for which this is the type area. The thickness of the succession is approximately equal to equivalent strata in the Radstock Syncline.

There are seven Bromley coals, of which three, 0.5 to 0.6 m thick, have been extensively worked. Out of eight coals in the Pensford coal group only two, both as thick as the Bromley seams, were widely worked. Exact correlation with the Radstock sequence is not possible because the coals used to define the formations there cannot be definitely recognised farther north, and faunal and floral differences add to the uncertainty. Using mainly lithological criteria, it is likely that the Bromley and Pensford formations roughly equate with the Farrington and Radstock formations, and the red beds between the Bromley and Pensford coal groups with the Barren Red Formation. Details of the Publow Formation were provided by the Hursley Hill Borehole, drilled by the National Coal Board between Pensford and Whitchurch (Kellaway 1970, pl. 1)^[5]. The formation, some 500 m thick, comprises mainly grey mudstone and siltstone with some mappable sandstones and occasional thin coal seams. A few of the coals were dug at outcrop on a very limited scale. Nonmarine bivalves of the tenuis Biozone are present at the base of the formation and a flora of Westphalian D age is present throughout.

Kingswood Anticline

A wide belt of Middle Coal Measures crops out in the core of an east-west-trending anticlinorium, long known as the Kingswood Anticline. Despite complex folding ([P948974](#)) and major faults, some 20 seams, ranging from 0.3 m to 2 m in thickness, have been extensively worked here.

The coals range from Lower into Upper Coal Measures. The lowest is the Ashton Group of coals, which includes the well-known Ashton Great Vein and Red Ash, and which has been extensively worked in the Ashton district. A recent section through the Lower Coal Measures was provided by the Ashton Park Borehole (Kellaway, 1967)^[6] which proved a previously unrecognised marine band with *Lingula* at about 12 m below the Ashton Great Vein, and stunted representatives of the *extenuata* faunal belt in the roof of the underlying Little Seam. Although not proved in situ there is evidence for the *Vanderbeckei* Marine Band overlying the Red Ash Coal. The most widely worked coals in the overlying Middle Coal Measures were the Kingswood Little or Two-Feet, the Kingswood Great or Bedminster Great, and the Lower Five Coals from below the Aegiranum Marine Band and the Kingswood Toad above it. Although the Cambriense Marine Band has not been located in the Kingswood Anticline, it is probable that the base of the mapped Pennant Measures approximates to the base of the Upper Coal Measures. The lowermost coals of these measures contain good coking coals, of which the Parrot, Buff, Millgrit and Rag have been worked extensively in the Oldland-Warmley district in the southern limb of the Kingswood Anticline.

Coalpit Heath Syncline

Lying to the north of the Kingswood Anticline this north-south-trending syncline extends as far north as Cromhall. Bedding dips are generally less than 40°. The syncline is divided into four parts by two intersecting faults. The north-south-trending Coalpit Heath Fault, slightly to the west of the fold hinge, has a downthrow of 100 m to the east; the Kidney Hill Fault lies at right angles to it and has a downthrow to the south.

The total thickness of the Lower and Middle Coal Measures is nearly 500 m. There are no workable coals in the presumed Lower Coal Measures but in the exposed north and north-eastern limb of the syncline the Middle Coal Measures have been worked on a limited scale in the Yate district. In marked contrast to the Kingswood Anticline, only two seams were mineable to any extent, i.e. the Yate Hard Vein and the Smith Coal, which correspond to coals in the Kingswood Great group.

Knowledge of the Lower and Middle Coal Measures and overlying strata in the southern and western part of the syncline was greatly extended after 1949 by a programme of nine deep exploratory boreholes drilled by the National Coal Board, which led to the opening of the Harry Stoke Drift Mine in the Kingswood Great group of seams. The boreholes enabled the accurate positioning of the main marine bands within the sequence.

The Upper Coal Measures outcrop is extensive and coals in the Supra-Pennant Measures were intensively worked and are virtually exhausted, whereas those below have been only selectively worked.

The Pennant Measures, which lie between the Cambriense Marine Band and the High Vein, vary in thickness from over 1000 m in the south to about 600 m in the northern part of the outcrop. The basal 120 to 180 m are markedly argillaceous, but, apart from some 40 m of mainly red beds underlying the High Vein at the top, the strata are dominantly composed of sandstone with relatively minor intervals of mudstone.

Using the Mangotsfield seams, which have been worked to a limited extent in the south, Kellaway

(1970)^[5] divided the Pennant Measures into the Mangotsfield Formation above and the Downend Formation below (P948968). The sandstones of the former are uniform throughout the area. The north and north-eastward diminution in thickness of the succession, therefore, is thought to be due to the disappearance northwards of the main arenaceous division of the Downend Formation, which is represented only by a basal more argillaceous facies in the Rangeworthy area (Kellaway, 1970, fig.3)^[5]. Coal workings are confined to the lower half of the Downend Formation adjacent to the Kingswood Anticline and the Mangots-field seams. The lower coals, of which the Hen (0.9 m) is the most consistently developed, are apparently equivalent to the seams worked more extensively on the south side of the Kingswood Anticline. Elsewhere the coals are unworkable and red beds are commonly developed in this part of the sequence. There is no faunal evidence of age for the strata above the Mangotsfield seams, whose roof measures contain *Anthraconauta phillipsii* in the Mangotsfield area, which indicates the *phillipsii* Biozone.

The Supra-Pennant Measures have been correlated with the Farrington and Barren Red formations of the Somerset Coalfield. The Farrington Formation contains three workable coals, the lowest of which, the High Vein at Coalpit Heath Colliery, averages about 1.5 m in thickness with a thin parting. Southwards this seam splits and is represented at the Parkfield Colliery, south of the Kidney Hill Fault, by the Hollybush and Great Seams, separated by 0.4 m of shale. The shale increases to 15 m at the southern end of the area. The Farrington seams are succeeded by up to 275 m of barren measures, mainly red-brown but including an intercalation of grey measures in the upper part. Faunally, the roof measures of the High Vein are characterised by an abundance of the branchiopod crustacean *Leaia* in association with *Anthraconauta phillipsii* and *A. tenuis*. The roofs of the seams carry a rich Westphalian D flora.

Nailsea Syncline

Coal workings here were abandoned between 1880 and 1890 because of heavily watered measures and the inferior quality of the coal, and there is little information about the succession. About 270 m of shales and subordinate sandstones with 12 recorded coal seams are presumed to be Lower and Middle Coal Measures. Of the 12 seams only White's Top (1.1 m) and the Dog (0.9 m) were mined to any extent. A maximum thickness of about 330 m of sandstone, presumably Upper Coal Measures, rests on the Middle Coal Measures. Two seams are known here, but only one of these, Grace's Seam (0.9 m thick), was worked.

A short distance to the north of the main coalfield, Pennant Measures rest directly on Carboniferous Limestone with or without the intervention of thin Namurian quartzitic sandstone, thus testifying to strong sub-Namurian and sub-upper Westphalian unconformities.

Clapton-in-Gordano Inlier

Coal was worked on a very limited scale in this small and partly concealed inlier, but little is known of the structure. The succession is apparently entirely Pennant Measures which overlie older Carboniferous and Devonian strata with marked unconformity.

Severn Coalfield

Apart from small inliers surrounded by Mesozoic rocks the coalfield is wholly concealed. Much disturbed Lower and Middle Coal Measures are exposed at Cattybrook, south-west of Almondsbury, and sandstones of the Pennant Measures crop out in reefs on the Welsh side of the River Severn and on the coast at Portishead and at Kings Weston. Much of the coalfield lies under the River Severn. Apart from the Cattybrook inlier, nothing is known of the lower part of the succession, though the Lower and Middle Coal Measures appear to be absent west of a line drawn between Olveston and

Henbury, due to the unconformable overlap of the Upper Coal Measures. The lower subdivision of the Upper Coal Measures, 300 to 400 m thick, consists of massive sandstone (Pennant Measures) with minor shaly and coaly intercalations and, towards the top, red beds. An upper subdivision, proved by boreholes in the centre of the Avonmouth Syncline to exceed 160 m, consists of grey and some red measures which in the lowest part include two workable coals, the Avonmouth No. 1 and No. 2 seams.

A coal, 1.4 m thick, near the base of the Pennant Measures west of the River Severn, proved in boreholes in the Portskewett area, has roof measures with *Anthraconauta phillipsii*. Kellaway (1970)^[5] tentatively correlated this coal with the Mangotsfield seams of Bristol. The strata between Avonmouth No. 1 and No. 2 seams, and below the latter, contain abundant *Anthraconauta phillipsii*, *A. tenuis* and *Leaia*, and are correlated with the Hollybush and Great Veins of Parkfield in the southern part of the Coalpit Heath Syncline. The associated strata are therefore considered to represent the Farrington Formation, and possibly part of the Barren Red Formation within the *tenuis* Biozone.

Forest of Dean Coalfield

In contrast with the basins of the Somerset and Bristol coalfields, the Forest of Dean Coalfield, some 90 km² in area, is completely exposed. Two roughly north-south folds, the Main Syncline in the east and the shallow asymmetric Worcester Syncline in the west, are separated from one another by the Cannop Fault Belt. This NNW-SSE fault zone includes up to 25 faults, each with a throw no greater than 17 m. In the centre of the Main Syncline the strata are almost flat, but they become inclined on its eastern side in the Staple Edge Monocline.

The oldest Westphalian rocks occur in the north-eastern corner of the Main Syncline in the Mitcheldean area, where the upper part of the Drybrook Sandstone, lying unconformably beneath the Upper Coal Measures, contains miospores of Westphalian A (Langsettian) age. Over most of the area, however, the oldest Westphalian rocks comprise the Trenchard Formation, 15 to 120 m thick, at the base of the Coal Measures and resting unconformably upon older formations ([P948969](#)). In the Coleford area the formation contains two coal seams which, farther south-east come together to form the 1.4 m-thick Trenchard Seam. South-west of a line drawn roughly north-west — south-east through Coleford, the Trenchard Formation consists of mainly grey sandstones, but to the north-east it passes into barren red shales and mudstones. The lowest part of this formation may lie within the *phillipsii* Biozone, but there is no fossil evidence to prove this.

The Pennant Formation ranges from 180 m in thickness in the north to 250 m in the south. At the base of this predominantly sandstone formation, the Coleford High Delf Seam, 1.15 to 1.5 m thick, has supplied 97 per cent of the total output of this coalfield since the Second World War. Two other seams in the Pennant Formation, the Whittington and the Yorkley, measure 0.8 to 0.9 m in thickness, but are workable over only a limited area. Where the Coleford High Delf has a shale roof it contains a similar fauna to that associated with the Avonmouth No. 1 and No. 2 seams and, like them, is referred to the *tenuis* Biozone. The flora associated with this and higher strata in the Pennant Formation indicates an early Westphalian D age.

The lower part of the Supra-Pennant Formation, about 90 m thick, is largely argillaceous and includes eight workable coals long known informally as the Household Coals. Many of the seams, however, are split into layers or 'leats' by soft mudstone partings and can usually be mined only where two or more leats have run together. The associated floras are of Westphalian D age. Above the highest of the Household Coals, known as the Crow or Dog, the upper part of the Supra-Pennant Formation attains some 240 to 250 m in thickness and includes an appreciable thickness of sandstone in its lower part. Near the top of the Supra-Pennant Formation, and preserved only in the

centre of the basin, are the Lower and Upper Woorgreen seams (about 0.9 m). These beds contain a flora believed to be of basal Cantabrian age which, together with the Grovesend Beds of South Wales, makes them the youngest known coal measures in Britain (Ramsbottom et al., 1973)^[1].

The 'Horse' and 'Little Horse' in the Coleford High Delf of the Worcester Syncline are good examples of 'wants' or 'washouts', which extend for distances of 2.5 km and have an average width of 150 m and 50 m respectively. They occur where a coal has been locally replaced by sediments deposited from a former stream that crossed the coal-swamp and eroded away the peaty or coal deposits along its course. They are most abundant where the coal is overlain by sandy sediments.

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1. ↑ [1.0](#) [1.1](#) [1.2](#) [1.3](#) [1.4](#) [1.5](#) Ramsbottom, W H C. 1973. Transgressions and regressions in the Dinantian: a new synthesis of British Dinantian stratigraphy. *Proceedings of the Yorkshire Geological Society*, Vol. 39, 567-607.
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