14. *On the FOSSIL FLORA of the PEMBROKESHIRE PORTION of the SOUTH WALES COALFIELD.* By REGINALD H. GOODE, B.A.
(Communicated by E. A. NEWELL ARBER, M.A., Sc.D., F.L.S., F.G.S. Read April 23rd, 1913.)

[PLATES XXVII-XXX.]

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I. INTRODUCTION.

THIS paper records the results of a study of the fossil plants which I have collected from the Pembrokeshire Coalfield during the last two years; of these the best specimens are now in the Sedgwick Museum, Cambridge.

I have confined my attention principally to the excellent coast-sections between Tenby and Ragwen Point, where the coalfield is eaten into by the sea along Carmarthen Bay; and those on the eastern side of St. Bride's Bay, from Talbenny on the south to Newgale on the north. I have also collected from various colliery-'tips' between Nolton and Newgale, and have worked much of the sections where the Eastern Cleddau, the Western Cleddau, and the Dauceddau eat into the coalfield south-east of Haverfordwest. These river-sections proved, however, to be very disappointing, with the exception of that in the neighbourhood of Picton Point, and in one or two other localities.

I wish here to record my indebtedness to Dr. E. A. Newell Arber, without whose aid this work would not have been undertaken. It was at his suggestion that I first proceeded to Pembrokeshire, with the view of studying the fossil flora of this portion of the South Wales Coalfield. He has supervised the identification of the plants, particularly affording me much help in the determination of difficult species, and has given me his advice throughout, for which I return my sincere thanks.

I also gratefully acknowledge the help which I have received from various officers of H.M. Geological Survey, who have freely given me information concerning the districts surveyed by them during the last decade, and have kindly allowed me to examine

their unpublished maps and sections. In this connexion I wish to express my thanks to Dr. A. Strahan, F.R.S. ; Mr. Herbert H. Thomas, M.A., B.Sc. ; Mr. T. C. Cantrill, B.Sc. ; Mr. E. E. L. Dixon, B.Sc. ; and also to Prof. O. T. Jones, M.A., D.Sc.

II. GENERAL GEOLOGY.

The Coal Measures of Pembrokeshire occupy a belt of country about 21 miles long, between Carmarthen Bay on the south-east, where the coalfield is disconnected with the main coalfield of South Wales, and St. Bride's Bay on the west. In the neighbourhood of Saundersfoot the outcrop is some 4 miles wide ; but south of Haverfordwest it is only about a mile wide, though it broadens out again towards the coast of St. Bride's Bay. Along the northern part of the eastern side of this bay there is an area of Coal Measures situated to the north of the main Pembroke coalfield, but separated from it by a belt of ' Millstone Grit ' and by a narrower belt of rock of Bala age, both of which extend to the coast. Except in the north, the strike in this area is chiefly north and south, thus contrary to the general east-and-west strike of the main mass of the coalfield.

For the greater part, the Coal Measures rest on ' Millstone Grit ' ; and this, between Haverfordwest and Carmarthen Bay, is followed by Carboniferous Limestone.

Roughly speaking, the eastern part of the coalfield has a synclinal form, as is indicated by the fact that the lowest measures, followed by the ' Millstone Grit ' and Carboniferous Limestone, come to the surface both on the north and on the south of the coalfield. The beds, however, lie in normal superposition only on the northern side of the basin, for in the central and the southern parts the beds are complicated by inverted folds and by a large number of overthrust faults. The prevailing dip in this central and southern region is southwards, thus introducing an element of deception along this portion of coast : for, as one approaches Tenby from the north, one notes that the beds, instead of ascending in the order of sequence as the direction of the dip would suggest, in reality belong to lower and lower horizons. This apparent dipping of the Coal Measures under the ' Millstone Grit,' and of this again under the Carboniferous Limestone, is due chiefly to repeated overthrusting from the south, but also partly to inversion.

Just as in the eastern part of the coalfield, so in the central area where the coalfield is eaten into by the Eastern Cleddau, the Western Cleddau, and the Dauceddau, a synclinal form can be recognized. Here, however, it is less apparent than farther east, the beds being still more disturbed, particularly so in the southern part of this region. In this district some of the coal-seams, or ' veins ' (as they are termed in Pembrokeshire), cannot be exactly correlated with those that occur farther east, for considerable changes have taken place. The ' Millstone Grit,' too, changes its character

as we pass westwards from the neighbourhood of the Eastern Cleddau, sandstones becoming more prominent at the expense of shales and mudstones.

In the coastal region around Little Haven, Broad Haven, etc., the beds are greatly folded and overthrust from the south, and are difficult to correlate with those farther east. The relation of the Settlings Beds and the Falling-Cliff Beds, from both of which fossil plants were obtained, one to the other and to the rest of the coalfield, will be discussed later.

It has already been mentioned that the strike of the beds in the Nolton-Newgale district (except in the north) is for the most part north and south, thus largely running parallel to the coast. The highest beds are found on the coast in the neighbourhood of Rickets Head; and, as we pass inland, we cross successively beds of lower and lower horizons. The beds of this district form a series which is quite distinct from those of other areas of the coalfield.

The shales of the coalfield are dark, sometimes markedly so, and for the most part split up into small fragments.

The earliest document that contains any material information concerning the Coal Measures of Pembrokeshire, is an essay on the 'History of Pembrokeshire'¹ left in manuscript in the year 1570 by Owen, but not published until 1796. This essay is a work of the highest interest, as it is the earliest-known example, in any language, of what can really be termed geological investigation. Between the years 1806 and 1836 mention of the coalfield was made chiefly by Martin,² De La Beche,³ Forster,⁴ and Murchison.⁵

In the following decade the district was surveyed by the Geological Survey, and the results were published in 1846 in a memoir by De La Beche.⁶ Geological maps of Pembrokeshire on the 1-inch scale (Sheets 38 & 40) were published in connexion with this survey in 1845, the latter being revised in 1857. References to the coalfield were made by Ramsay,⁷ in a memoir which was also published in 1846.

Brief mention was made, by an anonymous writer, of a portion of the coalfield in the 'Geologist'⁸ for 1862; and a description of the South Wales Coalfield by Brown,⁹ in which the Pembrokeshire portion is included, was published in 1874.

The chief account of the coalfield in recent years, pending the publication of the Geological Survey Memoirs, now in course of preparation, is to be found in the 'Summaries of Progress'¹⁰ for the years 1902 to 1909. An Index-Map of Pembrokeshire

¹ Owen (1796). The numerals in parentheses refer to the Bibliography, § VII, p. 275.

² Martin (1806).

³ Forster (1831).

⁴ De La Beche (1846) pp. 158-68, 221-27.

⁵ Ramsay (1846).

⁶ Brown (1874).

⁷ De La Beche (1826) pp. 17-20.

⁸ Murchison (1836).

⁹ Anon. (1862).

¹⁰ Strahan (1903-10).

(quarter-inch scale, Sheet 13 & part of 17), in connexion with the recent survey, was published in 1910; and maps on the 1-inch scale (New Series, Sheets 227, 228, & 245), and on the 6-inch scale, are now being prepared for publication.

In the following table are enumerated the coal-seams that occur in the Nolton and Newgale Measures. They are arranged in the order of sequence, and are taken from the section which has been constructed for this district by Mr. H. H. Thomas, to whom I am indebted for permission to make use of it.

It has been thought, partly owing to the thickness of the Coal Measures in this region, that the higher beds may possibly be equivalent to the Pennant Grit of the main South Wales Coalfield, as was first suggested by De La Beche.¹ In that case the coal-seams that occur above those that have been definitely placed in the Lower Coal Series, as seen in the section, would be included in the Pennant Grit. In these beds the prevailing strata are sandstones with, however, some shales and mudstones. In the Lower Coal Series there are three series of sandstones: namely, between the break which is a little below the Folkeston Vein and the Quarry Vein; also on the horizon of the Brawdy Coals; and, lastly, between the lowest 'Thin Coal' and the Olive Shales which lie at the base of the Lower Coal Series. The greatest thickness of shales and mudstones occurs between the Quarry Vein and the break which is a little above the Brawdy Coals, but they also occur interspersed among the sandstones.

		<i>Approximate distance in feet from the base of the Coal Measures.</i>	
LOWER COAL SERIES.	Rickets Head Vein		6580
	Black Cliff Vein		6360
	Cliff Vein		6050
	Hookes Vein.		
	Folly Vein.....		5070
	Thin Coal.		
	Folkeston Vein.		
		Break unknown	4235
	Haggard Vein.		
	Oxland Vein		3500
	Stonepit Vein.		
	Quarry Vein.		
	Foot Vein.		
	Yard Vein	} Simpson Coals.	2640
	Stink Vein		
	Five-Foot Vein		
	Three-Quarter Vein		2430
	Four Thin Coals.		
		Break unknown	1665
	Brawdy Coals.		
	Thin Coal.		
(Farewell Rock)			

¹ De La Beche (1846) p. 159.

The following section is taken from the 'Summary of Progress' for 1905, Mem. Geol. Surv. 1906, p. 52, and shows the position of the horizons from which plants were obtained in the sequence along the Tenby and Amroth coast, and also in the central district south-east of Haverfordwest.

'GENERALIZED SECTION OF THE COAL MEASURES OF EAST PEMBROKESHIRE.

		Thickness in		
		yards	feet	inches.
FOXHOLES SHAFT.	Measures proved in the Moreton upcast shaft; details unknown ...	58	0	0
	Measures with three thin seams.....	62	0	0
	Rock Vein of the Timber-Vein Series	0	3	0
	Measures	12	0	0
	Low Vein	0	1	8
	Measures	17	1	4
	Timber Vein	0	6	0
	Measures	78	2	0
	Rock Vein	0	1	0
	Measures	28	1	0
BONVILLE'S VENTILATING PIT, COURT. BONVILLE'S COURT.	Garland Vein	0	1	3
	Measures	6	2	3
	Fiddler's Vein	0	0	6
	Measures	7	2	1
	Under Garland Vein	0	1	4
	Measures	15	0	7
	Lower Level Vein.....	0	1	8
	Measures	26	2	5
	Catshole Vein	0	0	8
	Measures	44	0	0
	Kilgetty Vein	0	1	6
	Measures	17	0	0
	Lady's Frolic Vein			
	Measures	63	0	0
	Tin Pits Vein			
	Measures	10	0	0
	Farewell Rock			

III. THE FOSSIL FLORA.

So far as I am aware, there are no previous records of fossil plants from the Pembrokeshire Coalfield, with the exception that *Stigmaria* are mentioned by De La Beche¹ as occurring in underclays in the coast-section east of Wiseman's Bridge, near Saundersfoot. In the same paper 'vertical stems of *Calamites*' are also stated to have been found at one horizon in the same section.

Since the coalfield falls naturally into three districts, the beds of which cannot be correlated exactly one with the other, it is best to consider the flora of these areas separately.

The first district to be dealt with is that which extends roughly from Nolton to Newgale, and stretches inland from St. Bride's

¹ De La Beche (1846) pp. 162-67.

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Bay for about a mile and a half. This area will be considered first, because the highest beds of the coalfield are found here. The second district includes the region between Haroldston West and a little north of Talbenny. The third and largest area extends from Tenby to Ragwen Point, and stretching towards St. Bride's Bay is eaten into by the Eastern Cleddau, the Western Cleddau, and the Dauceddau.

I have succeeded in collecting from the shales associated with the Rickets Head Vein, two species, belonging to the genera *Annularia* and *Linopteris*, which are apparently new. The descriptions of these species will be found below (pp. 265-66), together with that of a species of *Lepidophyllum*, also from this vein, which has not been described before. Another species of *Linopteris* from the same coal-seam may be new also, but it seems best to refer it to *L. brongniarti* Gutb.: this plant has not, with certainty, been previously obtained from British Coal Measures.

From the Saundersfoot Measures I obtained a specimen of *Vetacapsula*, which Dr. L. Moysey thinks should be regarded as a new species. I am indebted to him for kindly supplying me with a description of it. I have omitted this species from the table in which the plants obtained from the beds of that district are set forth, since there is much doubt as to the nature of the genus *Vetacapsula*, the members probably being egg-capsules of certain fishes rather than fructifications.

(A) Nolton-Newgale District.

In the following table (p. 259) are enumerated the species which were collected from this part of the coalfield, together with their respective localities and horizons. I did not obtain any plants from the 'Millstone Grit' of this area.

(B) Haroldston West-Talbenny District.

Practically all the plants obtained from this area were collected from the Falling-Cliff Beds and the Settlings Beds. I did not obtain from the 'Millstone Grit' between Haroldston West and Druidston Haven any plants that could be identified.

The relation of the Settlings Beds to the other groups near Little Haven is not very clear, the beds along the coast being much disturbed. However, Prof. O. T. Jones, who has surveyed this district, informs me that, in his opinion, the beds below the overthrust at the Settlings are not far removed from the horizon of the group of veins worked at Broad Haven. He also believes that the sandstones of the Falling-Cliff Series are the same beds as those on the north side of the Settlings. If this be the case,

SPECIES. (From the Noltou-Newgale District.)	(P) PENNANT GRIT.										LOWER COAL SERIES.	
	Rickets Head. Near Madoc's Haven.	North Haven.	Black Cliff.	Maiden hall Point.	Noltou Colliery (tips).	Rising Sun Inn, Noltou (tips).	St. Madog's Ch., Noltou (tips).	South of Folkston Hill (tips).	Oxland Farm (tips).	Pitt's Farm (tips).	Folly Vein.	Simpson Coals.
EQUISETALES.												
<i>Calamites cisti</i> Brongn.	..	..	..	..	..	..	..	..	..	..	..	..
<i>Calamites schatzlarensis</i> (?) Stur	..	..	..	..	..	..	..	..	..	..	..	..
<i>Calamites ramosus</i> Artis	×	..	..	..	..	×	..	..	..	..	..	..
<i>Calamites</i> sp.	..	×	..	..	..	..	..	..	..	..	..	..
<i>Calamocladus equisetiformis</i> ? (Schloth.)	×	..	..	..	..	..	..	..	..	..	..	..
<i>Palæostachya</i> (?) sp.	×	..	..	..	..	..	..	..	..	..	..	..
<i>Annularia radiata</i> Brongn.	×	..	..	..	..	..	..	..	..	..	..	..
<i>Annularia ingens</i> , sp. nov.	×	..	..	..	..	..	..	..	..	..	..	..
<i>Annularia sphenophylloides</i> (Zenk.)	×	..	..	..	..	..	×	..	..	..	..	..
SPHENOPHYLLALES.												
<i>Sphenophyllum cuneifolium</i> (Sternb.)	×	..	..	×	?	×	..	×	..	..	..	..
<i>Sphenophyllum cuneifolium</i> (Sternb.) cf. var. <i>saxifragifolium</i> (Sternb.)	×	..	..	..	..	..	..	..	..	..	..	..
<i>Sphenophyllum majus</i> Brongn.	×	..	..	×	..	..	..	..	..	..	..	..
PTERIDOSPERMS and FILICALES.												
<i>Sphenopteris obtusiloba</i> Brongn.	×	..	..	..	..	..	..	..	..	..	..	..
<i>Sphenopteris spinosa</i> Göpp.	×	..	..	..	..	..	..	..	..	..	..	..
<i>Sphenopteris</i> cf. <i>Sph.</i> (<i>Renaultia</i>) <i>gracilis</i> (Brongn.)	×	..	..	..	..	..	..	..	..	..	..	..
<i>Eremopteris artemisiaefolia</i> (Sternb.)	×	×	..	..	..	..	..	..	..	..	..	..
<i>Mariopteris muricata</i> (Schloth.)	×	..	..	..	..	..	..	..	..	..	..	..
<i>Neuropteris heterophylla</i> Brongn.	×	..	..	..	..	..	..	..	..	..	..	..
<i>Neuropteris tenuifolia</i> (Schloth.)	×	..	..	?	×	?	..	..	..	..	..	..
<i>Neuropteris obliqua</i> (Brongn.)	×	..	..	×	×	×	..	..	×	..	..	..
<i>Neuropteris scheuchzeri</i> Hoffm.	×	..	..	?	×	×	..	..	×	..	..	..
<i>Neuropteris</i> sp.	×	×	..	..	..	..	×	..	..	×	..	..
<i>Neuropteris</i> (<i>Cyclopteris</i>) sp.	×	..	..	..	..	..	..	..	..	..	..	..
<i>Linopteris münsteri</i> (Eichw.)	×	..	..	..	..	..	..	..	..	..	..	..
<i>Linopteris brongniarti</i> ¹ Gutbier	×	..	..	..	..	..	..	..	..	..	..	..
<i>Linopteris sub-brongniarti</i> Grand'Eury	×	..	..	..	..	..	..	×	..	..	..	..
<i>Linopteris major</i> , sp. nov.	×	..	..	..	..	..	..	×	..	..	..	..
<i>Alethopteris tonchitica</i> (Schloth.)	..	..	..	..	..	..	..	×	..	..	..	..
<i>Alethopteris serli</i> (Brongn.)	..	..	..	..	..	..	..	×	..	..	..	..
SEMINA INCERTÆ SEDIS.												
<i>Cardiocarpus acutus</i> L. & H.	..	×	..	..	..	..	..	..	..	..	..	..
LYCOPODIALES.												
<i>Lepidodendron lycopodioides</i> Sternb.	×	..	..	..	..	..	..	..	..	..	..	..
<i>Lepidodendron</i> sp.	×	..	..	..	..	..	..	..	..	..	..	..
<i>Lepidophyllum lanceolatum</i> L. & H.	×	..	..	..	?	..	..	..	..	..	..	..
<i>Lepidophyllum minus</i> , sp. nov.	×	..	..	..	..	..	..	..	..	..	..	..
<i>Lepidophyllum</i> sp.	..	..	..	..	..	..	×	..	×	..	..	..
<i>Sigillaria lævigata</i> Brongn.	..	..	..	..	..	..	×	..	×	..	..	..
<i>Sigillaria ovata</i> Sauv.	..	..	..	..	..	..	×	..	×	..	..	..
<i>Sigillaria tessellata</i> Brongn.	×	..	..	..	..	..	×	..	×	..	..	..
<i>Sigillaria</i> sp.	×	..	..	..	..	..	×	..	×	..	..	..
<i>Stigmara ficoides</i> (Sternb.)	×	..	..	..	..	..	×	..	×	..	..	..
CORDAITALES.												
<i>Cordaites borassifolius</i> (Sternb.)	..	..	×	..	..	..	..	..	..	..	..	..

¹ As mentioned above (p. 258), this plant may be a new species, although it seems best to refer it to *L. brongniarti* Gutb. Cyclopterid pinnules which may be referred to this species were also obtained (see Pl. XXVII, figs. 2 & 5).

the plants obtained from the shales at the north-eastern corner of Musclevick, which are placed above the Falling-Cliff Sandstones, might be expected to lie on about the same horizon as those obtained from the shales below the overthrust at the Settlings.

From the structure of the district it is very difficult, if not impossible, to determine the position of the beds at the Settlings, which are above the plane of overthrust, for they are faulted against all other beds. Prof. O. T. Jones, however, thinks that these beds may be higher than those below the plane of overthrust, and may therefore be the highest beds seen in the cliffs between the neighbourhood of Haroldston West and Musclevick, Little Haven.

It is difficult to correlate the Broad-Haven coals with those of any other area. Prof. Jones considers that they are almost certainly not higher than the Timber-Vein group, and may in fact be the equivalents of that group. On the other hand, they may be the representatives of some of the lower seams occurring farther east, namely, the Lower Level Vein or the Catshole Vein. Prof. Jones, however, inclines to the former view. He also informs me that all the beds along that coast are certainly not higher than the Lower Coal Series.

(a) Settlings Beds.

SPECIES. (From the Haroldston West- Talbenny District.)	Cliff at the Settlings.	
	Above overthrust.	Below overthrust.
EQUISETALES.		
<i>Calamites suckowi</i> Brongn.		×
<i>Calamites cisti</i> (?) Brongn.		×
<i>Calamites ramosus</i> (?) Artis		×
<i>Calamites</i> sp.		×
<i>Annularia</i> (?) sp.		×
SPHENOPHYLLALES.		
<i>Sphenophyllum cuneifolium</i> (Sternb.)...		×
PTERIDOSPERMS and FILICALES.		
<i>Mariopteris muricata</i> (Schloth.)		×
<i>Neuropteris tenuifolia</i> (Schloth.)		×
<i>Neuropteris obliqua</i> (Brongn.)	×	
<i>Neuropteris scheuchzeri</i> Hoffm.		×

(b) Falling-Cliff Beds.

SPECIES. (From the Haroldston West- Talbeny District.)	Shales above the Falling-Cliff Sandstone.				
	Cliff at Musclevick.	Falling Cliff.	Falling Cliff.	Falling Cliff.	Cliff, Strawberry Hill.
EQUISETALES.					
<i>Calamites suckowi</i> (?) Brongn.	...	...	...	×	...
<i>Calamites cisti</i> (?) Brongn.	×	...	...	...	...
<i>Calamites ramosus</i> (?) Artis	...	...	×	...	...
<i>Calamites undulatus</i> Sternb.	...	...	×	...	...
<i>Calamites</i> sp.	...	...	×	...	×
<i>Calamocladus equisetiformis</i> ? (Schloth.) ...	...	...	×	×	...
<i>Calamostachys</i> (?) sp.	...	...	×	...	...
<i>Annularia galioides</i> (L. & H.)	...	...	×	...	...
<i>Annularia</i> sp.	...	...	×	...	...
SPHENOPHYLLALES.					
<i>Sphenophyllum cuneifolium</i> (Sternb.)	...	×	×	×	...
<i>Sphenophyllum</i> sp.	...	...	×	...	...
PTERIDOSPERMS AND FILICALES.					
<i>Mariopteris muricata</i> (Schloth.)	...	...	...	...	×
<i>Mariopteris</i> sp.	...	...	×	...	...
<i>Neuropteris heterophylla</i> Brongn.	...	...	×	...	...
<i>Neuropteris tenuifolia</i> (Schloth.)	...	...	×	...	...
<i>Neuropteris obliqua</i> ? (Brongn.)	...	×	...	...	...
<i>Neuropteris</i> sp.	...	...	×	...	...
<i>Odontopteris</i> sp.	...	...	×	...	...
<i>Alethopteris serli</i> ? (Brongn.)	...	...	...	...	×
<i>Pecopteris miltoni</i> (Artis)	...	...	...	×	...
<i>Pecopteris plumosa</i> (Brongn.)	...	×	...	...	...
LYCOPODIALES.					
<i>Lepidodendron obovatum</i> Sternb.	...	...	...	...	×
<i>Lepidodendron</i> (?) sp.	...	...	×	...	...
<i>Lepidophyllum lanceolatum</i> L. & H.	...	...	...	...	×
<i>Lepidophyllum</i> sp.	...	...	×	...	×
<i>Lepidostrobus</i> sp.	...	...	×	...	...
<i>Stigmaria ficoides</i> (Sternb.)	×	...	×	×	...
CORDAITALES.					
<i>Cordaites borassifolius</i> (Sternb.)	...	×	×	...	...
<i>Cordaites principalis</i> (Germar)	...	×	...	...	...

The following species were also obtained from Falling Cliff, but were not found *in situ* :—*Sphenophyllostachys* sp. and *Cordaianthus pitcairniæ* (L. & H.).

Calamites undulatus Sternb. A specimen from Falling Cliff shows the external surface, or bark, with scars of adventitious

Fig. 2.—*Calamites undulatus* Sternb. : external surface, showing root-scars below the node. Natural size.

roots below the node (see fig. 2). The cast of the medullary cavity is shown on the other face, an eighth of an inch, or less, intervening.

(C) Tenby-Ragwen Point and the Cleddau District.

— The flora of the Coal Measures is first enumerated, and then that of the 'Millstone Grit.'

(a) Coal Measures. (Lower Coal Series.)

SPECIES. (From Tenby-Ragwen Point and the Cleddau District.)	1 Timber Vein.	2 Below the Timber Vein.	3 Below the Garland Vein.	4 Bridge Patch (above the Fiddler's Vein).	5 Below the Fiddler's Vein	6 Above the Lower Level Vein.	7 Kilgetty Vein.	8 Lady's Frolic Vein.	9 (Low down in the series.)
	Freyestrop Colliery.	Picton Point.	Between Wiseman's Bridge & Amroth.	Between Wiseman's Bridge & Amroth.	Between Wiseman's Bridge & Amroth.	Cliff, Hean Castle, Saundersfoot.	Bonville's Court Colliery.	Amroth, Carmarthen- shire.	Between Watrynich & Monkstone Point.
EQUISETALES.									
<i>Calamites suckowi</i> Brongn.	..	..	×	×	×	..	..	..	?
<i>Calamites cisti</i> Brongn.	..	..	..	..	×	..	..	..	..
<i>Calamites schatzlarensis</i> Stur	..	..	..	..	×	..	..	..	..
<i>Calamites ramosus</i> Artis	..	×	..	..	×	..	..	×	×
<i>Calamites</i> sp.	×	..	..	..	..	..	..	..	×
<i>Calamocladus grandis</i> (Sternb.)	..	..	..	..	×	..	..	..	..
<i>Calamocladus equisetiformis</i> (Schloth.)	..	..	..	..	×	..	..	..	..
<i>Palæostachya pedunculata</i> ¹ Will.	..	..	..	..	×	×	..	..	..
<i>Palæostachya</i> sp.	..	..	..	..	×	×	..	..	×
<i>Annularia radiata</i> Brongn.	..	?	..	..	×	..	..	..	×
<i>Annularia sphenophylloides</i> (Zenk.)	..	..	..	×	..	..	..	..	..
SPHENOPHYLLALES.									
<i>Sphenophyllum cuneifolium</i> (Sternb.)	×	×	..	..	..	..	..	..	..
<i>Sphenophyllum</i> sp.	×	..	..	..	..	..	..	..	..
PTERIDOSPERMS and FILICALES.									
<i>Sphenopteris schillingsii</i> ² Andræ	..	..	..	×	..	..	..	..	×
<i>Sphenopteris</i> cf. <i>sauveuri</i> Crép.	..	..	..	..	..	..	..	..	..
<i>Sphenopteris furcata</i> (?) Brongn.	..	×	..	..	..	..	..	..	..
<i>Sphenopteris</i> sp.	×	..	..	..	..	..	..	..	..
<i>Eremopteris</i> (?) sp.	..	..	×	..	..	..	..	..	..
<i>Mariopteris muricata</i> (Schloth.)	..	×	..	×	..	..	..	..	×
<i>Mariopteris latifolia</i> (Brongn.)	..	..	..	..	..	..	..	..	×
<i>Mariopteris</i> sp.	..	..	..	..	..	..	..	..	×
<i>Neuropteris heterophylla</i> Brongn.	..	×	..	..	..	..	..	..	..
<i>Neuropteris obliqua</i> ? (Brongn.)	..	×	×	×	..	..	..	..	..
<i>Neuropteris scheuchzeri</i> (?) Hoffm.	..	..	..	×	..	..	..	..	..
<i>Neuropteris gigantea</i> Sternb.	?	×	..	..	..	..	..	..	..
<i>Neuropteris</i> sp.	..	×	..	..	..	..	..	..	..
<i>Neuropteris (Cyclopteris)</i> sp.	..	×	..	..	..	..	..	..	..
<i>Alethopteris lonchitica</i> (Schloth.)	×	×	..	×	..	..	..	..	×
<i>Alethopteris decurrens</i> (Artis)	..	×	..	..	..	..	..	..	..
<i>Alethopteris serli</i> (Brongn.)	..	×	..	..	..	..	..	..	?
<i>Alethopteris (Spiropteris)</i> sp.	..	×	..	..	..	..	..	..	..

¹ These cones would seem best placed under the name *Palæostachya pedunculata* Will.; but they may be the cones of *Calamocladus grandis* (Sternb.), being equally as dense as, though larger than, the examples shown in Prof. Zeiller's* figures.

² This may be the species *Sphenopteris adiantoides* of Lindley & Hutton.

* Zeiller (1886) pl. lix, figs. 5 & 6.

(a) Coal Measures (cont.).

SPECIES. (From Tenby-Ragwen Point and the Cleddau District.)	1 Freystrop Colliery.	2 Pictou Point.	3 Between Wiseman's Bridge & Amroth.	4 Between Wiseman's Bridge & Amroth.	5 Between Wiseman's Bridge & Amroth.	6 Cliff, Hean Castle, Saundersfoot.	7 Bonville's Court Colliery.	8 Amroth, Carmarthen- shire.	9 Between Waterynch & Monkstone Point.
SEMINA INCERTE SEDIS.									
<i>Cardiocarpus fluitans</i> Dawson.....	...	×							
LYCOPODIALES.									
<i>Lepidodendron obovatum</i> Sternb.....	...	...	...	...	...	...	...	...	×
<i>Lepidodendron</i> sp.	...	...	...	...	...	...	...	...	×
<i>Bothrodendron</i> sp.	...	...	...	...	...	...	...	...	×
<i>Lepidophyllum</i> cf. <i>lanceolatum</i> L. & H.	...	...	...	...	...	...	...	...	×
<i>Lepidophyllum</i> sp.	...	...	...	...	...	...	...	...	×
<i>Lepidostrobus</i> cf. <i>variabilis</i> L. & H.	...	...	...	...	...	...	...	...	×
<i>Lepidostrobus</i> sp.	...	...	...	...	...	...	...	...	×
<i>Sigillaria tessellata</i> Brongn.	...	...	...	...	...	...	...	...	×
<i>Sigillaria</i> sp.	...	...	...	...	...	...	×	...	×
<i>Stigmara ficoides</i> (Sternb.)	...	...	...	...	...	...	×	...	×
CORDAITALES.									
<i>Cordaites borassifolius</i> (Sternb.).....	...	...	...	...	...	...	...	×	
<i>Cordaites</i> sp.	...	×							

(b) The so-called 'Millstone Grit.'

SPECIES.	Monkstone Point.	Water- ynch.	Tenby.
EQUISETALES.			
<i>Calamites cisti</i> Brongn.....	...	×	
<i>Calamites ramosus</i> Artis	?	×	
<i>Calamites</i> sp.	...	...	×
<i>Calamocladus equisetiformis</i> ? (Schloth.) ...	...	×	
SPHENOPHYLLALES.			
<i>Sphenophyllum cuneifolium</i> (Sternb.).....	×		
PTERIDOSPERMS and FILICALES.			
<i>Sphenopteris schillingsii</i> ¹ Andræ	×		
<i>Mariopteris muricata</i> (Schloth.).....	×	×	
<i>Mariopteris latifolia</i> ? (Brongn.)	...	×	
<i>Neuropteris</i> sp.	×		
<i>Alethopteris lonchitica</i> (Schloth.)	...	×	
<i>Alethopteris decurrens</i> (Artis).....	...	×	
<i>Alethopteris</i> sp.	×		
LYCOPODIALES.			
<i>Lepidodendron obovatum</i> Sternb.	×	×	
<i>Lepidophloios acerosus</i> (L. & H.)	×		
<i>Lepidophyllum</i> cf. <i>lanceolatum</i> L. & H.	×		
<i>Lepidophyllum</i> sp.	×		
<i>Lepidostrobus</i> cf. <i>variabilis</i> L. & H.	×		
<i>Lepidostrobus</i> sp.	×		
<i>Stigmara ficoides</i> (Sternb.)	...	×	

¹ This may be the species *Sphenopteris adiantoides* of Lindley & Hutton.

Besides the species in the foregoing table, which were obtained from the 'Millstone Grit' between Tenby and Monkstone Point, the following were also collected:—*Calamites* sp. from Ragwen Point, Carmarthenshire (Basal Grit), and *Cordaïtes principalis*? (Germar) from Peepout Wood, Eastern Cleddau (Millstone Grit Shales).

Many specimens of branched roots were obtained from the Monkstone Point beds which might be placed in the genus *Pinnularia*, were it not for the fact that they exhibit no trace of segmentation.

(D) Descriptions of New Species.

ANNULARIA INGENS, sp. nov. (Pl. XXVIII, fig. 1.)

Horizon.—Pennant Grit (?).

Locality.—Rickets Head Vein, Rickets Head.

Diagnosis.—Stem 1 to 4 mm. wide, segmented, joints 7 to 20 mm. in length, finely striated, provided with whorls of leaves, those of successive whorls being longer than the intervening internodes. Leaves linear, acuminate, somewhat curved, 14 to 34 mm. long, 1 to 2 mm. wide in the basal half of leaf, uninerved, united at their base, numbering up to twelve in a whorl, differing slightly in length in the same whorl.

The specimen here described shows the termination of a branch bearing five whorls of leaves, which decrease rapidly in size towards the end of the branch. As the leaves are distinctly united at their bases, and the members of the same whorl differ somewhat in length, it seems justifiable to place this plant in the genus *Annularia*. It appears to me to be a new species, and I have therefore ventured to describe it under the name of *A. ingens*.

It closely approaches, however, a plant described by Renault under the name of *Asterophyllites flexuosus*.¹ It differs from this in that the leaves of the oldest whorl are larger, and taper more gradually at the apex. The stem, too, is stouter, and tapers much more rapidly. It seems that the species *A. flexuosus* should be transferred to the genus *Annularia*, especially as the leaves are described as being somewhat united at their bases.

It differs from *Annularia radiata* Brongn. in that the leaves are linear, not approaching the lanceolate type of leaf as those of that species do; and from *A. stellata* (Schloth.) in that the leaves do not become broader towards the apex, but taper gradually.

LINOPTERIS MAJOR, sp. nov. (Pl. XXVII, figs. 1 & 3.)

Horizon.—Pennant Grit (?).

Locality.—Rickets Head Vein, Rickets Head.

Only isolated pinnules of this species were found. It appears to be quite distinct from previously described species, hence I have ventured to refer to it under the name of *L. major*.

¹ Renault (1888-90) p. 417 & pl. xlviii, fig. 2.

Diagnosis.—Pinnules smooth, large, 65 to 70 mm. long, 20 to 25 mm. wide, ovate-lanceolate, margins undulating but roughly parallel for about half the length of the pinnule; the upper half of the pinnule is slightly bent and acuminate. The median nerve disappears at about half the length of the pinnule, and divides into secondary nerves. Secondary nerves numerous, fine, arising at acute angles, much arched, dividing repeatedly in their path to the margin of the pinnule and anastomosing between themselves to form a network with numerous, elongate, straight, or slightly arched meshes, which gradually become smaller towards the margin of the pinnule. The number of meshes between the median nerve and the edge of the pinnule is usually about six.

Just as *Linopteris sub-brongniarti* Grand'Eury resembles *Neuropteris gigantea* Sternb., and *L. münsteri* (Eichw.) resembles *N. heterophylla* Brongn., so *L. major* resembles *N. scheuchzeri* Hoffm., with the exception that hairs, which are so characteristic of the latter species, are absent.

LEPIDOPHYLLUM MINUS, sp. nov. (Pl. XXVIII, figs. 3 & 5.)

Horizon.—Pennant Grit (?).

Locality.—Rickets Head Vein, Rickets Head.

This type of sporangiophore is not a new one, but has previously been referred to as *Lepidophyllum* sp. As it seems to merit a name of its own, I have ventured to call it *L. minus*.

Diagnosis.—Lamina sagittate, the inferior angles being inflected at the base, wider at the base than the pedicel of the sporangiophore at its summit, 6 to 9 mm. long, 5 to 7 mm. wide at the base; apex acute, provided with a median nerve which is more clearly marked on the dorsal surface. Pedicel of sporangiophore cuneiform, 5 to 7 mm. long, 2 to 3 mm. wide at the summit, provided with a median nerve. In the inferior portion of the sporangiophore only the pedicel is usually present; but sometimes, also, there is an elongated area on each side of the pedicel which may be the walls of a sporangium that has become adpressed to the pedicel.

L. minus is conspicuously smaller than *L. triangulare*¹ Zeiller.

VETACAPSULA MINIMA, sp. nov. (Pl. XXX, fig. 3.)

Horizon.—Lower Coal Series.

Locality.—Bridge Patch (above the Fiddler's Vein), between Wiseman's Bridge and Amroth.

With regard to this species, Dr. L. Moysey says:—

‘A very small specimen of *Vetacapsula* flattened on the surface of a piece of dark carbonaceous shale, showing a long, relatively broad pedicel, 2 mm. in

¹ Zeiller (1886) pl. lxxvii, figs. 4-6; *id.* (1888) pp. 508-509; Arber (1910) p. 149 & pl. xvi, fig. 3.

width, curving at its broken termination. The pedicel expands gradually into a fusiform body, 5 mm. across at its broadest part, which, in a similar manner, gradually contracts into a beak that is not shown in the fossil. It is ornamented with very fine bands which run parallel to the long axis of the fossil and present no evidence of a spiral arrangement. Both the body and pedicel show to a marked degree the "central vertical suture" mentioned by Mackie¹ and again emphasized by Mr. J. W. Jackson² in his description of a Lancashire specimen.

'This specimen is by far the smallest that has come to hand. The fine bands or striae are similar to those of *Vetacapsula johnsoni*,³ but the two differ markedly in size—*V. johnsoni* measuring 20 mm. across. In size it approaches most nearly to a specimen found by Mr. Hemingway⁴ in rock below the Haigh-Moor Coal at Brightside, Sheffield (now in the possession of Dr. R. Kidston); but in that specimen the bands were much broader, being about 1 mm. in width, whereas in the present specimen about four bands would be found in 1 mm.

'It might be best to consider this as *Vetacapsula* sp. indet. until more material is forthcoming; or, possibly, to give it the non-committal name of *Vetacapsula minima*.

'With regard to the "median vertical suture," it seems to occur so persistently in all the specimens that it is difficult to assume that it is due to crushing; and it is possible that it may be found subsequently that the fossil was not truly cylindrical, but that it had two, or possibly four, angles in the contour of its transverse section.'

Since the above description was written, Dr. Moysey has stated in a letter :—

'The more I think of it, the more convinced I am that it must be a new species, which might be called *Vetacapsula minima*.'

IV. PALEOBOTANICAL EVIDENCE AS TO THE HORIZON OF THE BEDS.

The following table (pp. 268–69) embodies first, the complete list of the species collected from the coalfield; secondly, it shows the vertical distribution of each through the so-called 'Millstone Grit,' the Lower Coal Series, and the 'Pennant Grit' of Pembrokeshire; and, thirdly, it gives a comparison of the fossil plants with those of the Upper, Transition, Middle, and Lower Coal Measures of other British coalfields, in order to show the relationship of the horizons met with in Pembrokeshire to the four recognized divisions of the Coal Measures.

The number of records from the beds of the so-called 'Millstone Grit' is naturally less than that from those of the Lower Coal Series. Since the 'Millstone Grit' contains a much smaller proportion of shales than sandstones, well-preserved plants could only be obtained from a small number of localities. Likewise, the number of records from the 'Pennant Grit' is also less than that from the Lower Coal Series, the plants being obtained from a smaller number of localities and horizons than those obtained from the Lower Coal Series.

¹ Mackie (1865–67).

³ Moysey (1910) p. 333.

² Jackson (1911).

⁴ *Ibid.* p. 336.

TABLE SHOWING THE VERTICAL DISTRIBUTION OF THE FOSSIL PLANTS OF THE 'PENNAINT GRIT,' THE LOWER COAL SERIES, AND THE SO-CALLED 'MILLSTONE GRIT' OF THE PEMBROKESHIRE COALFIELD, AND EMBODYING A COMPARISON WITH THOSE OF THE BRITISH UPPER, TRANSITION, MIDDLE, AND LOWER COAL MEASURES.

[X = rare; XX = moderately abundant; XXX = very abundant.]

PEMBROKESHIRE.			GREAT BRITAIN.				
Pennant Grit (?).	Lower Coal Series.	'Millstone Grit.'	SPECIES.	Upper Coal Measures.	Transition Coal Measures.	Middle Coal Measures.	Lower Coal Measures.
EQUISETALES.							
	XX	...	<i>Calamites suckowi</i> Brongn.	*	*	*	*
	X	X	<i>Calamites cisti</i> Brongn.	*	*	*	*
?	X	...	<i>Calamites schatzlarensis</i> Stur.	*	*	*	*
X	XX	XX	<i>Calamites ramosus</i> Artis.	*	*	*	*
	X	...	<i>Calamites undulatus</i> Sternb.	*	?	*	*
	XX	...	<i>Calamocladus grandis</i> (Sternb.)	*	...	*	*
?	X	X	<i>Calamocladus equisetiformis</i> (Schloth.)	*	*	*	*
	XX	...	<i>Palæostachya pedunculata</i> Will.	*	...	*	*
X	X	...	<i>Annularia radiata</i> Brongn.	*	*	*	*
X	...	...	<i>Annularia ingens</i> , sp. nov.	*	*	*	*
XX	X	...	<i>Annularia sphenophylloides</i> (Zenk.)	*	*	*	*
	X	...	<i>Annularia galioides</i> (L. & H.)	...	*	*	*
SPHENOPHYLLALES.							
XX	XX	XX	<i>Sphenophyllum cuneifolium</i> (Sternb.)	...	*	*	*
X	...	...	<i>Sphenophyllum cuneifolium</i> (Sternb.) cf. var. <i>saxifragæfolium</i> (Sternb.)	...	...	*	*
X	...	...	<i>Sphenophyllum majus</i> Brongn.	*	...	*	*
PTERIDOSPERMS and FILICALES.							
X	...	...	<i>Sphenopteris obtusiloba</i> Brongn.	...	*	*	*
	X	XX	<i>Sphenopteris schillingsii</i> Andræ.	...	...	*	?
X	...	...	<i>Sphenopteris spinosa</i> Gæpp.	...	...	*	*
	X	...	<i>Sphenopteris</i> cf. <i>sauveuri</i> Crép.	...	...	*	*
X	...	...	<i>Sphenopteris</i> cf. <i>Sph. (Renaultia) gracilis</i> (Brongn.)	...	...	*	?
	?	...	<i>Sphenopteris furcata</i> Brongn.	...	...	*	*
X	...	...	<i>Eremopteris artemisiæfolia</i> (Sternb.)	...	*	*	*
X	XX	XX	<i>Mariopteris muricata</i> (Schloth.)	*	*	*	*
	XX	?	<i>Mariopteris latifolia</i> (Brongn.)	...	...	*	*
X	X	...	<i>Neuropteris heterophylla</i> Brongn.	*	*	*	*
XX	XX	...	<i>Neuropteris tenuifolia</i> (Schloth.)	...	*	*	*
XX	X	...	<i>Neuropteris obliqua</i> (Brongn.)	...	*	*	*
X	X	...	<i>Neuropteris scheuchzeri</i> Hoffm.	*	*	*	*
	XX	...	<i>Neuropteris gigantea</i> Sternb.	...	*	*	*
XX	...	...	<i>Linopteris münsteri</i> (Eichw.)	*	*	*	*
X	...	...	<i>Linopteris bronngiarti</i> Gutb.	...	...	*	*
XX	...	...	<i>Linopteris sub-bronngiarti</i> Grand'Eury ...	...	*	*	*
X	...	...	<i>Linopteris major</i> , sp. nov.	...	...	...	...
	XX	XX	<i>Alethopteris lonchitica</i> (Schloth.)	*	*	*	*
	XX	XX	<i>Alethopteris decurrens</i> (Artis)	*	*	*	*
X	X	...	<i>Alethopteris serli</i> (Brongn.)	*	*	*	*
	XX	...	<i>Pecopteris miltoni</i> (Artis)	*	*	*	*
	X	...	<i>Pecopteris plumosa</i> (Brongn.)	*	...	*	*

TABLE SHOWING THE VERTICAL DISTRIBUTION OF THE FOSSIL PLANTS (*cont.*).

PEMBROKESHIRE.			SPECIES.	GREAT BRITAIN.			
Pennant Grit (?).	Lower Coal Series.	'Millstone Grit.'		Upper Coal Measures.	Transition Coal Measures.	Middle Coal Measures.	Lower Coal Measures.
SEMINA INCERTÆ SEDIS.							
×	..	..	<i>Cardiocarpus acutus</i> L. & H.	..	*	*	
	×	..	<i>Cardiocarpus fluitans</i> Dawson.....	*	..	*	
LYCOPODIALES.							
	×	×	<i>Lepidodendron obovatum</i> Sternb.	..	..	*	*
×	..	..	<i>Lepidodendron lycopodioides</i> Sternb.	..	*	*	*
	×	×	<i>Lepidophlois acerosus</i> (L. & H.)	..	*	*	*
×	×	×	<i>Lepidophyllum lanceolatum</i> L. & H.	*	*	*	*
×	×	..	<i>Lepidophyllum minus</i> , sp. nov.	..	..	*	*
×	×	×	<i>Lepidostrobus</i> cf. <i>variabilis</i> L. & H.	*	*	*	*
×	..	..	<i>Sigillaria lævigata</i> Brongn.....	*	..	*	*
×	..	..	<i>Sigillaria ovata</i> Sauv.	..	*	*	*
×	×	..	<i>Sigillaria tessellata</i> Brongn.	*	*	*	*
×	×	×	<i>Stigmara ficoides</i> (Sternb.)	*	*	*	*
CORDAITALES.							
×	×	..	<i>Cordaites borassifolius</i> (Sternb.).....	*	*	*	*
	×	?	<i>Cordaites principalis</i> (Germar)	..	*	*	*
	×	..	<i>Cordaianthus pilcainiæ</i> (L. & H.).....	..	..	*	*

Comparing the flora of the 'Pennant Grit' with that of the Lower Coal Series, we find that all the species obtained from the former were also obtained from the latter, except:—

<i>Annularia ingens</i> , sp. nov.	<i>Linopteris münsteri</i> (Eichw.).
<i>Sphenophyllum cuneifolium</i> cf. var.	<i>Linopteris bronngniarti</i> Gutb.
<i>saxifragæfolium</i> (Sternb.).	<i>Linopteris sub-bronngniarti</i> Grand'Eury.
<i>Sphenophyllum majus</i> Bronn.	<i>Linopteris major</i> , sp. nov.
<i>Sphenopteris obtusiloba</i> Brongn.	<i>Cardiocarpus acutus</i> L. & H.
<i>Sphenopteris spinosa</i> Gæpp.	<i>Lepidodendron lycopodioides</i> Sternb.
<i>Sphenopteris</i> cf. <i>Sph.</i> (<i>Renaultia</i>)	<i>Lepidophyllum minus</i> , sp. nov.
<i>gracilis</i> Brongn.	<i>Sigillaria lævigata</i> Brongn.
<i>Eremopteris artemisiaefolia</i> (Sternb.).	<i>Sigillaria ovata</i> Sauv.

Of these all are rare in the 'Pennant Grit,' being represented by only a very few specimens, with the exception of the following, which are abundant:—

<i>Linopteris münsteri</i> (Eichw.).	<i>Lepidophyllum minus</i> , sp. nov.
<i>Linopteris sub-bronngniarti</i> Grand'Eury.	

The commonest species on this horizon are:—

<i>Sphenophyllum cuneifolium</i> (Sternb.).	<i>Linopteris sub-bronngniarti</i> Grand'Eury.
<i>Neuropteris obliqua</i> (Brongn.).	<i>Lepidophyllum minus</i> , sp. nov.
<i>Linopteris münsteri</i> (Eichw.).	

Of these, *Sphenophyllum cuneifolium* (Sternb.) is also very abundant, and *Neuropteris obliqua* (Brongn.) is not so common, in the Lower Coal Series, while the other three species have not been recorded from these beds. The commonest plants at this latter horizon are:—

<i>Sphenophyllum cuneifolium</i> (Sternb.).		<i>Alethopteris lonchitica</i> (Schloth.).
<i>Mariopteris muricata</i> (Schloth.).		<i>Pecopteris miltoni</i> (Artis).
<i>Neuropteris tenuifolia</i> (Schloth.).		<i>Stigmaria ficoides</i> (Sternb.).

Turning to the so-called 'Millstone Grit,' we find only one species that has not been obtained from the higher beds, all the other species having been found in the Lower Coal Series. This species is *Lepidophloios acerosus* (L. & H.). In these beds the commonest species are *Mariopteris muricata* (Schloth.) and *Alethopteris lonchitica* (Schloth.).

(1) Pennant Grit (?).

Comparing the fossil flora of the 'Pennant Grit' with that of the Upper, Transition, Middle, and Lower Coal Measures elsewhere in Britain; leaving out of consideration the two doubtful and the three new species, and also *Linopteris brongniarti* Guth. which has not with certainty been previously obtained from British Coal Measures, we find that out of the twenty-seven species recorded, fifteen occur in the Upper Coal Measures, none of which are characteristic of that horizon; twenty-two in the Transition Coal Measures; all occur in the Middle Coal Measures, three: namely, *Sphenophyllum cuneifolium* var. *saxifragæfolium* (Sternb.), *Sphenopteris spinosa* Göpp., and *Sph. (Renaultia) gracilis* (Brongn.), not occurring above and nine not below that horizon; while seventeen are found in, and one, namely, *Sph. (Renaultia) gracilis* (Brongn.), is doubtfully recorded from, the Lower Coal Measures, nine of these being common to all the divisions of the Coal Measures.

These beds cannot, therefore, be regarded as belonging to the Pennant Grit, for the fossil flora distinctly indicates a Middle, and not a Transition,¹ Coal-Measure horizon, there being no admixture of species characteristic of the Upper and of the Middle Coal Measures. In other words, no plants occur which are not found at a lower horizon than the Transition Series, though some are present which do not extend higher than these beds or even the Middle Coal Measures.

(2) Lower Coal Series.

Turning now to the Lower Coal Series, we find, leaving out one doubtful species, that out of the thirty-five species recorded, twenty-one occur in the Upper Coal Measures, none of these, however,

¹ Kidston (1894) p. 574.

being characteristic of that horizon; twenty-four occur in, and one, namely, *Calamites undulatus* Sternb., is a doubtful determination from, the Transition Coal Measures; all occur in the Middle Coal Measures, of which two: namely, *Calamites schatzlarensis* Stur and *Sphenopteris sauveuri* Crép., are characteristic of, and seven do not occur below, that horizon; while twenty-seven are found in the Lower Coal Measures, fifteen of these being common to all the divisions of the Coal Measures.

Since all the species obtained from the Lower Coal Series occur in, and some are not found below, and others not above, the Middle Coal Measures, this must be regarded as a typical Middle Coal-Measure horizon.

Settlings Beds.

From the Settlings Beds I obtained *Neuropteris tenuifolia* (Schloth.), which I did not find in the Lower Coal Series farther east, either along the Saundersfoot coast or in the central area south-east of Haverfordwest. I also obtained *Neuropteris obliqua* (Brongn.) and *N. scheuchzeri* Hoffm., which were doubtfully recorded from the eastern districts.

The flora of these beds, and especially the occurrence of *N. scheuchzeri* Hoffm., seems to indicate that they belong to a fairly high Middle Coal-Measure horizon, probably higher than the beds of the Lower Coal Series exposed along the Saundersfoot coast; they may even belong to a higher horizon than the Timber Vein group.

Falling-Cliff Beds.

From the Falling-Cliff Beds I obtained the following species which are not recorded from the Lower Coal Series of the eastern areas:—

Calamites undulatus Sternb.
Calamostachys (?) sp.
Annularia galioides (L. & H.).
Sphenophyllostachys sp.
Neuropteris tenuifolia (Schloth.).

Odontopteris sp.
Pecopteris miltoni (Artis).
Pecopteris plumosa (Brongn.).
Cordaianthus piteairnæ (L. & H.).

Besides these, *Neuropteris obliqua*? (Brongn.) and *Lepidophyllum lanceolatum* L. & H. were obtained, which are doubtfully recorded from the Lower Coal Series of the eastern districts, and also *Cordaites principalis* (Germar), which was a somewhat uncertain determination from the 'Millstone Grit' of the Eastern Cleddau.

This flora does not seem to supply any definite indication that these beds belong to a higher horizon than those which occur farther east. If, however, these beds lie immediately below the Settlings Beds (as has been suggested by Prof. O. T. Jones), and if we rely on the evidence which the flora of these latter beds affords, it seems possible that the Falling-Cliff Beds may also belong to a higher horizon than those which occur farther east.

(3) The so-called 'Millstone Grit.'

The fossil plants obtained from the so-called 'Millstone Grit' were nearly all collected from the beds between Monkstone Point and a little south of Waterwynch on the Tenby coast.

In these beds, leaving out of account two doubtful determinations, we find that all of the thirteen species recorded occur in the Middle and Lower Coal Measures. Four, namely, *Sphenophyllum cuneifolium* (Sternb.), *Sphenopteris schillingsii* Andræ, *Lepidodendron obovatum* Sternb., and *Lepidophloios acerosus* (L. & H.) are unknown from the Upper Coal Measures, and two, *Sphenopteris schillingsii* Andræ and *Lepidodendron obovatum* Sternb., are unknown from the Transition Series. Thus the horizon is clearly either Middle or Lower Coal Measures. The occurrence of *Sphenopteris schillingsii* Andræ and *Lepidophloios acerosus* (L. & H.) in the Monkstone Point beds, both of which are very rare in the Lower Coal Measures, makes it more probable that at least these beds belong to the Middle division rather than to the Lower, though the proof offered is not conclusive.

Further, the flora of these Monkstone Point and Waterwynch beds is very similar to that of the beds in the intervening ground which have been placed low down in the Lower Coal Series. These latter beds undoubtedly belong to the Middle Coal Measures, especially as specimens which may be compared with *Alethopteris serli* (Brongn.) have been obtained from them. There is, also, no apparent unconformity between these Middle Coal Measures and the so-called 'Millstone Grit' of Monkstone Point, or between the former and those seen in the cliff between 480 and 780 yards south-west of Monkstone Point. Hence it may be inferred that these 'Millstone Grit' beds and those of the neighbouring Lower Coal Series are on almost the same horizon. It seems, therefore, that at least these particular 'Millstone Grit' beds belong to the Middle Coal Measures, those near Waterwynch being here excluded, as they are separated by overthrust faults from the Coal Measures.

V. THE FOSSIL FLORA OF THE PEMBROKESHIRE COALFIELD COMPARED WITH THAT OF THE MAIN PORTION OF THE SOUTH WALES COALFIELD.

The only extant account of the fossil flora of the South Wales Coalfield is that by Dr. Kidston¹ which was published in 1894. Our knowledge of the fossil flora of this coalfield is still, however, very imperfect, and much remains to be done.

(a) The Fossil Floras of the 'Pennant Grit' of Pembrokeshire and the Lower Pennant, or Pennant Grit, of South Wales.

The fossil flora of the 'Pennant Grit' of Pembrokeshire is, as we have seen, a Middle Coal-Measure flora; while that of the

¹ Kidston (1894).

Lower Pennant of the main portion of the South Wales Coalfield has been shown by Dr. Kidston to be a true Transition Coal-Measure flora. A comparison of the two floras, however, shows that all the species occurring in the Lower Pennant which are Upper Coal-Measure forms, are absent from the 'Pennant Grit' of Pembrokeshire, thus confirming the conclusions which were arrived at above. These Upper Coal-Measure plants are:—

Annularia stellata (Schloth.).
Sphenophyllum emarginatum Brongn.
Sphenopteris neuropteroides (Boulay).
Neuropteris flexuosa Brongn.
Neuropteris macrophylla Brongn.

Neuropteris ovata Hoffm.¹
Odontopteris lindleyana Sternb.
Lepidodendron dichotomum Zeiller.
Cordaites angulostriatus Grand'Eury.

These have not been obtained from Pembrokeshire.

There are also at least nineteen species which have been recorded from the Lower Pennant of the main portion of the South Wales Coalfield, but have not been obtained from the 'Pennant Grit' of Pembrokeshire.

There are, in fact, only nine² species known in common to the two series. *Calamocladus equisetiformis* (Schloth.) is recorded from the Lower Pennant of South Wales, but is only a doubtful determination from the 'Pennant Grit' of Pembrokeshire.

Further, there are twenty-one or twenty-two Pembrokeshire species which are unknown from the Lower Pennant of the main portion of the South Wales Coalfield.

It is obvious, therefore, that there is a considerable difference between the fossil floras of the 'Pennant Grit' of Pembrokeshire and the Lower Pennant of the main part of the South Wales Coalfield, even though most of the species which are recorded from the latter are plants which occur in the Middle Coal Measures.

(b) The Fossil Floras of the Lower Coal Series, including that of the 'Pennant Grit,' of Pembrokeshire and the White Ash Series of South Wales.

The fossil plants of the Lower Coal Series of Pembrokeshire, including those of the 'Pennant Grit,' can be more exactly compared with those recorded from the White Ash Series, or Lower Coal Series, of the main portion of the South Wales Coalfield: for all belong to the Middle Coal-Measure horizon.

There are, however, at least twenty-five species which have been recorded from the White Ash Series, but have not been obtained from the Lower Coal Series, or the 'Pennant Grit,' of Pembrokeshire.

Twenty species are common to the Lower Coal Series, including the 'Pennant Grit,' of Pembrokeshire, and the White Ash Series.

¹ Recorded by Mr. E. E. L. Dixon. See Strahan (1907) p. 156.

² Two of these have been recorded from the Pennant Series of the main part of the South Wales Coalfield by Mr. E. E. L. Dixon. See Strahan (1907) p. 156.

Further, the following nineteen species have been obtained from the Lower Coal Series of Pembrokeshire, but have not been recorded from the White Ash Series; they are, therefore, additions to our knowledge of the Middle Coal Measures of South Wales:—

<i>Calamites cisti</i> Brongn.	<i>Mariopteris latifolia</i> (Brongn.).
<i>Calamites schatzlarensis</i> Stur.	<i>Neuropteris obliqua</i> (Brongn.).
<i>Calamocladus grandis</i> (Sternb.).	<i>Neuropteris scheuchzeri</i> Hoffm.
<i>Palæostachya pedunculata</i> Will.	<i>Alethopteris serli</i> (Brongn.).
<i>Annularia radiata</i> Brongn.	<i>Pecopteris plumosa</i> (Brongn.).
<i>Annularia sphenophylloides</i> (Zenk.).	<i>Cardiocarpus fluitans</i> Dawson.
<i>Annularia galioides</i> (L. & H.).	<i>Lepidostrobus cf. variabilis</i> L. & H.
<i>Sphenopteris schillingsii</i> Andræ.	<i>Cordaites borassifolius</i> (Sternb.).
<i>Sphenopteris cf. sauveuri</i> Crép.	<i>Cordaianthus pitcairniæ</i> (L. & H.).
<i>Sphenopteris furcata</i> (?) Brongn.	

Furthermore, from the 'Pennant Grit' of Pembrokeshire, which, as we have seen above, may be regarded as belonging to the Middle Coal-Measure horizon, the following thirteen species have been obtained. These species have not been recorded from the Lower Coal Series, either of Pembrokeshire or of the main portion of the South Wales Coalfield, and may therefore be regarded as additional records to those mentioned above for the Middle Coal Measures of South Wales:—

<i>Annularia ingens</i> , sp. nov.	<i>Linopteris brongniarti</i> Gutb.
<i>Sphenophyllum cuneifolium</i> cf. var.	<i>Linopteris sub-brongniarti</i> Grand'Eury.
<i>saxifragæfolium</i> (Sternb.).	<i>Linopteris major</i> , sp. nov.
<i>Sphenophyllum majus</i> Bronn.	<i>Cardiocarpus acutus</i> L. & H.
<i>Sphenopteris spinosa</i> Gœpp.	<i>Lepidodendron lycopodioides</i> Sternb.
<i>Sphenopteris cf. Sph. (Renaultia)</i>	<i>Lepidophyllum minus</i> , sp. nov.
<i>gracilis</i> Brongn.	<i>Sigillaria ovata</i> Sauv.
<i>Linopteris münsteri</i> (Eichw.).	

It will be seen that, although both the Lower Coal Series of Pembrokeshire, including the 'Pennant Grit,' and the White Ash Series of the main portion of the South Wales Coalfield are Middle Coal Measures, there is considerable difference in the occurrence of the species. There are, however, more species common to these beds than to the 'Pennant Grit' of Pembrokeshire, by itself, and the Lower Pennant of the main part of the South Wales Coalfield.

It is not possible to compare the fossil flora of the so-called 'Millstone Grit' of Pembrokeshire with that of these beds in the main portion of the South Wales Coalfield, for there are no records from the latter beds.

VI. CONCLUSIONS.

Of the fifty-three species here recorded from the Pembrokeshire Coalfield, three are new species, and one, *Linopteris brongniarti* Gutb., has not with certainty been found before in Britain.

From the palæobotanical evidence it has been shown that the 'Pennant Grit' of Pembrokeshire cannot be regarded as the equivalent of the Pennant Grit of the main portion of the South Wales Coalfield: for the plants indicate that these beds are Middle

Coal Measures, and do not belong to the Transition Series. The Lower Coal Series of Pembrokeshire has also been proved to belong to the Middle Coal Measures; while the Settling Beds, and perhaps the Falling-Cliff Beds as well, have also been shown to lie probably at a higher horizon than the Lower Coal Series as developed farther east along the Saundersfoot coast, and possibly higher than the Timber Vein Group.

Until more plants have been obtained from the so-called 'Millstone Grit' of Pembrokeshire, it is impossible to fix definitely the horizon of this group from the palæobotanical evidence. However, the so-called 'Millstone Grit' beds of Monkstone Point have been shown to belong probably to the Middle Coal Measures.

It has also been shown that there are considerable differences in the occurrence of the species in the Pembrokeshire Coalfield, when they are compared with those which have been recorded from the main portion of the South Wales Coalfield. In this connexion it has been indicated that thirty-two species have been added to our lists of the flora of the Middle Coal Measures of South Wales.

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EXPLANATION OF PLATES XXVII-XXX.

[All the specimens figured are in the Sedgwick Museum, Cambridge.
The photographs were taken by Mr. W. Tams, of Cambridge.]

PLATE XXVII.

- Fig. 1. *Linopteris major*, sp. nov. Portion of a pinnule, from the Rickets Head Vein, Rickets Head. Natural size. (See pp. 265-66.)
2. *Linopteris (Cyclopteris) brongniarti* Gutb. Portion of a pinnule, from the Rickets Head Vein, Rickets Head. $\times \frac{1}{2}$. (See pp. 258 & 259.)
3. *Linopteris major*, sp. nov. Portion of a pinnule, from the Rickets Head Vein, Rickets Head. Very slightly reduced.
4. *Linopteris sub-brongniarti* Grand'Eury. Pinnules, from Folly Vein 'tips' near Folkeston Hill, Noltun. $\times \frac{3}{4}$.
5. *Linopteris brongniarti* Gutb. A pinnule, from the Rickets Head Vein, Rickets Head. $\times 2$.

PLATE XXVIII.

- Fig. 1. *Annularia ingens*, sp. nov. Termination of a branch with whorled leaves, from the Rickets Head Vein, Rickets Head. Very slightly enlarged. (See p. 265.)
2. *Alethopteris serli* (Brongn.). Rachis with pinnules, from Folly Vein 'tips' near Folkeston Hill, Noltun. Natural size.
3. *Lepidophyllum minus*, sp. nov. Portion of a sporangiophore, from the Rickets Head Vein, Rickets Head. $\times \frac{1}{2}$. (See p. 266.)
4. *Sigillaria tessellata* Brongn. Part of stem with leaf-scars, from the Rickets Head Vein, Rickets Head. Very slightly reduced.
5. *Lepidophyllum minus*, sp. nov. A sporangiophore, from the Rickets Head Vein, Rickets Head. $\times \frac{1}{2}$.
6. *Cardiocarpus acutus* L. & H. Seed, from the Rickets Head Vein, near Madoc's Haven. $\times \frac{1}{2}$.

PLATE XXIX.

- Fig. 1. *Palæostachya pedunculata* Will. Fertile shoot, bearing cones, from below the Fiddler's Vein, between Wiseman's Bridge and Amroth. Natural size. (See p. 263.)
2. *Sphenophyllostachys* sp. A cone, from Falling Cliff, Little Haven. $\times 3$.
3. *Palæostachya pedunculata* Will. Portions of cones, from below the Fiddler's Vein, between Wiseman's Bridge and Amroth. Natural size. (See p. 263.)
4. *Palæostachya* sp. Portions of cones, from below the Fiddler's Vein, between Wiseman's Bridge and Amroth. Very slightly reduced.
5. *Cordaianthus pitcairniæ* (L. & H.). Portion of cone, from Falling Cliff, Little Haven. Very slightly enlarged.

PLATE XXX.

- Fig. 1. *Calamocladus grandis* (Sternb.). Portion of a leafy, branched shoot, from below the Fiddler's Vein, between Wiseman's Bridge and Amroth. Slightly reduced.
2. *Sphenopteris schillingsii* Andræ. A branched stem bearing pinnules, from the 'Millstone Grit,' Monkstone Point. Natural size. (See p. 264.)
3. *Vetacapsula minima*, sp. nov. From the Bridge Patch (above the Fiddler's Vein), between Wiseman's Bridge and Amroth. $\times \frac{1}{2}$. (See pp. 266-67.)

W. Tams, Photo.

Bemrose, Colln., Derby.

PEMBROKESHIRE COAL-MEASURE PLANTS.

1.

$3 \times \frac{7}{2}$

2.

W. Tams, Photo.

Bemrose, Collo., Derby.

PEMBROKESHIRE COAL-MEASURE PLANTS.

DISCUSSION.

Dr. ARBER desired to congratulate the Author on the very considerable additions which he had made to our knowledge of the fossil flora of South Wales. The new species described by the Author were of interest, especially those referred to the genus *Linopteris*. As the speaker had pointed out some years ago, the species of this genus mimic in habit those of *Neuropteris* in an extraordinary degree. Among the new species of *Linopteris* described by the Author appears to be the long-expected homœomorph of *Neuropteris scheuchzeri* Hoffm.

The fact that all the plants described by the Author indicated a Middle Coal-Measure horizon was certainly a remarkable conclusion; but the speaker felt less surprised at this result, now that the horizon of the beds in the Forest-of-Dean Coalfield on the eastern side of the great South Wales Coalfield was known. So far, it would appear safer to assume that the Pembrokeshire, South Wales, and Forest-of-Dean coalfields were unrelated areas, except tectonically.

The point raised by the Author with regard to the possible absence of true Millstone Grits in Pembrokeshire was certainly in keeping with recent conclusions as to the absence of this horizon in the West-of-England coalfields; but, as the Author doubtless admitted, further proof of this contention must be forthcoming before the matter could be regarded as settled.

Prof. O. T. JONES associated himself with the previous speaker in congratulating the Author on a valuable and interesting piece of research, carried out in a region of great difficulty. While not desiring to criticize the Author's work, the speaker wished to point to some of the possible consequences of the investigation. It was suggested that the Millstone Grit yielded plants of Middle Coal-Measure age. In many parts of Pembrokeshire it was clear that there was an unconformity at the base of the Millstone Grit, so that it was conceivable that higher portions of the Upper Carboniferous might thereby rest upon Carboniferous Limestone. Against this supposition there were several facts:—(1) In other parts of Pembrokeshire there was a close connexion between the higher beds of the Limestone and the basal members of the Millstone Grit, thus rendering it improbable that a physical break existed there; (2) The Millstone Grit of Pembrokeshire was exceedingly similar in its succession of lithological characters to that of the northern outcrop of the coalfield farther east (Carmarthenshire and Glamorgan), where strict conformity prevails, and a perfectly gradual transition occurs between the two formations.

Either, therefore, the Millstone Grit of Carmarthenshire and Pembrokeshire are of the same Middle Coal-Measure age, and the representatives of the underlying Lower Coal Measures must be looked for among the Carboniferous Limestone Series; or they are of different ages, in which case the two similar formations would be homotaxial but not contemporaneous: or, again, the

apparent conformity between the formations is illusory, and conceals a great break in the physical history of these regions.

Further, various parts of the Millstone Grit of South Wales have yielded marine fossils which have been claimed as Pendleside species. If this determination is correct, it is hardly compatible with the Middle Coal-Measure age suggested by the Author.

These possibilities should be borne in mind before undue weight is attached to the palæobotanical evidence, especially when this appears to contradict the stratigraphical evidence, as also the palæontological evidence derived from a study of other groups of fossils.

Mr. E. E. L. DIXON commented on the lack of evidence of Lower Coal Measures in South Wales, mentioned by the previous speaker. In Pembrokeshire a continuous sequence from Carboniferous Limestone into Coal Measures was, unfortunately, nowhere observable along the south side of the coal-basin, where greater freedom from unconformities might be expected than along the north side. However, there was no doubt that the coast-section north of Tenby included part of the Pendleside Series, and that a considerable thickness of strata intervened between the latter and the lowest of the beds that had yielded a Middle Coal-Measure flora. The rocks were chiefly marine, and had yielded few plants; again, they were interrupted by several disturbances of unknown magnitude. Hence it would be premature, in the present state of our knowledge, to say that a representative of the Lower Coal Measures does not exist on the south side of the Pembrokeshire Coalfield. South of the main part of the South Wales Coalfield, a representative might possibly be found north of the Carboniferous Limestone of the Gower peninsula; for there the Pendleside Series, with *Glyptioceras spirale*, was in evidence and, doubtless, passed up into the Coal Measures through an intermediate series of shales with sandstones. Unfortunately, there was no continuous coast-section.

Dr. T. F. SIBLY spoke of the difficulties which were being revealed in increasing degree by progress in the zonal investigation of the Lower and Upper Carboniferous rocks. Palæontological studies had shown that the marine Lower Carboniferous extended to higher horizons in the Midland regions than in South Wales; while palæobotanical evidence indicated that the Upper Carboniferous of the Midlands included lower horizons than had been detected in the Upper Carboniferous of South Wales. He suggested that the solution of the problem might ultimately be found in the existence of at least one widespread unconformity or break within the Carboniferous succession of South Wales and the adjoining regions.

With reference to the question of the age of the Millstone Grit, mentioned by a previous speaker, he drew attention to the fact that the 'Pennant Grit' transgressed persistently from lower to higher floral horizons in passing eastwards from Pembrokeshire to Monmouthshire and the Forest of Dean; and he suggested that an explanation involving similar transgression, but upwards from east

to west, might be applicable to a portion at least of the Millstone Grit of South Wales.

Prof. HULL pointed out that the dissimilarity between the South Wales Coalfield and those of the Midlands was amply to be accounted for on the grounds that these coal-areas were never connected, but were separated one from the other by a ridge of pre-Carboniferous rocks, extending from North Wales and Shropshire into the centre and east of England under the Mesozoic formations. With regard to the Lower Coal Measures of South Wales, they differed from the succeeding Middle and Upper divisions, as they contained numerous species of marine shells, such as *Productus*, *Orthis*, *Nautilus*, etc. These marine, though shallow-water, deposits were succeeded by deposits of freshwater origin.

The AUTHOR, in reply, thanked the Fellows present for their kind reception of the paper. He pointed out that he only obtained fossil plants from some of the highest beds of the so-called 'Millstone Grit': namely, from those at, and in the neighbourhood of, Monkstone Point; with the principal exception of some from beds immediately south of Waterwynch, which, however, give no definite indication of the horizon of the beds in that district. He thought that the evidence as to the horizon of the Monkstone-Point beds would be seen more clearly when the paper was published.