

XXXVII. *On the Occurrence of True Coal Measures at Port Seton, East Lothian.* By E. B. BAILEY, B.A., and D. TAIT, of H.M. Geological Survey.

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PORT SETON lies on the axis of the East Lothian basin of Carboniferous rocks, and within an area which has hitherto been mapped as belonging to the Carboniferous Limestone Series. The structure of the district as revealed along the coast is simple, the beds on both sides of the harbour dip towards it at angles varying from 20 to 30 degrees, forming a syncline, the harbour being exactly on its centre. The section to the east extends for a distance of about half a mile, and is remarkably clear, but westwards the exposure of the stratified rocks ceases within a short distance of the harbour, and in their stead a large basalt dyke rises directly from the water's edge. Where this basalt runs out to sea at Cockenzie Haven the sediments reappear and are inclined at very low angles. Still further to the west, near Preston Links Colliery, the section is crossed by a fault running almost due east and west. This dislocation, which was referred to by Milne Home in his paper read before the Royal Society of Edinburgh,¹ has a downthrow to the north of about forty fathoms. Inland there is another fault represented on the Geological Survey Map as terminating the outcrops of certain limestone bands east of Port Seton, but it has now been proved by bores to be of minor importance. The whole section is traversed by numerous small faults, one of which has a reversed hade, but in no case did these faults interfere with the accurate measurement of the strata.

It is well known that the East Lothian basin is very shallow compared with that of Mid-Lothian, and it is unlikely that it contains beds higher than those of the Edge Coal Group over most of the area. On the coast east of Port Seton, however, Mr Howell mapped two thin limestone bands which he considered should be referred to the Upper Limestone Group.²

During the recent revision of the district, Mr Howell's inference has not only been confirmed, but the occurrence at Port Seton of representatives of the Roslin Sandstone Group and of the Lower Coal Measures has been demonstrated.

The subdivisions of the Carboniferous System referred to in this paper are, in descending order, as follows:—

¹ *Trans.* 1839, vol. xiv., "The Coal-Fields of the Lothians," p. 346.

² "Mem. of Geol. Surv. Geology of East Lothian," 1866, p. 61.

Upper	}	The Lower Coal Measures
Carboniferous		The Roslin Sandstone Group.
Lower	}	The Upper Limestone Group.
Carboniferous		The Edge Coal Group.

UPPER LIMESTONE GROUP AND UPPER PART OF EDGE COALS.

East of Port Seton and close to the shore, three old spoil heaps may still be seen, though the pits which they represent have long ceased to be worked. We are indebted to Messrs Williamson, Miller, and Robertson for important information regarding them. The two easterly pits were sunk, it is said, to the Great Seam of the Edge Coals, and in the middle one of the three this coal was reached at a depth of only fourteen fathoms. As the position of this pit lies almost precisely on the outcrop of the lowest limestone, there can be no doubt that this bed represents the No. 4 or Index Limestone, the lowest of the Upper Limestone Group.

The following section which was measured along the eastern shore shows the succession of strata in descending order:—

	Feet.	Inches.
No. 6. Limestone	2	6
Sandstone with stigmara	1	—
Fossiliferous sandy shale	4	10
Sandstone	41	—
Various strata	7	—
Parrot coal	—	1-4
Gannister	2	—
Coal	—	2
Various strata	12	5
Sandstone	44	—
Shale	24	—
No. 5. { Limestone	1	—
{ Limey shale	—	8
{ Various strata	32	9
The "Extra" Limestone	—	9
{ Various strata	17	11
{ Coal	—	6
{ Various strata	7	—
{ Coal streak	—	—
{ Shale	8	—
{ Sandstone	35	—
{ Various strata	19	2
{ Sandstone	48	—
{ Shale	5	9
No. 4. Limestone	1	2
Total	316	8

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	Feet.	Inches.
Various strata	84	—
Great seam	5	6

In the foregoing table the following points are worthy of note:—

1. The group is highly arenaceous, and contains four thick beds of sandstone, the most important of which is just a little above the lowest limestone, and recalls the thick bed of sandstone on the same horizon at Niddrie, in the Mid-Lothian basin.

2. Compared with the Upper Limestone group of Mid-Lothian, which at Niddrie, six miles to the west, is 1070 feet thick, the same division here is remarkably thin, being only 316 feet thick.

3. Not only has the group as a whole diminished in thickness, but its coal seams have undergone a similar attenuation, for this same series in the north-eastern portion of the Mid-Lothian basin contains three workable seams of coal, besides many others of less importance. It thus appears that the division of the Upper Limestones, when traced from Mid- to East Lothian, presents an analogous variation to that already well known in the case of the Edge Coal Group.

4. It is significant that the limestone bands are also very thin. They are four in number, whereas it has hitherto been customary to refer to "the three limestones" of the upper group in the Midlothian area.¹ Mr Howell² has indeed noted two cases, on the east side of the basin, which he considered exceptional, where bore journals contain the record of an "extra limestone." This year, in two railway cuttings, the one at Niddrie and the other at Gilmerton, the presence of four limestones has been demonstrated. An abstract of the measurements taken in these two sections is here given, and the bore records at Wallyford and Cowden quoted by Mr Howell are also added for comparison. At Gilmerton only the two middle limestones are actually seen in the cutting, so that the measurements are necessarily incomplete:—

	Niddrie.	Gilmerton.	Cowden.	Wallyford.
<i>a.</i> Limestone	19 ft.	—	2 ft. 5 in.	—
Strata	343 ft.	—	155 ft.	—
<i>b.</i> Limestone	3 ft. 5 in.	4 ft.	2 ft. 11 in.	1 ft. 9 in.
Strata	292 ft.	240 ft.	385 ft.	227 ft.
<i>c.</i> Limestone	19 ft. 3 in.	12 ft.	4 in.	4 in.
Strata	392 ft.	—	134 ft.	129 ft.
<i>d.</i> Limestone	3 ft. 4 in.	—	4 ft. 8 in.	1 ft. 6 in.

¹ "The Coal-Fields of the Lothians," 1839, p. 88.

² "Mem. Geol. Survey, the Geol. of the Neighbourhood of Edinburgh," 1861, p. 102.

These sections obviously have no close agreement among themselves or with that at Port Seton previously given. It should be remarked, however, that the limestone *c* at Niddrie and Gilmerton is mostly a very fossiliferous marl, with thin irregular courses of true limestone. Whether a correlation of the individual bands is possible in these localities is doubtful, but the sections clearly show that the occurrence of four limestones in this group is not unknown in the Mid-Lothian basin, and it is a significant fact that wherever seen—namely, at Port Seton, Niddrie, and Gilmerton—the second limestone from the bottom is crowded with *Productus latissimus*.

A comparison with Milne Home's vertical section clearly shows that as regards Niddrie and Gilmerton, at least, the upper of the two middle limestones is the No. 5 of the older authors. In the absence of definite evidence, the same correlation may provisionally be applied to the Port Seton section.

The following fossils have been obtained from this group at Port Seton, and have been determined by our colleague, Dr Crampton.

From No. 6 Limestone.

Cauda galli (Spirophyton).
Crinoid stems.
Productus sp.

From shale 3 to 6 feet below No. 6 Limestone.

Aviculopecten knockonniensis, *M^cCoy*, sp.
Cardiomorpha limosa, *Hind*.
Edmondia expansa, *Hind*.
Myalina Flemingi, *M^cCoy*, sp.
Sanguinolites costellatus, *M^cCoy*, sp.
Worm burrows.
Bellerophon sp.

From No. 5 Limestone.

Crinoid stems.

From the "Extra Limestone."

Coral indet.
Orthis resupinata, *Martin*.
Productus latissimus, *Sow.* (abundant).
Productus longispinus, *Sow.*
Spirifera trigonalis (?), *Martin*.
Macrocheilus sp.

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From No. 4 Limestone.

- Crinoid stems.
- Fenestella sp.
- Productus sp.
- Bellerophon sp.

From shale a few feet below No. 4 Limestone, and therefore belonging to the Edge Coal Group.

Sphenopteris elegans, *Brongt.*

ROSLIN SANDSTONE GROUP.

The Roslin Sandstone Group is here taken to include all the beds which come between No. 6 Limestone and the top of the thick massive sandstone on which the eastern wall of the Port Seton harbour has been built. There is reason to believe that the upper limit here defined corresponds approximately with that mapped by Mr Howell in Mid-Lothian.¹

The details of the section as measured on the eastern side of the harbour are given below in a condensed form.

	Feet.	Inches.
1. Sandstone	44	—
2. Various strata with Upper Carb. plants	28	—
3. Sandstone	104	—
4. Sandstone and red mottled fireclays with thin coals towards the top	84	—
5. Shale with Upper Carb. plants on top and Producti below	15	—
6. Mottled fireclay or marl	8	—
7. Sandstone	57	—
8. Red nodular calcareous ironstone with marine fossils	2	—
9. Various strata down to the top of the No. 6 Limestone	160	—
	502	

In lithological character the Port Seton section resembles the type sections of the Roslin Sandstone group in Mid-Lothian. The thick sandstone, No. 3 in the foregoing section, contains large pebbles of white and yellow vein quartz, well rounded and distributed in a most sporadic manner, while the mottled red, white, and blue fireclays so typical of the group in Mid-Lothian are finely represented.

A peculiar interest attaches to the fossil contents of this

¹ See this year's "H.M. Geol. Survey Summary of Progress for 1903."
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Roslin Sandstone since, owing to the researches of Mr Kidston¹ and Dr Traquair,² it is now known that somewhere within its limits a marked palæontological break, both as regards the flora and the fish fauna, divides the Carboniferous System palæontologically into two divisions. Mr Kidston has determined the plants which have been obtained from this section, and the evidence proves that Lower Coal Measure forms (Upper Carboniferous) extend far down into the Roslin Sandstone Group. Unfortunately no recognisable plants were obtained from the lower beds of the group, and no fish remains were found in any part of the section.

The recognition of two marine bands (Nos. 5 and 8 in the section) is also a point of great interest in connection with what may be termed the natural history of the group, and also because, as will be shown in the sequel, there is reason to believe that the bands may be of great value as stratigraphical horizons. The lower of the two bands is a red calcareous ironstone of a peculiar nodular character and contains *Productus* and other thoroughly marine forms.

The upper marine band occurs 65 feet higher up in the sequence and is a dark reddish shale with ironstone nodules, in the upper fissile part of which two pinnules of *Alethopteris lonchitica* (?) and a specimen of *Cordaites* have been obtained. On the evidence of these plants Mr Kidston places this bed in the Upper Carboniferous Series.

The two marine beds are seen on both limbs of the syncline on the east and on the west side of the harbour, and to the west the section ends a short distance below them.

Another bed which yielded the following Upper Carboniferous plants was found on the east side of the harbour about nine feet below the highest thick sandstone (No. 1 in section), viz. :—

Alethopteris lonchitica, *Schl.*, sp.
Mariopteris muricata, *Schl.*, sp.
Neuropteris gigantea, *Sternb.*
Sphenophyllum cuneifolium, *Sternb.*, sp.
Calamites sp.

On the other side of the syncline in the western division of the harbour and approximately on the same horizon, lamelli-branches of estuarine type occur :—

Anthracomya Williamsoni, *Brown*, sp.
Naiadites modiolaris, *Sow.*, sp.

¹ "Summ. of Progress Geol. Survey for 1902" (pub. 1903), p. 118.

² *Trans. Roy. Soc. Edin.*, "On the Distribution of Fossil Fish Remains in the Carboniferous Rocks of the Edinburgh District," vol. xl. part iii. (No. 28), 1903, p. 707.

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For the purpose of correlation, a visit was paid to the coast section between Dysart and Pathhead in Fife, to ascertain whether these marine bands might be recognised on the other side of the Forth. Though the sandstones there form picturesque features on the shore, many of the softer beds are quite concealed by sand. However, an ironstone nodule in a clayey shale yielded a large specimen of *Discina nitida*, while a slightly higher shale in the same group furnished the following Upper Carboniferous plants:—

- Calamocladus equisetiformis, *Schl.*, sp.
- Lepidodendron obovatum, *Sternb.*
- Cordaites principalis, *Germer.*, sp.

These shales occur in the group of sandstones, shales, and thin coals which, according to Sir Archibald Geikie's description,¹ lie about 290 feet above the No. 6 Limestone. The bed with *Discina* therefore agrees well in position with the upper of the Port Seton marine horizons, when it is remembered that the whole group at the latter place is developed on rather a small scale.

LOWER COAL MEASURES.

At Port Seton the Coal Measure basin is only 200 yards across from east to west. The following section is based upon measurements made in the harbour itself:—

	Feet.	Inches.
Sandstone . . .	(?)	
Coal . . .	6	4
Various strata . . .	12	10
Coal . . .	—	4
Various strata . . .	6	6
Coal . . .	7	—
Various strata . . .	23	—
Foul coal . . .	5	—
Various strata . . .	23	—
Carbonicola shale . . .	4	—
Coal with parrot . . .	1	—
Various strata . . .	44	—
	133	—

On the north-eastern side a few of the lowest beds belonging to this division are exposed outside the harbour; one of these is a tough ferruginous sandstone rib which crops out on the

¹ "Mem. Geol. Survey, Central and West Fife," 1900, p. 143.

seaward side of the eastern breakwater, and has yielded the following Upper Carboniferous plants:—

- Neuropteris heterophylla, *Brongt.*
- Spiropteris sp.
- Cyclopteroid pinnule.
- Annularia radiata, *Brongt.*
- Sphenophyllum cuneifolium, *Sternb.*, sp.
- Cordaites principalis, *Germar.*, sp.

The shaly beds in the western division of the harbour which also lie immediately below the Carbonicola bed have furnished the following forms:—

- Alethopteris lonchitica, *Schl.*, sp.
- Mariopteris muricata, *Schl.*, sp.
- Calamites cistii, *Brongt.*
- " Suckowii, *Brongt.*
- " undulatus, *Sternb.*
- Sphenophyllum cuneifolium, *Sternb.*, sp.
- Cordaites principalis, *Germar.*, sp.
- Stigmaria ficoides, *Sternb.*, var. undulata, *Göpp.*

The specimens collected from the *Carbonicola* bed were examined by Dr Wheelton Hind, who finds that they all belong to one species—*C. robusta*. The shells are usually preserved in ironstone and often have both valves in position. Attached to one of the specimens there was found a tube of the little annelid *Spirorbis*.

Viewed from a stratigraphical standpoint this band merits special attention, for in the Mid-Lothian basin a similar *Carbonicola* bed is found near the base of the Coal Measures. It has been recorded from the following localities by Milne Home¹:—Cowpits, Pinkie Burn, Joppa Shore, Easter Duddingston Old Engine Pit, Wanton Wells Deep Level, and near Somerside.² It is right to state that if we assume that the *Carbonicola* shale found this year at Port Seton belongs to the same horizon as the above, we must recognise that certain important coals occurring below it at Joppa have disappeared before reaching Port Seton.

In the east division of the harbour, in strata overlying the *Carbonicola* bed, the following plants were collected:—

- Sphenopteris acuta, *Brongt.*
- Calamites ramosus, *Artis.*
- Calamocladus equisetiformis, *Schl.*, sp.

¹ Milne Home, "The Coal-Fields of the Lothians," 1839, p. 18.

² For further information regarding the extension of this band, see this year's "Summary of Progress of H.M.G.S. for 1903."

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It will be seen, then, that both in the occurrence of Lower Coal Measure plants and of the lamellibranch—*Carbonicola robusta*—the evidence of the presence of Upper Carboniferous Strata at Port Seton is conclusive. It ought to be borne in mind, as already indicated, that Upper Carboniferous plants of Lower Coal Measure age occur well below the line which has here been taken as the base of the Coal Measures. In this description both palæontological and lithological evidence has been employed to bring the classification of the Carboniferous rocks at Port Seton into line with that established chiefly by Mr Howell¹ for Mid-Lothian.

With reference to the local development of the Coal Measures, it is worthy of note that the old workings of the Edge Coals in East Lothian prove that the Port Seton outlier has only a limited extension inland. The basin is closed on the seaward side almost at the harbour mouth by the underlying Roslin Sandstone. The section, however, is one of great economic importance for the following reasons:—

1. Despite the mapping of the geological survey it has been the general belief of mining men who know the district that the big coal of Port Seton harbour is the great seam of the Edge Coals. On the other hand, it is now proved that the latter seam is eleven hundred feet below the surface at Port Seton. There remains, therefore, a considerable portion of this valuable seam yet unworked on the mainland of East Lothian, for in the days of haulage by women, coal was not worked at a greater depth than forty fathoms,² even in situations where drainage was easy, and had the basin been exploited in later times there would have been some record of the fact.

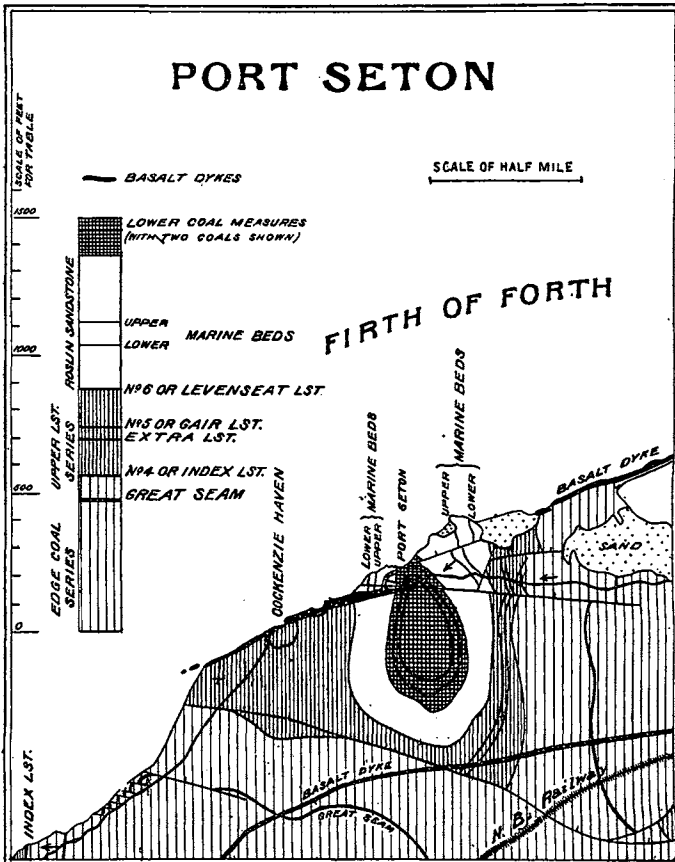
2. There is sufficient evidence at Port Seton to show that the Coal Measures there have near their base two good coal seams; so that if a basin of Coal Measures does exist off the East Lothian shore, there is reasonable ground for the belief that it may contain workable coals.

3. An opportunity has been afforded of measuring the thickness of strata occurring between the Great Seam of the Edge Coal Group and the lowest good coal of the Coal Measures. This thickness is found to be about a thousand feet at Port Seton, which compares very favourably with that at Niddrie, which is about 1900 feet. The Great Seam is now being worked under the sea west of Port Seton, so that it will be an easy matter to determine when a cross cut, driven from the great seam workings, is likely to reach workable coals in the Coal Measures. A glance

¹ "Geol. Surv. Mem. the Geol. of the Neighbourhood of Edinburgh," 1861.

² Milne (Home), "The Coal-Fields of the Lothians," 1839, p. 141.

at the Geological Survey maps, sheets 32 and 33, shows that it is highly probable that the Coal Measure seams do in reality follow the Great Seam as it bends round the Roman Camp anticline, and that they occupy the heart of the under sea portion of the East Lothian basin. In this connection the occurrence of the Little Port Seton outlier is significant.

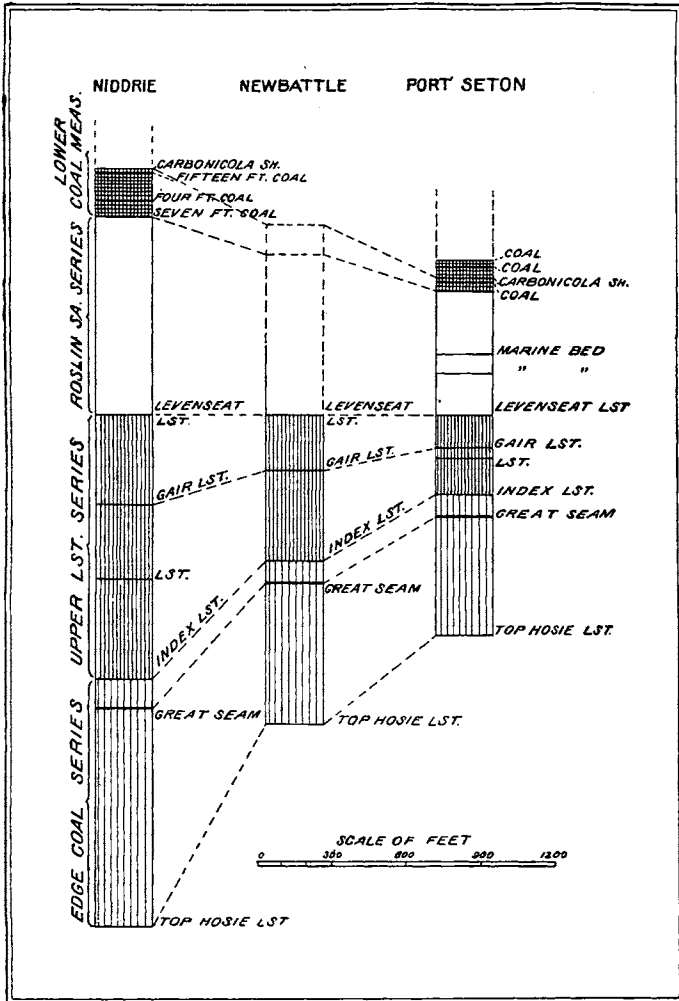


Another feature which appears on these maps, to which attention was first forcibly directed by Milne Home,¹ is the great predominance in the Lothian basins of faults with a downthrow to the north over those with a downthrow to the south. As a general rule, therefore, it may be expected that the faults met with off the Lothian shores will have the effect of deepening

¹ "The Coal-Fields of the Lothians," 1839, p. 20.

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and extending the areas covered by Coal Measures. It is premature to speak of a connection with Fife, but it must be observed that along the southern shore of that county faults with a southerly downthrow are predominant, which certainly



favours the idea of a large extension of the Coal Measures under the Firth of Forth.

EXPLANATION OF THE VERTICAL SECTIONS.

Mr Martin, manager of the Niddrie Collieries, has kindly

supplied the section here shown from the *Carbonicola* shale to the Seven Foot Coal Seam, and also the thickness of the Edge Coal Group as developed at Niddrie.

Mr Mackay, manager of the Newbattle Collieries, has kindly supplied the section of the Upper Limestone and Edge Coal Groups as developed at Newbattle.

The thicknesses of the Roslin Sandstone Group at Niddrie and of the Edge Coal Group at Port Seton have been taken from the Geological Survey Memoirs, while the remaining data have been furnished by actual measurements made at the surface.