26. *On the UPPER BEDS of the FIFESHIRE COAL-MEASURES.* By EDW. W. BINNEY, Esq., F.R.S., and JAS. W. KIRKBY, Esq. (Read January 25, 1882.)

[PLATE VI.]

OVERLYING the profitable portion of the Fifeshire Coal-measures there is a series of red barren beds, of which we have not seen any description. Possibly Mr. Howell refers to similar measures, as occurring in Mid Lothian, in the Edinburgh memoir of the Geological Survey (pp. 110, 111); and since the date of that memoir an upper series of beds, evidently identical with that of Fife, has been recognized by the Geological Survey in Lanarkshire, and described as a separate subdivision (*d5'*) of the Coal-measures*.

The best exposure of these red measures in Fife is on the coast from the mouth of the Leven to East Wemyss. Having somewhat carefully examined this section, we shall notice it briefly in detail—first as to the succession of strata, and afterwards as to the fossils found in them—and so give some account of the series.

The section in question forms part of the Wemyss coal-field, which, with the smaller adjoining fields of other lairds, is the most northerly piece of true Coal Measures existent in Britain†. The dip of the strata is easterly, rarely exceeding 10°, generally less; and as the trend of the coast is north-east and south-west, a section in descending order is to be observed by traversing the shore from the Leven westward.

The highest rock seen near the Leven is a red and purplish sandstone, which is well exposed opposite to the village of Innerleven, and which extends westward 600 yards or more, near to Methil. It is a softish rather fine-grained rock, lying apparently rather flat, though the amount of inclination is not always easy to see, owing to irregular bedding. At the lowest water of spring tides it is seen extending seaward; so that its full thickness is evidently not shown. Towards the west it is usually more or less covered with sand; and it is only after storms or the prevalence of certain winds that this portion of it is exposed. Its thickness is estimated at fully 200 feet.

(This sandstone is considered to be part of the Coal-measures, as it apparently dips with the underlying beds; but we have observed no fossils in it, and it may possibly belong to a later formation. It is certainly the highest palæozoic rock (sedimentary) seen in Fife; and it may be assumed that still higher measures may come into the dip, seaward, beneath the Firth of Forth, that may be Permian.)

About 12 feet of soft red marl lies below the sandstone; but it is rarely seen. From beneath it rises a red marly sandstone of very

* Explanation of Sheet 23, p. 17; and of Sheet 31, p. 11.

† The great bulk of the coal wrought in Fife comes from the middle portion of the Carboniferous-Limestone series, and in quality it is fully equal to that obtained from the true Coal-measures.

irregular structure, and full of light-coloured slightly calcareous concretions. It passes underneath into a bright red false-bedded sandstone, which ranges behind and beneath the east pier at Methil. The fairway of the harbour is said to occupy the place of a soft stratum which we have not seen. Then comes in the thick mass of red sandstone (stained with yellow at the top) that forms the Beacon Rock to the west of the fairway. This sandstone is fully 30 feet thick, thus making nearly 290 feet of measures from the commencement of the section.

Following come about 100 feet of marl, fireclays, and shales, with thin sandstones, all of which are more or less red in colour. The marls are often marked with green spots, and contain calcareous concretions; and the fireclays are, in places, variegated with yellow and purple. Remains of plants occur in some of the beds*.

Below the latter series of strata is about 8 feet of purple and grey sandstone, which is hard and calcareous. Afterwards come 20 feet of red and grey shale and fireclay, with two thin and very coarse coals or black bands, and several thin bands of argillaceous limestone. The remains of fish, Limuloid crustacea, and plants are found in these beds.

Two or three feet of calcareous sandstone follow, and then nearly 50 feet of red, pink, purple, and grey shale, enclosing three or four bands of argillaceous limestone and a thin bed of sandstone, having for base a bed of hard red and greenish calcareous sandstone, from two to three feet thick, and of very irregular bedding and structure. In these beds occur the remains of fish, mollusca, and plants.

The rocks we have noticed west of the Beacon rock at Methil are all seen in irregular succession within a distance of 600 yards of the harbour.

A series of faults then disturbs the sequence of the strata, and causes many repetitions of some of the beds. At one or two places lower strata are seen, as a little to the west of Muiredge Den, where a thick red marl (with green spots) and some yellow sandstone are seen underlying the bed of hard calcareous sandstone. The disturbed ground continues to near the west end of Buckhaven Links, where, on the west side of a large fault, the two thin coals with shales, and a thick red sandstone† overlying (forming the rocks known as the Broadhills), are thrown again into section, and seen for the last time.

Between the point last named and Buckhaven the strata are

* In some of the fireclays are cylindrical pieces of grey limestone from 10 to 12 inches in length and an inch in diameter, resembling in form the root-lets of *Stigmara*, and occurring in a vertical position. One of them, on analysis, gave:—

Carbonate of lime.....	50·61
Alumina	16·29
Magnesia	17·57
Silica	6·16
Oxide of iron	0·47

† Apparently the sandstone No. 27 of detailed section (p. 253) locally thickened.

masked by sand, except at one place, where the three-foot bed of calcareous sandstone comes up and forms a narrow reef. At the east end of Buckhaven the rocks again come to the surface, and form a continuous section westward. The first rock seen is a yellow sandstone, which is considered to be the same as that observed below the red marl west of Muiredge Den. About four feet of red marl underlies it; and then follows a thick bed of light red sandstone.. This latter rock is coarse and gritty, and contains white quartz pebbles.

Repeated alternations of sandstone and shale and fireclay follow; and these form the rocks that are exposed in front of Buckhaven. The sandstones are yellow, red, and purple; and the fireclays (which prevail) and shales are red, purple, yellow, and white, and often finely variegated. Two bands of ochre occur in the upper portion of this series; and in other places some of the fireclays are very ochreous. The thickness of this set of beds is 100 feet. One of the shales contains the remains of *Calamites*; but as a rule the beds appear to be unfossiliferous.

Immediately to the east of Buckhaven Harbour a thick reef of sandstone rises from under the strata just noticed. This rock is red, purple, and whitish in colour, soft and thick-bedded, rather coarse and pebbly towards the base; and it is about 30 feet thick. Within the harbour are numerous strata of red, yellow, and white shale or fire-clay, and red and white sandstone, some of which are seen in the low cliffs just above the west pier.

For 500 yards or more west of Buckhaven the prevailing rock is fireclay, with here and there thin and irregular beds of sandstone. The latter are red and yellow in colour. The fireclays are red, purple, yellow, and white, of various bright shades, and most beautifully variegated *. These beds (which lie very flat) are estimated to be about 130 feet thick.

A thick mass of red sandstone now comes to the surface, and continues in section for nearly a mile, owing to the trend of the coast being here almost parallel with the strike. This rock is soft, sometimes coarse, and with pebbles of quartz and shale, laminated in places, and much false-bedded. Its thickness is apparently not less than 100 feet. It is well exposed both between tide-marks and in the cliffs to the east and west of East Wemyss.

To the west of East Wemyss, below the red rock, the measures take more the appearance of coal-bearing strata; and further on still, near to West Wemyss, workable coals come to the surface; but to these measures we need not at present allude, as we look upon the thick red sandstone last described as the base of the upper group of beds.

From the red sandstone at the mouth of the Leven to the red sandstone at East Wemyss there appears to be a thickness of over 900 feet of strata, with possibly other still higher beds continued beneath the sea.

* After a gale, when these fireclays have been swept bare of sand, the colouring is something gorgeous.

These upper beds are again seen on the coast to the east and west of Largo Harbour; but the section is not so consecutive or so extensive as the one we have noticed. Occasional outcrops of some of the beds are also to be seen by the sides of the dens that run inland from the coast. In former times various sinkings were made in them to the ochre-beds, which mineral appears to be the sole commercial product of the series; and the working of it is now abandoned.

Quite recently the Fife Coal Company have sunk through over 500 feet of these red measures near to Leven, and very successfully won the Chemise Coal at a depth of 870 feet from the surface. The section penetrated at these pits commences in the red shales (No. 47, p. 254) lying some little distance below the thin coals to the west of Methil, about 430 feet beneath the top of the sandstone at the mouth of the Leven, thus indicating an aggregate thickness for these beds about the same as we have arrived at for the coast section*.

In Lanarkshire and Ayrshire the Geological Survey have observed a slight unconformability between these upper beds and the ordinary underlying Coal-measures. We have not noticed any such break in the succession of the Fifeshire strata.

Note on the Calcareous Beds and thin Coals west of Methil.—The limestones which characterize this portion of the section are all thin and more or less impure. Some perhaps would be more properly termed marlstones, on account of the predominance of argillaceous matter in their composition. They are usually red or purple in colour, hard, compact, and with an even fracture. Sometimes they are grey and of an earthy texture; and where very impure they show cone-in-cone structure. All of them are very inconstant in thickness; and they thin out or run together within very short distances. The latter is the case with beds 39 and 41 (see detailed section, p. 254), which at high-water mark form a stratum fully a foot thick. This limestone has the surface very curiously marked with large concentric ripples or corrugations. Others have a blistered or flatly mamillated sort of surface. Four of the beds which have been analysed give 30, 38, 41, and 60 per cent. of carbonate of lime. The strata associated with the limestones are commonly more or less calcareous. The sandstones often effervesce freely on the application of acid; and the argillaceous beds in many cases are marls rather than shales or fireclays.

With these calcareous beds occur the two carbonaceous bands that we have termed coals. They are very thin and very coarse. Towards high-water mark, where they are about six feet apart, they do not exceed three inches in thickness. Both of them rest on fireclays full of rootlets. The lower band is overlain by a limestone; the upper band has a shale roof, highly charged with plant-remains near the coal. Towards low-water mark the former becomes more like a true coal, and thickens to over six inches; and

* We are indebted for this information to the courtesy of Mr. Charles Carlow, the general manager of the colliery.

at extreme low water the upper seam passes into black-band iron-stone, eight inches thick, and charged abundantly with the carapace-valves of *Leaia* and other Entomostraca. These are the only carbonaceous and ferruginous beds that we have seen in the whole section from the Leven to East Wemyss, nothing so black being again met with until the ordinary coal strata are reached beneath and to the west of the thick red sandstone at the last-named place.

Palæontology of the Beds west of Methil.—The highest bed in which we have detected fossils is the shale No. 12 (see detailed section, p. 253), 30 feet below the West Beacon, which contains Stigmarian rootlets.

In the marl No. 16 there occur imperfect specimens of *Neuropteris* sp., *Lepidodendron* sp., and large fern-stems.

In the red marl and shale No. 24 there are abundant but very imperfect remains of an *Alethopteris* (leaflets nearly of equal size, strong midrib, with nervures nearly at right angles to it).

Bed No. 26 contains *Calamites*, Stigmarian rootlets, and other obscure remains of plants.

The next fossiliferous zone is the roof of the upper thin coal, which has yielded the following species:—

<i>Otenacanthus hybodoideus</i> , <i>Egerton</i> .	} Fish.
<i>Megalichthys Hibberti</i> , <i>Ag.</i> , teeth.	
<i>Strepsodus sauroides</i> , <i>Huxl.</i> , teeth.	
<i>Bellinurus trilobitoideus</i> , <i>König</i> .	} Crustacea.
<i>Eurypterus mammatus</i> , <i>Salter</i> .	
<i>Prestwichia anthrax</i> , <i>H. Woodward</i> .	
<i>Anthracomya</i> , sp. nov.?	
<i>Annularia longifolia</i> , <i>Brongn.</i>	
<i>Calamites Suckovii</i> , <i>Brongn.</i>	
<i>Cordaitea</i> , sp.	
<i>Lepidodendron elegans</i> , <i>Brongn.</i>	} = <i>L. obovatum</i> , <i>Sternb.</i>
— <i>gracile</i> , <i>Lindl.</i>	
<i>Lepidophyllum lanceolatum</i> , <i>Lindl.</i>	
<i>Lepidostrobus variabilis</i> , <i>Lindl.</i>	
<i>Sternbergia approximata</i> , <i>Brongn.</i>	
<i>Sigillaria pachyderma</i> ? <i>Brongn.</i>	
<i>Sphenophyllum erosum</i> , <i>Lindl.</i>	
<i>Trigonocarpon dubium</i> (<i>Sternb.</i>).	
Finely striated stems = <i>Diploxylon elegans</i> ?, <i>Corda</i> .	
<i>Alethopteris lonchitica</i> , <i>Brongn.</i>	
<i>Neuropteris auriculata</i> , <i>Brongn.</i>	
<i>Pecopteris</i> , sp.	
<i>Sphenopteris latifolia</i> , <i>Lindl.</i>	
Algæ—or rootlets.	

The above fossils are all found within six or eight inches of the coal. The fish, crustacean, and molluscan remains are intermixed with the plants. The animal remains occur rarely; but the plants are so numerous in some places as to quite blacken the shale. None of the species are in good preservation; and on this account some are only doubtfully determined. The most remarkable fossil of this group of species is that doubtfully referred to Algæ, which may possibly belong to an unknown form of rootlet, and which will be afterwards more fully referred to (p. 251).

The coal itself contains many large stems, flattened and coarsely

furrowed. Seaward, where it passes into a calcareous black-band ironstone, it contains the following fossils * :—

Leaia Leidyi, *Lea*.
Carbonia fabulina, *Jones & Kirkby*.
— *Rankiniana*, *J. & K.*
— *secans*, *J. & K.*
Spirorbis carbonarius, *Murch.*
Ganoid scales and fragments of fish-bones.
Stigmarian rootlets.

The fireclay under the coal contains many rootlets; and in the shale No. 33, overlying the lower coal and thin limestone, there occur rootlets which differ from the ordinary Stigmarian type by branching or forking nearly at right angles at intervals of a foot or so. With the rootlets are rare specimens of species of *Neuropteris*, *Pecopteris*, and *Cyclopteris*, along with an *Anthracomya*.

Towards the base of the shale No. 42 there is a thin band of reddle composed of the remains of the Entomostracan *Carbonia Rankiniana*, with a few stray Ganoid scales and small fish-spines.

From the thin parting of dark shale No. 45 (and partly imbedded in the upper surface of the calcareous sandstone beneath) we have procured the species enumerated below, most of which are (or were) comparatively common.

Acanthodus spines.
Ctenacanthus hybodoideus, *Egerton*.
Ctenodus sp., operculum, ribs, sphenoid and other bones.
Diplodus gibbosus, *Ag.*
Megalichthys Hibberti, *Ag.*
Palæoniscus sp., scales and plates.
Coprolites.
Lepidodendron aculeatum, *Sternb.*

At various horizons of the red and grey shale No. 47 occur numerous casts of a small *Anthracomya*, possibly *A. modiolaris*, or near it; also stray specimens of small Ganoid scales and teeth, *Carbonia Rankiniana*, and species of *Lepidodendron* and *Calamites*.

Low down in this thick shale there is a zone of plant-remains. From it have been obtained :—

Ganoid scales.
Calamites Suckovii, *Brongn.*
Lepidodendron sp.
Lepidophyllum lanceolatum, *Lindl.*
Neuropteris auriculata, *Brongn.*
Neuropteris sp.
Trigonocarpon olivaeforme, *Lindl.*

It has already been mentioned that fragments of wood and spines of *Acanthodus* are found on the surface of the calcareous sandstone No. 48; and this is the only other bed, at Methil, in which we have observed fossils.

The fossils we have noticed are, with few exceptions, badly preserved, and not such as easily attract attention, though very abundant in places, and easily enough found when looked for. The beds con-

* This locality, which is the only one in the Coal-measures where we have found *Leaia* at all plentiful, is best got at during equinoctial spring tides; at other times the rock is rarely laid bare at dead low water.

taining them are all exposed between tide-marks, in the space included from a little west of Methil Harbour to the mouth of Muir-edge Den.

We are much indebted to the assistance of Dr. H. Woodward, Mr. R. Howse, and Dr. Traquair, in determining the species.

Note on the Algæ or Rootlets occurring in Bed No. 28. (Pl. VI.).—These Algæ, or rootlets, are only found in about an inch or less of the shale overlying the upper thin coal, and some three inches or so above it. They are not seen where the other vegetable fossils are most numerous, which, as has been stated, is in the portion of the shale immediately over the coal. They are very delicate and membranous, showing no structure or surface-marking, except in the larger specimens, where is seen the remains of an internal filament or cord (figs. 1, 2, & 4), apparently indicating what was once the centre of a very succulent plant. The subrectangular mode of branching of many of the specimens is very peculiar, as is also the symmetry, often to be observed, of the branching on each side of a stem or main branch (figs. 8, 9, & 10). We have noticed nothing like fructification on any of the specimens; nor are we at all certain that any of our examples show the natural ending of the smaller branches. And we have certainly not seen what the main stems spring from.

These singular fossils, which have been rarely met with in Carboniferous strata, so far as our knowledge extends, might be taken for the remains of marine Algæ of the genus *Chondrus*, from their appearance; but as they can only be proved to be such by their organs of reproduction, and none of the latter have been met with, we can only adduce their external characters in favour of this view. From this evidence alone, however, M. Adolphe Brongniart* described and figured *Fucoides strictus* and *F. multifidus*, and Professor Schimper, Göppert, and Count De Saporta *Chondrus fruticulosus*†. M. Lesquereux has found *Fucoides cauda-galli*‡ in ordinary Coal-measures (as we should expect from the presence of salt water in many of our deep mines where surface-water has been prevented from getting down into the workings); so there is really no great improbability of Fucoids being met with in such strata, as it is well known that the fauna there found has more of a marine than a freshwater *facies*. The analysis of the limestone previously given, showing the presence of salts of lime and magnesia in the waters from which it was deposited, also points to any thing but a freshwater origin.

The only fossils that we have been able to find at all resembling our specimens are some described and figured by M. Heer§ in his description of the plant-remains brought by Professor Nordenskjöld from Bear Island, in the Arctic Ocean, which that author takes to be the roots of *Lepidodendron*. Certainly the larger Methil fossils

* Histoire des Végétaux fossiles, plate ii. fig. 4; plate v. figs. 9 and 10.

† Traité de Paléontologie Végétale, plate ii. fig. 5.

‡ "On *Fucoides* in the Coal-formations," Trans. Amer. Phil. Soc. Philad. vol. xiii. p. 313.

§ Fossile Flora der Bären-Insel (Stockholm, 1871), taf. xiii. figs. 1 and 2.

so much resemble the Bear-Island ones that, in all probability, whatever the latter are finally determined to be, ours must follow*.

What are the roots of *Lepidodendron* is at present doubtful. One of us has shown that in structure *Halonia* exactly resembles *Lepidodendron*, and was probably the root of the latter plant. Up to the present time, so far as our knowledge extends, no well-marked specimen of *Lepidodendron* with its roots attached to it has been discovered, although M. Heer may have seen such. M. Lesquereux, one of the most experienced living authorities, in his description of *Halonia tortuosa*, appears to have observed his specimen *in situ*, and saw that it had not been flattened, but was in its original shape, that its natural position was not vertical but horizontal or prostrate, and that it was a fragment of a plant growing and expanding its branches upon the ground†. This fact in some degree sustains the view that *Halonia* was the root or rhizoma of *Lepidodendron*, with which, as previously stated, it is identical in structure.

It may be remarked, in conclusion, that these red rocks of Fife are higher Coal-measures than any seen on the east side of England, so far at least as we have observed in Northumberland, Durham, Yorkshire, and Derbyshire. The high position and general character of the strata naturally suggest that they are the equivalents, either in full or in part, of the Upper Coal-measures of Lancashire and other western districts of England. In one particular, however, they differ from the upper series of western England, as there is nothing in the Fife beds like the *Spirorbis*-limestone, which, in one or more bands, is so characteristic a feature of the Upper Coal-measures of the west, in their range from the Forest of Wyre northwards into Dumfriesshire and Ayrshire; neither is the development of the series in Fife so great as on the west side of the country, 2000 feet and upwards being its thickness in Lancashire and other districts in the west compared with less than 1000 feet in Fife; so that while the Coal-measures of Fife are evidently more complete in the possession of an upper set of beds than elsewhere on the east side of the country, it is probable that the thick mass of Lower, Middle, and Upper Coal-measures of the west country may represent more thoroughly, and more nearly approach the close of, this great upper division of Carboniferous strata‡.

* The Editor has very kindly drawn my attention to the close resemblance of some of our figures of this fossil to those given by D. Stur as representing the foliage of what he terms *Archæocalamites radiatus*, Brongn., in his "Culmiflora des mähr.-schles. Dachschiefers," in the 8th vol. of the 'Abhandlungen' of the Austrian Geological Institution, as will be seen on comparing figs. 5, 6, and 8 of his pl. iv., with our figs. 2, 3, 6, 7, and 8.—J. W. K.

† "Observations on the Structure of Fossil Plants found in the Carboniferous Strata," part iii. p. 94, vol. for 1871; and 'Pennsylvania Second Geol. Survey,' p. 413.

‡ Originally the Coal-measures on the east side of England were probably as complete as those on the west; for their junction with the overlying Permian rocks is always unconformable, so that it is not possible to say what amount of higher measures have been denuded. The highest Coal-measures that we have seen on the east side appear to be the Rotherham Red Rock, in South Yorkshire. It is possible that still higher beds may come in as the measures dip beneath the Permian and Triassic strata of South Yorkshire and Lincolnshire, which may be some day proved as the search for coal is continued eastward.

Detailed Section of Strata seen on the Coast between the River Leven and East Wemyss.*

	ft.	in.
1. Red and purplish sandstone, rather fine-grained, soft and false-bedded. (Seen opposite to Innerleven and westward towards Methil, but not wholly exposed.)	200	0
2. Red marl, stained with yellow in places	12	0
3. Fine-grained marly red sandstone, full of light-coloured, slightly calcareous concretions, the latter prevailing so much in some parts as to change the character of the rock, and passing into No. 4	12	0
4. Red sandstone, fine-grained and false-bedded (forming the rock on which is built the east pier of Methil Harbour).	20	0
5. A soft bed, said to lie in the fairway of the harbour, which we have not seen	10	0
6. Red sandstone, blotched with yellow at the top, fine-grained, thick and cross-bedded. (The West Beacon rock.)	33	0
7. Yellow and red sandstone, thin-bedded	3	0
8. Red shale, sandy and soft	6	0
9. Red sandstone, laminated	4	0
10. Red marl, speckled with green	15	0
11. Reddish purple sandstone	3	0
12. Red shale. (Stigmarian rootlets.)	2	0
13. Red sandstone	3	0
14. Red, purple, and yellow shale, variegated	1	0
15. Variegated sandstone, hard		8
16. Red marl, blotched with green and yellow at the top, and very red in places below. (<i>Neuropteris</i> and <i>Lepidodendron</i> .)	8	0
17. Brownish purple sandstone		8
18. Red marl, full of small calcareous concretions	6	0
19. Red shale with strong sandy bands	7	0
20. Red shale with yellow streaks, laminated	3	0
21. Purple red shale, firm, and with green spots	4	0
22. Red marl or fireclay	15	0
23. Purplish sandstone, spotted with green	1	0
24. Purple and red marl, with whitish blotches (at top) and concretions of irregular shape. (Ferns.)	12	0
25. Red stone, hard and flinty	1	6
26. Red, pinkish, purple, and greenish shale and fireclay, with hard concretions. (Calamites, Stigmarian rootlets, &c.)	14	6
27. Purple and greenish sandstone	8	0
28. Purple, red, and greenish shale. (Plants, fish, and Crustacean remains.)	10	6
29. Coarse coal		2
30. Grey fireclay, with red spots. (Stigmarian rootlets.)	4	0
31. Grey and purple shale, laminated	2	0
32. Purple and grey limestone		6
33. Grey and purple shale. (<i>Neuropteris</i> , Stigmarian rootlets, &c.)	2	0
34. Argillaceous limestone		9
35. Coarse coal		3
36. Greenish grey fireclay. (Stigmarian rootlets.)	1	6
37. Grey sandstone, stained with red at top, soft and shaly	3	6
Carried forward	430	6

* Taken about midway between high- and low-water mark.

Detailed Section of Strata (continued).

	ft.	in.
Brought forward.....	430	6
38. Red, pinkish, and light grey shale. (Stigmarian rootlets and <i>Lepidodendron</i> .)	9	0
39. Purple limestone, argillaceous and hard	6	
40. Light grey shale	1	0
41. Argillaceous limestone.....	4	
42. Red shale	2	6
43. Reddle or hæmatite. (Composed of <i>Entomostraca</i> .)	1	
44. Grey shale.....	8	
45. Dark sandy shale. (Fish-bed.)	1	
46. Reddish purple sandstone	1	0
47. Red, grey, purple, and pink shales, strong and sandy in places, soft in others, well laminated, with large discoidal calcareous concretions, and one or more bands of argillaceous limestone. (<i>Anthracomya</i> and plant-remains.)	36	0
48. Red and yellowish sandstone, calcareous and hard, of very irregular structure, with false-bedding and ripple-marks. (This bed stands out as a reef rather to the west of Muiredge Den, and again to the east of Buckhaven. Beds 7-48 are all seen between Methil Harbour and a little to the west of Muiredge Den.) ...	3	0
49. Red marl, with light green spots above and many calcareous concretions below	15	0
50. Yellow sandstone.....	6	0
51. Red or purplish marl, or fireclay	4	0
52. Faint-red or purplish sandstone* (with light-coloured bands in places, coarse and gritty below, and with quartz-pebbles)	12	0
53. Shale, not clearly seen.....	2	0
54. Yellow or whitish sandstone above, light red with yellow bands below	11	0
55. Purple sandy shale, with an irregular band of ochre	1	6
56. Purple and yellow fireclay, variegated	5	0
57. Yellow and purple sandstone, massive; with 1 foot of white sandstone at base	9	0
58. Red shale, with yellow ochreous spots. (<i>Calamites</i> .)	10	0
59. Yellow, white, and red sandstone, with a foot of white sandstone at the base	9	0
60. Red shaly fireclay, with a band of coarse ochre near the top.....		
61. Yellow and red sandstone in thin irregular beds.....	3	0
62. Red shale, coarse	2	0
63. Red sandstone, with a white band at the base	4	0
64. Red and yellow shaly fireclay, with white veins	7	0
65. Light purple (variegated with yellow, red, and white) fireclay, which in places is very yellow and ochreous. (Stigmarian rootlets.).....	7	0
66. Red and white sandstone, hard at the top	3	0
67. Red sandy shale	1	0
68. Red fireclay, speckled with white, coarse and sandy in places	5	0
69. Red calcareous sandstone, coarse grained, and with a white band at the base	3	0
Carried forward	604	2

* An outcrop of this sandstone is seen in Muiredge Den, near the mouth.

Detailed Section of Strata (continued).

	ft.	in.
Brought forward.....	604	2
70. Reddish purple shale	2	6
71. Red and white sandstone of irregular structure	1	6
72. Whitish and red fireclay, variegated, with irregular intercalations of white sandstone	9	0
73. Purple and yellow sandy shale, ochreous in places	1	6
74. Intercalations of red shaly sandstone and sandy shale ...	3	0
75. Dull red fireclay veined with white, coarse and sandy. (Beds 70-75 are all exposed in front of Buckhaven.) ...	6	0
76. Red, light red, and purple sandstone, with whitish parts, softish, thick-bedded, and weathering irregularly; coarse, and with quartz pebbles at the base. (Forms the reef immediately to the east of Buckhaven Harbour.)	30	0
77. Repeated alternations of red, purple, and yellow shale or fireclay, and red and white sandstone—cropping out chiefly within the harbour, and partly in the low cliffs to the west of it	46	0
78. Bright red fine-grained sandstone, with yellow patches below.....	5	0
79. Yellow and purple sandy fireclay	12	0
80. Dark red and yellow sandstone, thin-bedded and irregular in structure	4	0
81. Yellow and light purple shale, sandy	1	6
82. Light purple and yellow fireclay	4	0
83. Purplish and yellow sandstone, an irregular bed.....	1	6
84. Dull red and light-purple fireclay	5	0
85. An irregular bed of purple and yellow sandstone	3	0
86. Sandy fireclay, light-coloured.....	2	0
87. Whitish, light purple, yellow, and red fireclay, beautifully variegated, and with large sandy intercalations	30	0
88. Red and yellow sandstone	6	0
89. White and red fireclay above; yellow, red, and purple below; beautifully variegated	15	0
90. Red sandstone. (Stigmarian rootlets.).....	3	0
91. Red shale. (Calamites.).....	1	0
92. Whitish fireclay and shale, variegated with yellow and purple. (Stigmarian rootlets.).....	10	0
93. Red sandstone, an irregular bed.....	1	0
94. Red, purple, yellow, and white fireclay and shale, finely variegated, and laminated in places	15	0
95. Purple and whitish sandstone.....	1	6
96. Red, purple, yellow, and white fireclay and shale, variegated and spotted	10	0
97. Purple and yellowish sandstone.....	8	0
98. Purple shale, with yellow spots above, sandy, not all seen	5	0
99. Red sandstone, laminated and shaly above, generally softish, but hard in some places, and coarse and gritty, with quartz and clay-pebbles in other places, and much false bedded. (Seen on the shore and in the cliffs from east of the Gas-works to the west of East Wemyss.) ...	100	0
	<u>947</u>	<u>2</u>

EXPLANATION OF PLATE VI.

This Plate illustrates the various forms of the *Algæ* or rootlets from Methil. The figures are all of natural size.

DISCUSSION.

The PRESIDENT spoke of the value of the physical and palæontological information conveyed in this paper.

Mr. TIDDEMAN spoke of a section he had found along the Greta, near Ingleton, where some thin limestones occur at a considerable height above the true Coal-measures: over the latter were plant-bearing sandstones, shales, and clays; and apparently corresponding with them, on the other side of a synclinal, were beds of similar rocks, but with limestone interbedded. These were almost dolomitic. No organic remains had been found in them. It was, however, just possible that these limestones, being near the Great Craven Fault, might not be Upper Coal-measures but Yoredale-beds; but on the whole the probability lay the other way.

Mr. CRUTTWELL inquired the thickness of the limestone. In Australia there were limestones with *Productus reticulatus* under the productive Coal-measures.

Dr. MURIE said he thought that rootlets of *Lepidodendron* had been found *in situ* in the north. He thought these beds could be traced westward to the other coal of Scotland.

The PRESIDENT remarked that it was singular how closely some of the Australian fossils corresponded with those of Britain.

J.W.K.

PLANT REMAINS FROM METHIL.

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