

Sutural angle about  $95^{\circ}$ . Basal angle  $100^{\circ}$ . Greatest diameter  $\frac{3}{4}$  of an inch.

Found in limestone of the subcretaceous series at the village of Sarjento-mór, six miles north of Coimbra.

PLATE XIII. fig. 4 *a*. Exterior.

Fig. 4 *b*. Internal cast.

Fig. 4 *c*. Section.

#### EXPLANATION OF THE PLATES.

##### PLATE XII.

Fig. 1. *Nerinaea nobilis*.

Fig. 3. *Nerinaea Titan*.

Fig. 2. *Nerinaea turbinata*.

##### PLATE XIII.

Fig. 1. *Nerinaea annulata*.

Fig. 3. *Nerinaea Olisiponensis*.

Fig. 2. *Nerinaea Eschwegii*.

Fig. 4. *Nerinaea Conimbrica*.

#### 2. *Section of the LOWER COAL-MEASURES of the SYDNEY COAL-FIELD, in the ISLAND OF CAPE BRETON.* By RICHARD BROWN, Esq.

[Communicated by the Secretary.]

THE coal-measures of Nova Scotia Proper have been carefully examined and described by Sir Charles Lyell. Mr. Logan has also published a "Section of the Nova Scotia Coal-Measures, as developed at the Joggins in the Bay of Fundy," which appears to have attracted much attention; but the Cape Breton coal-fields, in every point of view the most important in British America, appear to have been almost wholly neglected by geologists. I have been for some years engaged in collecting materials for a description of the Sydney coal-field, but seeing no immediate prospect, amidst the engrossing duties of an arduous profession, of completing such an extensive work, I have concluded to submit to the Society a detailed section of the lower part of the productive coal-measures, as developed on the shores of Sydney Harbour, under the impression that it will furnish many valuable facts and data calculated in an eminent degree to elucidate the origin of the coal beds, and at the same time to assist geologists in instituting a comparison with the Bay of Fundy section, from which it will be found to differ in at least one very important feature, to which I shall refer more particularly in the sequel.

This coal formation, as has been already stated in vol. i. p. 23 of this Journal, consists of the following group of strata:—

4. The productive coal-measures.
3. A thick deposit of sandstone.
2. Limestones and shales, occasionally containing beds of gypsum.
1. A coarse conglomerate.

The lowest member of this group (1), the representative probably of the old red sandstone of Europe, crops out from beneath the carboniferous limestone at the head of the north-west branch of Sydney Harbour, where it consists of thick beds of conglomerate alternating

with red shale. The conglomerate is chiefly composed of fragments of red granite and quartz pebbles, cemented together in a base of ferruginous red clay. Its thickness has not been ascertained.

The next member of the group (2) consists of alternating beds of limestone, red and brown shales, and friable micaceous sandstones. No beds of gypsum are visible in this section; it is only in the neighbourhood of the protruded masses of granite and trap that gypsum is met with. The total thickness of this series is 820 feet. Fossils are rare and of few species; the most common are *Producta Lyelli*, *P. spinosa*, *P. Martini*, *P. Scotica*, *Spirifer glaber*; and a few undetermined scales of fishes, in one of the upper limestone beds. Some of the shales are finely laminated and rippled. *Stigmariæ*, apparently drifted, as no rootlets are attached to them, occur in a bed of arenaceous shale in the higher part of the section.

The sandstone deposit (3), which is analogous in position to the millstone grit of the English coal-fields, is 1800 feet in thickness. The lower beds are coarse and pebbly; the upper, fine-grained, and often flaggy, containing impressions of *Sigillariæ*, *Calamites*, and *Lepidodendra*. A few thin beds of grey shale are interstratified with the sandstones at wide intervals.

The productive coal-measures (4) cover an area of 250 square miles, but owing to several extensive dislocations it is impossible to ascertain their total thickness with any degree of accuracy; from the best information in my possession I conclude that it exceeds 10,000 feet. We have one continuous section on the north shore of Boulardrie Island 5400 feet in thickness, and in the middle portion of the field, several detached sections varying from 1000 to 2000 feet in thickness, whose exact relative positions have not yet been determined, although it is quite clear that they are higher up in the formation than the *highest* beds of the Boulardrie section. These points can only be ascertained by a careful survey of the whole district; I therefore propose, as I said before, to confine my observations at present to the small portion exhibited in the cliff on the north-west shore of Sydney Harbour.

The coal-measures commence at Stubbord's Point, where they repose conformably upon the millstone grit, and terminate at Cranberry Head on the sea-shore; the total length of the section being 5000 yards, and the thickness from actual measurements, taken at right angles to the plane of stratification, 1860 feet. The dip is north 60° E. at an angle of 7°.

In the following table the beds are placed in their natural order, No. 367 being the highest bed at Cranberry Head, and No. 1 the lowest, in contact with the millstone grit at Stubbord's Point.

*Section of the Coal-Measures on the north-west shore of Sydney Harbour, in the descending order.*

No.	ft.	in.
367. Slaty sandstone .....	10	0
366. Soft blue argillaceous shale .....	0	6
365. Argillaceous shale containing a few small nodules of iron-stone near the bottom (plants) .....	4	0
364. Argillaceous shale (plants) .....	2	0

No.		ft.	in.
363.	Coal .....	0	1
362.	Underclay (Stigmaria) .....	2	0
361.	Arenaceous shale (plants) .....	3	0
360.	Coal (Cranberry Head, top seam) .....	3	8
359.	Underclay (Stigmaria) .....	0	10
358.	Hard arenaceous shale (Stigmaria) .....	4	8
357.	Arenaceous shale (plants) .....	3	0
356.	Coal (not persistent) .....	0	0½
355.	Arenaceous shale (plants, erect trees and Stigmaria) .....	7	0
354.	Soft blue clay .....	0	2
	ft. in.		
353.	{ Coal..... 0 2 } { Soft clay..... 0 2 } (Cranberry Head, bottom seam).. { Coal..... 0 8 }	1	0
352.	Underclay (Stigmaria) .....	0	7
351.	Argillaceous shale with thin carbonaceous layers (Stigmaria) .....	0	10
350.	Hard arenaceous shale (Stigmaria) .....	2	6
349.	Strong slaty sandstone (ripple-marks) .....	2	8
348.	Slaty, waving sandstone.....	4	6
347.	Sandstone and argillaceous shale, mixed .....	2	0
346.	Argillaceous shale .....	0	6
345.	Arenaceous shale alternating with sandstones in layers of 2 to 12 inches thick (plants and erect trees).....	8	0
344.	Argillaceous shale (plants and erect trees) .....	11	0
343.	Alternating laminæ of shale and carbonaceous matter.....	5	6
342.	Argillaceous shale (ferruginous concretions) .....	7	0
341.	Arenaceous shale.....	2	0
340.	Arenaceous shale, passes into soft sandstone .....	4	0
339.	Mixed sandstone and shale .....	7	0
338.	Soft clay .....	0	2
337.	Purple argillaceous shale .....	1	6
336.	Argillaceous shale .....	1	0
335.	Purple argillaceous shale .....	1	4
334.	Greenish arenaceous shale .....	5	0
333.	Purple argillaceous shale .....	0	9
332.	Sandstone in thin laminæ .....	8	0
331.	Red argillaceous shale with thin green layers .....	8	6
330.	Arenaceous shale.....	7	0
329.	Red argillaceous shale.....	2	9
328.	Arenaceous shale.....	2	10
327.	Red argillaceous shale .....	1	4
326.	Greenish laminated sandstone .....	14	0
325.	Red argillaceous shale containing 6 inches of sandstone...	1	9
324.	Slaty sandstone .....	8	0
323.	Brown argillaceous shale .....	0	8
322.	Arenaceous shale with four layers of red argillaceous shale at intervals of 5 feet.....	25	8
321.	Slaty sandstone with two thin layers of red shale .....	9	7
320.	Intermingled brown, grey, and red arenaceous shales.....	9	0
319.	Red argillaceous shale .....	9	0
318.	Arenaceous shale.....	3	0
317.	Sandstone .....	10	0
316.	Alternating layers of shale and sandstone 1 to 4 inches each	3	0
315.	Sandstone .....	6	0
314.	Ferruginous arenaceous shale.....	9	4
313.	Argillaceous shale containing thin carbonaceous layers ...	0	9
312.	Arenaceous shale.....	4	8
311.	Soft crumbling sandstone .....	2	0
310.	Strong sandstone (plants) .....	13	0
309.	Argillaceous shale .....	1	0
308.	Mixed argillaceous shale and impure coal.....	0	6

No.		ft.	in.
307.	Underclay (Stigmaria) .....	2	0
306.	Mixed argillaceous shale and coal .....	1	0
305.	Underclay (Stigmaria) .....	6	0
304.	Argillaceous shale (plants) .....	2	0
303.	Argillaceous shale containing small nodules of ironstone (erect trees) .....	3	0
302.	Soft argillaceous shale .....	2	6
		ft.	in.
	{ Coal..... 0 2 }		
301.	{ Soft shale ..... 0 8 }	1	1
	{ Coal..... 0 3 }		
300.	Underclay (Stigmaria) .....	1	8
299.	Sandstone (erect Calamites) .....	7	10
298.	Argillaceous shale (plants) .....	4	2
297.	Mixed layers, argillaceous and carbonaceous shale .....	0	7
296.	Argillaceous shale containing ironstone nodules (plants)...	3	0
295.	Coal (Lloyd's Cove seam) .....	5	0
294.	Underclay (Stigmaria) .....	3	4
293.	Laminated arenaceous shales .....	10	6
292.	Laminated sandstone .....	4	10
291.	Laminated arenaceous shales .....	5	6
290.	Strong slaty sandstone .....	2	4
289.	Greenish arenaceous shale .....	8	0
288.	Alternating slaty sandstones and arenaceous shales .....	19	0
287.	Unseen beds, horizontal distance 480 yards* .....	144	0
286.	Argillaceous shale .....	2	0
285.	Traces of a thin coal not exceeding .....	0	3
284.	Underclay (Stigmaria) .....	4	0
283.	Arenaceous shale .....	5	6
282.	Strong sandstone (plants) .....	41	0
		ft.	in.
	{ Coal..... 0 7 }		
281.	{ Soft shale ..... 0 5 }	1	4
	{ Coal..... 0 4 }		
280.	Soft clay .....	0	1
279.	Underclay (Stigmaria) .....	3	0
278.	Argillaceous shale .....	3	0
277.	Coal and carbonaceous shale .....	0	5
276.	Underclay (Stigmaria) .....	4	4
275.	Argillaceous shale containing nodules of ironstone .....	6	8
274.	Arenaceous shale (Stigmaria) .....	5	1
273.	Arenaceous shale, passes into sandstone .....	13	0
272.	Strong sandstone (plants) .....	31	0
271.	Argillaceous shale (plants) .....	4	2
270.	Argillaceous shale containing nodules of ironstone .....	9	4
269.	Coal and carbonaceous shale .....	0	9
268.	Underclay (Stigmaria) .....	4	10
267.	Strong sandstone (plants) .....	14	0
266.	Arenaceous and argillaceous shales (plants) .....	6	2
265.	Argillaceous shale .....	1	1
		ft.	in.
	{ Coal..... 1 4 }		
264.	{ Soft shale ..... 0 4 }	2	1
	{ Coal and carbonaceous shale... 0 5 }		

\* These beds are concealed by the beach gravel in the direct line of our section, but their outcrop can be distinctly traced on the sea-shore on the opposite side of the promontory of Cranberry Head: they consist of alternating shales and sandstones; the latter run out in long ledges, but the former have been washed away by the surf, and can only be seen at low-water of spring tides.

No.	ft.	in.
263. Underclay ( <i>Stigmaria</i> ) .....	0	5
262. Arenaceous shale containing nodules of ironstone .....	2	0
261. Coal .....	0	4
260. Underclay ( <i>Stigmaria</i> ) .....	5	0
259. Arenaceous shale.....	1	9
258. Argillaceous shale .....	7	2
257. Laminated arenaceous shale .....	3	6
256. Argillaceous shale .....	4	1
255. Coal .....	0	3
254. Underclay ( <i>Stigmaria</i> ) .....	1	11
253. Arenaceous shale.....	12	6
252. Reddish brown argillaceous shale .....	5	0
251. Grey and red argillaceous shale.....	12	0
250. Strong sandstone .....	10	4
249. Purple mottled argillaceous shale .....	10	8
248. Green arenaceous shale .....	11	0
247. Arenaceous shale.....	2	0
246. Argillaceous shale .....	11	3
245. Sandstone .....	47	0
244. Argillaceous shale .....	0	9
243. Black bituminous shale (fish-scales, coprolites, <i>Cypris</i> ) ...	0	2
242. Calcareo-bituminous shale (fish-scales, teeth, <i>Cypris</i> ) .....	0	2
241. Carbonaceous shale.....	0	1
240. Underclay ( <i>Stigmaria</i> ) .....	2	0
239. Laminated sandstone (plants) .....	0	11
238. Underclay ( <i>Stigmaria</i> ) .....	2	0
237. Laminated grey sandstone (ripple-marks) .....	0	6
236. Argillaceous shale containing nodules of ironstone .....	0	1
235. Crumbling arenaceous shale containing large masses of concretionary sandstone .....	3	2
234. Laminated grey sandstone ( <i>Fucoids</i> ).....	1	2
233. Arenaceous shale.....	0	1
232. Laminated grey sandstone ( <i>Fucoids</i> ).....	1	4
231. Mixed sandstone and crumbling arenaceous shale contain- ing large concretionary masses of sandstone .....	2	4
230. Arenaceous shale.....	2	6
229. Slaty sandstone .....	1	2
228. Arenaceous shale.....	7	0
227. Black bituminous shale (fish-scales, teeth, coprolites and exuviae of <i>Cypris</i> ) .....	1	6
226. Soft argillaceous shale .....	0	2
225. Bituminous shale (fish-scales, coprolites, <i>Cypris</i> and <i>Mo-</i> <i>diola</i> ).....	1	6
224. Green arenaceous shale .....	1	7
223. Mixed sandstone and shale .....	1	6
222. Argillaceous shale .....	0	2
221. Arenaceous shale containing a few nodules of ironstone...	4	4
220. Strong sandstone.....	1	0
219. Argillaceous shale .....	2	10
218. Coal .....	0	4
217. Underclay ( <i>Stigmaria</i> ).....	4	0
216. Argillaceous shale .....	5	10
215. Arenaceous shale.....	4	8
214. Red argillaceous shale, replaced by sandstone higher up in the cliff ( <i>Fucoids</i> and rain-drops in sandstone) .....	5	0
213. Green arenaceous shale .....	8	2
212. Red argillaceous shale .....	1	6
211. Arenaceous shale ( <i>Fucoids</i> , ripple-marks) .....	7	2
210. Strong sandstone .....	7	8
209. Argillaceous shale .....	1	0

No.	ft.	in.
208. Waving alternating sandstones and arenaceous shales.....	12	0
207. Strong sandstone .....	21	0
206. Argillaceous shale .....	0	10
205. Arenaceous shale.....	11	4
204. Laminated sandstone .....	12	8
203. Arenaceous shale (plants) .....	6	2
202. Hard band of carbonaceous shale (Modiola).....	0	1½
201. Argillaceous shale .....	6	0
200. Bluish bituminous shale (Cypris, Modiola, plants) .....	6	6
199. Black bituminous shale (Cypris, Modiola, fish-scales, teeth and spines, coprolites) .....	0	7
198. Soft bluish-white clay.....	0	1
197. Laminated slightly bituminous shale (Modiola) .....	2	7
196. Slaty sandstone (plants, a bivalve shell) .....	0	3
195. Arenaceous shale.....	2	0
194. Argillaceous shale .....	2	9
193. Carbonaceous shale.....	0	2
192. Argillaceous shale .....	1	9
191. Mixed sandstones and arenaceous shales .....	19	0
190. Strong sandstone.....	24	0
189. Argillaceous shale (erect trees, plants, Stigmara), varies in thickness from 2 to 6 feet .....	4	0
188. Coal (the main coal seam) .....	6	0
187. Underclay (Stigmara) .....	8	0
186. Argillaceous shale .....	1	3
185. Arenaceous shale (erect trees, plants, Stigmara) .....	5	0
184. Soft blue clay .....	0	0½
183. Arenaceous shale (erect trees, plants, Stigmara) .....	4	0
182. Argillaceous shale mixed with coal .....	0	3
181. Underclay (Stigmara) .....	3	2
180. Carbonaceous matter .....	0	0½
179. Underclay (Stigmara) .....	2	4
178. Strong sandstone .....	8	0
177. Arenaceous shale.....	2	2
176. Argillaceous shale (plants).....	1	10
175. Arenaceous shale (erect trees) .....	4	0
174. Argillaceous shale .....	2	7
173. Argillaceous shale containing layers of coal .....	0	5
172. Coal (Calamites in this seam) .....	0	9
171. Underclay (Stigmara) .....	1	0
170. Arenaceous shale (plants).....	6	3
169. Argillaceous shale containing layers of coal .....	0	2
168. Underclay (Stigmara) .....	4	8
167. Coal.....	0	4
166. Underclay (Stigmara) .....	2	3
165. Soft blue clay .....	0	2
164. Argillaceous shale .....	8	11
163. Sandstone (erect trees) .....	7	0
162. Argillaceous shale .....	1	3
161. Coal mixed with argillaceous shale .....	0	3
160. Underclay (Stigmara) .....	1	2
159. Sandstone .....	4	10
158. Arenaceous shale containing concretions of sandstone ....	6	1
157. Arenaceous shale.....	4	9
156. Coarse sparry limestone (fish-scales, teeth, spines, fins, bones, and coprolites) .....	0	7
155. Hard nodular arenaceous shale .....	1	0
154. Limestone (scales, teeth, &c. of fishes).....	0	2
153. Argillaceous shale .....	0	3
152. Limestone (scales, teeth, &c. of fishes).....	0	4

No.		ft.	in.
151.	Green arenaceous shale .....	1	2
150.	Red argillaceous shale with mottled green layers.....	8	4
149.	Mixed red and grey argillaceous shales.....	3	0
148.	Coarse brown pebbly sandstone.....	0	7
147.	Red argillaceous shale.....	0	4
146.	Coarse brown pebbly sandstone.....	0	3
145.	Brown argillaceous shale .....	0	2
144.	Mixed sandstone and shale.....	0	6
143.	Strong brown conglomerate .....	0	8
142.	Mixed red and grey argillaceous shale, green mottles.....	13	2
141.	Green laminated sandstone.....	3	11
140.	Mixed argillaceous and bituminous shales .....	0	2
139.	Black slaty limestone.....	0	2
138.	Coarse grey limestone (fish-scales, coprolites) .....	0	7
137.	Brown and green mottled argillaceous shales .....	6	0
136.	Strong green sandstone .....	2	11
135.	Red argillaceous shale.....	3	0
134.	Arenaceous shale.....	1	10
133.	Argillaceous shale .....	2	0
132.	Deep red argillaceous shale .....	10	3
131.	Arenaceous shale.....	14	0
130.	Sandstone .....	9	0
129.	Argillaceous shale, thickness varies from 1 to 12 inches ...	0	6
128.	Sandstone (plants) .....	8	6
127.	Argillaceous shale (plants).....	0	11
in.			
126.	{ Coal .....	2	{ (Quarry seam).....
	{ Carbonaceous shale... 1	1	
	{ Coal .....	3	
	{ Carbonaceous shale... 2	2	
	{ Coal .....	3	
125.	Underclay (Stigmara) .....	3	0
124.	Argillaceous shale, a layer of ironstone of 1 in., 5 ft. from top	8	8
123.	Red and grey mottled argillaceous shale .....	26	0
122.	Arenaceous shale.....	9	2
121.	Finely laminated arenaceous shale.....	3	6
120.	Ironstone .....	0	1
119.	Arenaceous shales (Fucoids, plants, erect trees) .....	9	0
118.	Grey and red mottled arenaceous shale.....	13	3
117.	Argillaceous shale .....	3	9
116.	Carbonaceous shale.....	0	4
115.	Coal .....	0	4
114.	Underclay (Stigmara) .....	5	6
113.	Alternating layers of sandstone and arenaceous shales containing a few thin layers of ironstone.....	11	9
112.	Alternating sandstones and shales (plants) .....	12	0
111.	Argillaceous shale containing ironstone nodules .....	3	9
110.	Laminated sandstone .....	10	4
109.	Arenaceous shale (plants) .....	2	8
in.			
108.	{ Coal.....	5	{ (Cypris, Spirorbis in shale) } 0
	{ Calcareo-carbonaceous shale... 2	2	
	{ Coal.....	1	
107.	Underclay (Stigmara) .....	4	0
106.	Alternating sandstones and arenaceous shales .....	8	2
105.	Strong waving sandstone .....	10	0
104.	Argillaceous shale .....	1	2
103.	Argillaceous and carbonaceous shales .....	0	6
102.	Bituminous shale (plants, Cypris, Spirorbis, Modiola).....	3	0
101.	Coal .....	1	3

No.	ft.	in.
100. Underclay (Stigmaria) .....	3	1
99. Strong sandstone.....	18	0
98. Red, brown and grey argillaceous shales .....	32	0
97. Green sandstone .....	1	4
96. Argillaceous shale containing ironstone nodules .....	2	0
95. Laminated sandstone .....	3	3
94. Red argillaceous shale.....	2	10
93. Soft white clay .....	0	2
92. Pure white limestone ( <i>Microconchus carbonarius</i> ) .....	0	2
91. Greenish arenaceous shale .....	4	2
90. Argillaceous shale .....	0	10
89. Arenaceous shale.....	8	6
88. Slaty micaceous sandstones with layers of shale (plants, erect Calamites) .....	10	6
87. Arenaceous shale.....	4	0
86. Argillaceous shale .....	3	6
85. Arenaceous shale (erect trees, Stigmaria).....	5	6
84. Laminated carbonaceous shale .....	0	6
83. Underclay (Stigmaria) .....	0	8
82. Alternating layers of bituminous and arenaceous shale with thin plies of coal .....	5	9
81. Argillaceous and arenaceous shale containing layers of sandstone (Fucoids in sandstone, Stigmaria in shale) ...	7	0
80. Arenaceous and bituminous shale in layers of about 1 inch thick ( <i>Modiola</i> , <i>Cypris</i> ) .....	3	9
79. Bituminous shale ( <i>Modiola</i> , <i>Cypris</i> , fish-scales, teeth and spines, comminuted shells) .....	2	10
78. Coal (Indian Cove seam) .....	4	8
77. Underclay (Stigmaria) .....	2	3
76. Argillaceous and arenaceous shales containing a few no- dules of ironstone .....	15	9
75. Red and brown argillaceous shales .....	11	0
74. Arenaceous shale.....	6	6
73. Argillaceous shale .....	4	0
72. Arenaceous shale.....	5	3
71. Argillaceous shale .....	3	3
70. Sandstone containing nodules of ironstone .....	4	0
69. Arenaceous shale .....	3	3
68. Bituminous shale (comminuted shells).....	1	5
67. Bituminous limestone, clay parting in the middle .....	1	3
66. Arenaceous shale containing a layer of ironstone 1 inch ...	1	0
65. Argillaceous shale with carbonaceous layers.....	0	6
64. Argillaceous shale (plants).....	2	4
63. Coal .....	0	11
62. Underclay (Stigmaria, plants) .....	3	1
61. Arenaceous shale containing ironstone nodules (plants) ...	16	0
60. Argillaceous shale containing ironstone nodules (plants) ..	2	10
59. Coal.....	1	4
58. Underclay (Stigmaria) .....	5	10
57. Sandstone (plants) .....	13	0
56. Argillaceous shale (Stigmaria) .....	2	0
55. Coal.....	0	7
54. Underclay (Stigmaria, plants) .....	8	11
53. Coal.....	0	2
52. Underclay (Stigmaria and nodules of ironstone, erect trees)	4	8
51. Argillaceous shale (erect trees) .....	7	10
50. Coal .....	0	2
49. Underclay (Stigmaria) .....	6	0
48. Arenaceous shale .....	3	0
47. Mottled brown and green arenaceous shale .....	4	4

No.		ft.	in.
46.	Deep red argillaceous shale, mottled green .....	19	0
45.	Arenaceous shale .....	5	2
44.	Sandstone .....	4	10
43.	Alternating layers of sandstone and arenaceous shale .....	4	2
42.	Laminated sandstone .....	8	8
41.	Strong sandstone .....	8	4
40.	Arenaceous shale containing nodules of ironstone .....	6	8
39.	Argillaceous shale .....	2	11
38.	Bituminous shale .....	1	8
in.			
37.	Coal .....	1	
	Argillaceous shale .....	3	
	Coal .....	2	
	Argillaceous shale .....	2	
	Coal .....	2	
		0	10
36.	Underclay (Stigmara and nodules of ironstone) .....	1	0
35.	Coal .....	0	0 $\frac{1}{2}$
34.	Underclay (Stigmara) .....	0	8
33.	Soft blue clay .....	0	2
ft. in.			
32.	Coal .....	1	2
	Carbonaceous shale...	0	2
	Soft blue clay .....	0	2
	Coal .....	1	3
	Carbonaceous shale...	0	3
	Coal .....	0	2
	(Stony seam) .....	3	2
31.	Underclay (Stigmara) .....	1	0
30.	Carbonaceous shale .....	0	3
29.	Calcareous shale (fish-scales and coprolites) .....	0	2
28.	Soft argillaceous shale with a few thin layers of carbonaceous matter .....	0	6
in.			
27.	Coal .....	2	
	Argillaceous shale ...	1	
	Coal .....	1	
	Carbonaceous shale...	6	
	Coal .....	2	
	(Shelly seam) .....	1	0
26.	Bluish black limestone (fish-scales, coprolites, Cypris) .....	0	6
25.	Hard arenaceous shale .....	7	0
24.	Laminated waving sandstone .....	7	8
23.	Argillaceous shale .....	3	6
22.	Greenish grey argillaceous shale .....	23	6
21.	Sandstone (Stigmara, Fucoids, ironstone nodules) .....	16	0
20.	Argillaceous shale (plants) .....	0	9
19.	Sandstone (plants) .....	6	3
18.	Coal .....	1	0
17.	Underclay (Stigmara) .....	1	9
16.	Argillaceous shale with some carbonaceous layers .....	1	0
15.	Coal .....	0	1
14.	Underclay (Stigmara) .....	3	4
13.	Argillaceous shale .....	3	0
12.	Coal .....	0	0 $\frac{1}{2}$
11.	Underclay (Stigmara) .....	5	4
10.	Arenaceous shale .....	2	8
9.	Argillaceous shale .....	14	2
8.	Coal .....	0	0 $\frac{1}{2}$
7.	Underclay (Stigmara) .....	4	10
6.	Argillaceous shale, mere traces of coal at bottom .....	9	0
5.	Underclay (Stigmara) .....	3	0
4.	Laminated arenaceous shale .....	4	10

No.	ft.	in.
3. Laminated sandstone .....	5	4
2. Laminated arenaceous shale .....	3	0
1. Laminated sandstone .....	11	0

The highest bed of the millstone grit, a flaggy sandstone.

Total thickness of coal-measures... 1860 0

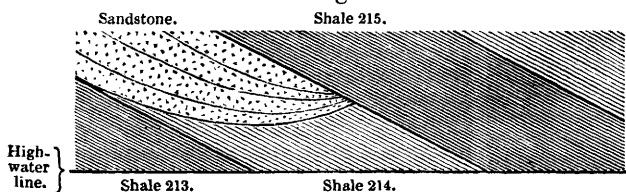
*Analysis of the preceding Section.*

	ft.	in.
Arenaceous and argillaceous shales ...	1127	3
Underclays .....	99	6
Sandstones .....	562	0
Coal.....	37	0
Bituminous shales .....	26	5
Carbonaceous shales .....	3	3
Limestones .....	3	11
Conglomerate .....	0	8

1860 0

From this analysis it appears that the argillaceous and arenaceous shales occupy about two-thirds of the whole section; they are generally of a grey or bluish grey colour, but occasionally red, purple, or brown, as specified in the section. Their composition is variable, passing from soft unctuous clays, through every conceivable grade, into arenaceous beds so highly charged with siliceous matter, as to be with difficulty distinguished from fine-grained sandstones. They are generally laminated, but there are many beds, some of great thickness, which present no traces of lamination; these disintegrate rapidly when exposed to the air, and might more properly perhaps be designated marls. Viewed at some distance from the water the parallelism and persistence of the shale beds appear to be perfect; it is only by a close examination that we occasionally discover a bed of shale replaced by sandstone, as in the annexed cut, where the bed of red

Fig. 1.

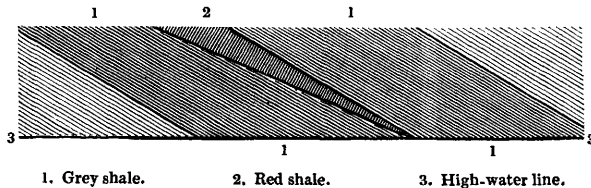


shale, No. 214, terminates at the height of eight feet above high-water line, and is replaced by hard laminated sandstone, which overlaps the edge of the shale. The underside of the sandstone, in contact with the subjacent shale No. 213, presents markings of fucoids, which cannot be observed upon the underside of the red shale, showing, that in the interval between the deposition of the red shale and the sandstone unconformably upon its edges, a layer of sea-weeds had been spread over the uncovered portion of the surface of the shale No. 213.

The red shales are very irregular in thickness; thin beds of twelve or fifteen inches sometimes increase to three or four feet in depth

within a space of thirty feet. In some instances a bed of shale of a deep red colour at the outcrop passes gradually through all the shades of red, purple, brown and grey, until, at the foot of the cliff, it cannot be distinguished from common grey shale; and in others, as represented in the cut, a bed three feet thick at the outcrop thins out altogether before it reaches high-water mark.

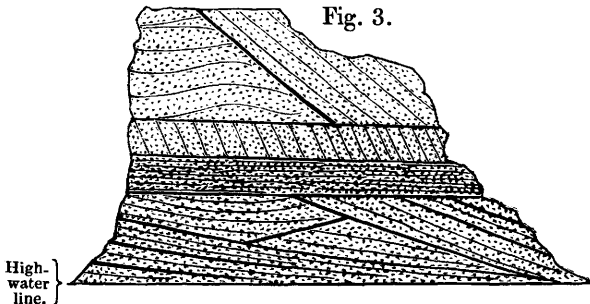
Fig. 2.



Argillaceous ironstone is found in small detached nodules, rarely in continuous layers, in many of the shales, but never in sufficient quantity for working profitably.

The total thickness of the sandstone beds is 562 feet; they are of a greyish white colour, sometimes tinged brown or green. The thick beds are generally coarse; those numbered 272, 282 and 310 contain rounded pebbles of white quartz of all sizes up to one inch in diameter. False stratification is very common in the thick beds; one of the most remarkable examples is shown in fig. 3, which is a

Fig. 3.



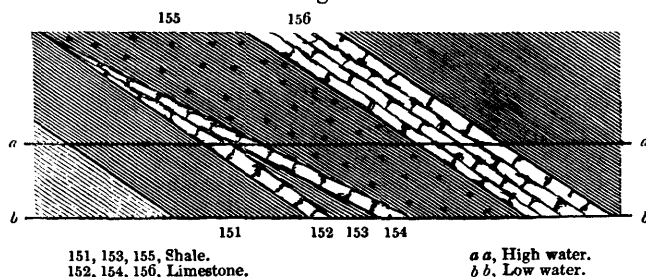
sketch of an outlying mass separated from bed No. 272; its height is 9 feet. Many of the sandstones are micaceous and flaggy; some (Nos. 42, 292, 293, 294 and 332) so finely laminated and regular in their bedding, that from twenty to thirty distinct layers can be counted in one inch of depth.

The bituminous shales are not numerous, their united thickness being only 26 feet; they are of a black colour, and all more or less inflammable; those numbered 225 and 227 may be designated impure Cannel coals, being very compact, possessing a conchoidal fracture, and burning for a short time with a bright yellow flame. The remainder are soft and laminated. They are all highly fossiliferous, as will be noticed in the sequel.

The carbonaceous shales, composed of argillaceous mud charged with decaying vegetable matter, occur interstratified with thin layers of coal.

The beds of limestone are rare, and with the exception of the two-inch layer, No. 92, very coarse and impure, being charged with carbon, bitumen, or siliceous matter. The persistence and uniform thickness of all the limestone beds, except those numbered 152 and 154, are very remarkable. The two last are separated at low-water mark by a three-inch layer of shale; at high-water mark they merge into one bed, and at eight feet higher up thin out, as represented in the annexed cut.

Fig. 4.



Only one bed of conglomerate (No. 143) occurs in this section; it is composed of small quartz and granite pebbles united in a base of brown ferruginous clay.

The sandstones, shales and limestones are traversed by two sets of joints at right angles to the plane of stratification, the course of one set being S. 80° E., and the other S. 5° W., which consequently divide the beds vertically into blocks of a rectangular form, as nearly as may be. These joints are of great service in quarrying the sandstone beds for building purposes.

There are thirty-one seams of coal in this section, whose aggregate thickness is 37 feet; four only are of sufficient thickness to be worked profitably, viz.—

Nos.	ft.	in.
78. Indian Cove Seam . . . . .	4	8
188. Main Coal . . . . .	6	0
295. Lloyd's Cove Seam . . . . .	5	0
360. Cranberry Head Top Seam . . .	3	8

The relative positions of the several seams may be best understood by referring to the section. The coal is in every instance bituminous; the quality of that obtained from the four seams above-named is unexceptionable\*.

All the coal-seams save one (No. 27), which will shortly be noticed, and indeed almost every layer of carbonaceous shale, lie upon under-

\* About 80,000 tons of coal are raised annually from the Main Seam, of which 30,000 tons are consumed in Nova Scotia, the remainder being chiefly shipped to Newfoundland and the United States.

clays. The upper layers of the underclays immediately in contact with the coal are argillaceous, forming sometimes good fireclays : from six to twelve inches below the coal they contain variable proportions of siliceous matter, being in a few instances scarcely distinguishable from sandstones.

Stigmariae are found in all the underclays, in several of the shale roofs of the coal-seams, and in some beds of shale (Nos. 81, 238 and 274) which constitute neither floors nor roofs. In the first case they are very numerous, and of several species, although *S. ficoides* is the most common. In the second they are not so plentiful, occurring probably only in connexion with the erect trees, of which they are the roots. In the last case they are very rare, and where they are not united to erect trees, most probably have been drifted, carrying with them a portion of their long rootlets, of which there is one very decided example in another part of the Sydney coal-field\*.

It does not appear that the thickest underclays, containing the greatest number of Stigmariae, are overlaid by proportionably thick seams of coal ; the reverse is often the fact : for instance, the three lowest seams in our section (Nos. 8, 12 and 15), none of which exceed 1 inch, lie upon underclays 4 ft. 10 in., 5 ft. 4 in. and 3 ft. 4 in. in thickness, respectively, while on the other hand, the seams Nos. 78 and 295, the one 4 ft. 8 in. and the other 5 ft., rest upon underclays by no means rich in Stigmariae, only 2 ft. 3 in. and 3 ft. 4 in. in thickness. In the two latter cases, probably, the increase of Stigmariae was interrupted by a subsidence which produced the conditions required for the growth or accumulation of the vegetable mass from which the coal beds were formed. In the former instances, similar conditions having been obtained and the growth of the vegetable mass just commenced, a subsidence took place almost immediately, which at once put a stop to the increase of the material required to form coal. If the strata had been suffered to remain in a state of rest for a longer period, the bed of coal No. 8, which is only half an inch, might have attained a thickness equal or superior to any in the section.

As before mentioned, the seam of coal No. 27 forms an exception to the general rule ; it lies upon a coarse limestone 6 inches thick, which rests upon a hard arenaceous shale, not unlike some of the more sandy underclays ; but it neither crumbles on exposure to the weather, nor does it contain the slightest trace of a Stigmara or its rootlet. As the limestone contains Cyprides, with the scales and coprolites of fishes, which could only have been deposited in water apparently of a very moderate depth †, we must admit that the thin layers of coal

\* Whilst examining the cliffs about three years ago near the entrance of the Brasd'or lake, accompanied by Prof. Johnson of Philadelphia, we found a piece of Stigmara 6 inches long and 3 inches in diameter, with rootlets attached, in the middle of an upright fossil tree. This could only have been drifted : probably those found in the shales numbered 81, 238, &c. were drifted in the same way.

† The depth of the water could not have exceeded 3 feet, because at that height above the coal we find a soil (underclay) containing the roots (Stigmariae) of trees which once grew on its surface, unless we assume that the strata had been elevated after the deposition of the coal.

constituting this seam were formed from drifted vegetable matter, for we find layers of carbonaceous and argillaceous shale alternating with three layers of coal whose united thickness amounts only to one foot, which is precisely the arrangement likely to obtain from vegetable matter drifted down with mud into an estuary. If then a seam clearly formed from drifted materials assume this arrangement, it is evident that thick beds of pure coal perfectly free from clay, or mud mixed with vegetable matter, could never have been accumulated in the same manner.

I have marked all the beds in the section in which plants have been found, but it is very probable that they occur in many other beds and have been overlooked. The shales are the most prolific in plants, especially those which form the roofs of the coal-seams. It is a singular fact, that not even the trace of a fossil plant, nor any organic substance has been found in any of the red shales, although they have been carefully examined for that purpose. Wherever erect trees occur, ferns, *Asterophyllites*, *Sphenophylla*, and other delicate leaves, are found in the greatest abundance, from which I infer that they fell from growing trees and shrubs, having been covered up by successive layers of fine mud deposited at frequent intervals over a low, marshy district. In these localities single fronds of ferns are sometimes found covering a slab of shale two feet square, as sharp and distinct in their outline as if they had been gathered only yesterday from a recent fern and spread out with the greatest possible care, not a single leaflet being wanting or even doubled up. Some beds also seem to contain one species of plant only, all others being excluded; of this we have a striking example in the argillaceous shale No. 60; in the top of this bed, through a depth of three inches, we find *Asterophyllites foliosa* piled up layer above layer from the base of the cliff to the top of the bed, a distance of 200 feet, clearly proving that these plants grew on the spot.

Plants are not very common in the sandstones; those numbered 272, 282 and 310 are the only sandstones which contain any considerable quantity: they consist of fragments of *Sigillariæ*, *Lepidodendra*, and *Calamites* confusedly mixed together, and evidently drifted from a distance.

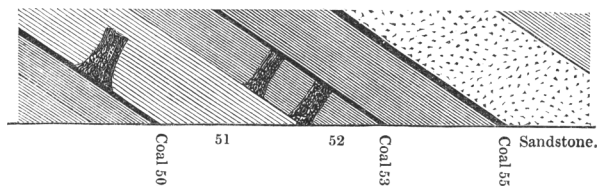
The impressions of *Fucoids* without any carbonaceous matter are found in several beds, as specified in the section; in every instance they occur on the undersides of hard arenaceous shales or sandstones in contact with soft shales beneath. They appear to have been long tubular stems, from one-tenth of an inch to one inch in diameter, and are accompanied by detached ovate and globular bodies very much like the capsules and vesicles of recent *Algæ*. Fine ripple-marked sandstones are generally found very near to the *Fucoids*, and in two instances impressions of rain-drops.

The most interesting fossils in our section are the numerous groups of erect trees situated at so many different levels, which I shall now briefly notice, purposing to send to the Society more detailed descriptions at a future time, having with that view taken an accurate drawing of almost every individual tree.

*a.* Starting from the base of the section, the first erect tree is met with in the bed of argillaceous shale No. 51, 222 feet above the millstone grit. It is a fluted *Sigillaria*, 15 inches in diameter and 3 feet high; the base spreads out over the two-inch coal No. 50, but no roots are visible. The interior of the stem is filled with argillaceous shale. See Fig. 5.

*b.* In the next superior bed of argillaceous underclay, two upright stems of *Sigillariæ* occur only 4 feet apart; one is 18 inches and the other 27 inches in diameter at the top, their height being 4 feet. The stems are fluted and covered with a bark of coal three-fourths of an inch thick. They enlarge considerably as they descend, but no roots are visible. We have here conclusive evidence that a slow and gentle subsidence of the coal-measures was in progress during their

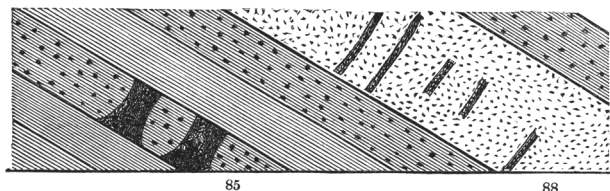
Fig. 5.



accumulation; the two-inch coal No. 50, at one period the surface on which the first tree grew, having subsided a depth of eight feet, the shallow water was filled up with mud until it reached the surface, on which the two trees in the underclay No. 52 flourished.

*c.* At the height of 147 feet above the last trees, and 21 above the Indian Cove Seam, two large stems of fluted *Sigillariæ* with a coally bark half an inch thick occur; their length is 5 feet and their dia-

Fig. 6.



meter at the top 24 inches, which increases rapidly as they descend, but no traces of roots can be seen, owing to the soft carbonaceous shale which underlies them having fallen away from beneath.

*d.* About eight feet higher in the section, several erect *Calamites*, from 4 to 8 feet in length and 3 to 5 inches in diameter, occur in the micaceous sandstone No. 88. They do not present any traces of roots.

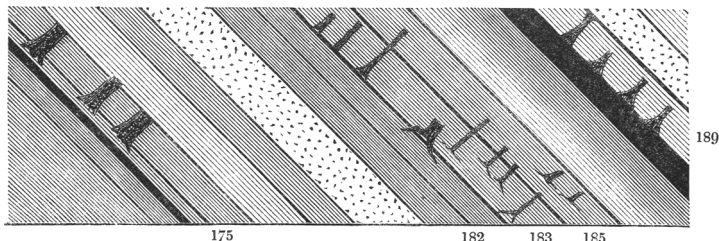
*e.* Erect *Calamites*, varying from 3 to 8 feet in height, and about 5 inches in diameter, are also met with in the bed of arenaceous shale No. 119, being 151 feet above the sandstone No. 88, last mentioned. No roots are observable.

*f.* The next erect trees are found 164 feet higher up, in the sandstone No. 163; here we have two large fluted *Sigillariæ*, 24 inches in diameter and 5 feet in height, standing only eight feet apart: they enlarge rapidly towards their bases, and were probably rooted on the surface of the three-inch coal No. 161, but being very near the high-water line the surf has washed out the soft, argillaceous shale No. 162 from under the stems, and obliterated all traces of roots.

We now arrive at a group of strata, the lowest only 28 feet above the preceding, exceedingly rich in upright trees, all standing in view together at six distinct levels within a vertical height of 52 feet.

*g.* The first in the series are three large trunks in the shale No. 175, apparently 30 inches in diameter; they are situated too high up in the cliff to be examined properly; they all bulge out as they descend,

Fig. 7.



and seem to terminate downwards in the argillaceous shale above the coal No. 172.

*h.* Some of the trees in the beds Nos. 183 and 185 have been already described in the Journal of the Society\*; but since that description was written, owing to the constant wasting of the cliffs, several new trees have been exposed, particularly a fine fluted *Sigillaria*, 18 inches in diameter (seen in fig. 7), with strong roots penetrating downwards at an angle of  $45^\circ$ , and piercing through the three-inch layer of mixed coal and shale No. 182.

*i* and *k.* In the arenaceous shale No. 183, several small *Sigillariæ* are found at two distinct levels, some being rooted about the middle of the bed and others near the top. They have *Stigmaria* roots with rootlets, which, as before mentioned, have already been described in this Journal†.

*l.* Two small *Sigillariæ* occur in bed No. 185: *Stigmaria* roots are seen near them, but not in actual contact.

*m.* The shale roof No. 189 of the Main Coal has furnished a great number of upright trees with long spreading roots and rootlets, which it is not necessary to enumerate here, three of the most interesting having been described at length in the Journal, viz. a *Lepidodendron*‡ with *Stigmaria*-like roots, and two curious specimens of *Sigillaria alternans*§. I may observe that *Sigillariæ* appear to be the most common, but I have never seen any larger than 14 inches in diameter.

\* Vol. ii. p. 393.

† *Ibid.*

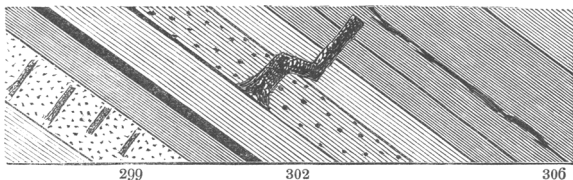
‡ Vol. iv. p. 46.

§ Vol. v. p. 354.

*n.* A long interval now follows without any erect trees, the next in order being *Calamites* without roots in the sandstone No. 299, which is 735 feet above the Main Coal No. 188.

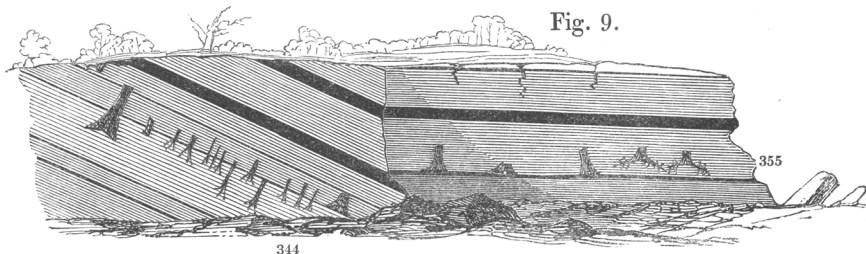
*o.* Six feet only above the sandstone last mentioned, a fine erect *Sigillaria* occurs, based upon the surface of the argillaceous shale No. 302, and extending ten feet upwards into the superincumbent beds. At the height of three feet from the base it is bent over nearly into a horizontal position, the length of the inclined portion

Fig. 8.



being two feet; it then resumes its upright position, which it maintains to the top, terminating under the mixed coal and shale No. 306. The diameter at the top is 15 inches, and at one foot from the base 24 inches. It is furrowed throughout the whole length, but leaf-scars are visible only in the upper portion. Two large roots proceed from the base, but no rootlets or resemblance to *Stigmaria* can be found.

Prostrate plants and *Stigmariæ* are found in some of the beds above the shale No. 302, as high up as the top of the sandstone No. 310; but above this sandstone not the trace of a plant of any description can be found until we arrive at the argillaceous shale No. 344, 217 feet above the last upright tree. This shale No. 344 is the commencement of a series of beds exceedingly rich in both prostrate plants and erect trees, which terminate only with the highest bed in our section at Cranberry Head. I have endeavoured to show the position of all the upright trees at one view in the annexed sketch (Fig. 9), the lower portion being visible in the south-eastern face of the cliff, and the



upper round the angle of the headland, where the coast-line runs nearly in the direction of the strike of the strata: this will explain why the beds dip so rapidly in one part, and appear nearly horizontal in the other part of the sketch.

*p.* Four feet and a half below the surface of the shale No. 344, there are a large *Lepidodendron* and several *Calamites*. The *Lepidodendron*, which is the highest tree in the cliff, as shown in the sketch, is 9 feet in height, its diameter at the top being 24, and at the base 36 inches. It is covered with a rough scaly bark of coal 1 inch thick. The trunk is filled up with alternating beds of shale and sandstone with several thin layers of ironstone. I could only trace one piece of root 2 feet in length, which externally was marked in the same scaly manner as the stem, being filled up with soft shale containing small egg-shaped nodules of ironstone. The *Calamites*, which do not exceed 2 inches in diameter, have long fibrous roots running nearly perpendicularly downwards.

*q.* I counted ten small upright *Calamites* and *Sigillariæ* in the next superior bed No. 345, based upon the surface of the shale No. 344, into which their long fibrous roots penetrated from two to three feet downwards. Two of these *Sigillariæ*? are about 8 inches in diameter; they are filled with soft friable shale, and have central columns or piths  $1\frac{1}{2}$  inch in diameter, composed of pure bright coal arranged in thin horizontal laminæ. There is also the stem of a fluted *Sigillaria* in the same bed of larger size near high-water mark, but only a small portion can yet be seen.

*r.* Twenty-three feet higher up, in the arenaceous shale No. 355, there are three large erect trees whose long *Stigmaria* roots spread over the flat surface of the Cranberry Head bottom seam. One is a *Lepidodendron*, the two others are *Sigillariæ*. They are all about 27 inches in diameter, but of different lengths.

*s.* In the same arenaceous shale No. 355, but four feet above the coal, there are two more trees of about the same size as the last, which are apparently *Lepidodendra*. Long rootlets run in every direction from their *Stigmaria*-like roots. These are the last upright trees in our section, making in all eighteen forests, each on a distinct level and consequently of different ages, within a vertical range of 1600 feet, the first being 220 feet above the millstone grit, and the last 40 feet below the highest bed at Cranberry Head.

The animal remains, as will be observed by reference to the section, are chiefly found in the bituminous shales and limestones: in these beds they are very plentiful, but apparently limited to few genera and species. I have only been able to recognize the following\*:—*Modiola* (2 sp.), *Spirorbis*, *Unio*, *Microconchus carbonarius*, *Cypris* (2 sp.), and the scales, teeth, &c. of *Holoptychius*, *Megalichthys*, *Palæoniscus*, *Amblypterus* and *Gyrolepis*, which are very abundant, together with vast numbers of coprolites. The *Unio* and *Microconchus* are found alone; the first in the slaty sandstone No. 196, and the latter in the thin limestone No. 92. The *Modiolæ* and

\* I made up separate parcels of the shells and ichthyolites, intending to send one to Mr. Conrad of Philadelphia, and the other to Prof. Agassiz of Cambridge, U.S., but by mistake the shells were sent to Prof. Agassiz and the ichthyolites to Mr. Conrad. This has since been remedied, and I hope soon to be favoured with the remarks of those eminent palæontologists on the Sydney fossils.

*Cyprides* are found with the remains of *Holoptychius* and *Palæoniscus* in the bituminous shales.

On comparing our section with that of the Bay of Fundy coal-measures, although the analogy is in many respects very striking, there is this remarkable difference, that, whilst we have the remains of some decidedly salt-water fish and fucoids at various levels in a section embracing a depth of 1860 feet only, "not a trace of any substance of a marine character" \* has been found in the Bay of Fundy section, through a vertical range of 14,570 feet.

Although the great mass of evidence afforded by this section is on the side of those geologists who contend that coal beds were formed from trees or plants which grew upon the spot where the coal now exists, yet we certainly have one distinct example of a thin seam (No. 27) formed from drifted materials deposited in very shallow water.

In conclusion, I may remark, that many interesting phænomena have necessarily been unnoticed in this brief sketch of the lower portion of the productive coal-measures of Sydney, which I shall endeavour to describe in a future communication.

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### 3. *On the Occurrence of Productive Iron Ore in the Eocene Formations of HAMPSHIRE.* By ALFRED TYLOR, Esq., F.G.S.

THE presence of large ferruginous *Septaria*, containing carbonized wood, principally in small fragments, was noticed in the lower part of the Barton clays, between Barton Cliff and Muddiford, by Mr. Prestwich and myself about two years ago. At that time we did not proceed west of Christchurch; and I was unable to accompany Mr. Prestwich in his more recent visit to the cliffs between Christchurch and Poole, when Mr. Prestwich also noticed the very ferruginous condition of these large tabular *Septaria*†.

Having lately had an opportunity of paying a visit to Hengistbury Head, I was much interested in finding that these blocks have been found to contain so large a per-centage of iron as to be available for economic purposes. As productive iron ores have not previously been known to occur in the English tertiaries, I have thought the fact of sufficient interest to be laid before the Geological Society.

Mr. Holloway, of Christchurch, who has undertaken these works, informs me that the occurrence of large masses containing iron in these cliffs appears to have been discovered in the reign of Charles II., during a survey of the adjoining harbour of Christchurch. The king was recommended to establish iron-works here for the purpose of founding cannon; the ore was to be obtained from the shore, and the charcoal from the neighbouring New Forest; this scheme, however, was not carried out. Within the last three years Mr. Holloway sent specimens to South Wales for examination. The first impression of the ironmasters was unfavourable; for although, from the

\* President's Address, Quart. Journ. Geol. Soc. vol. ii. p. 179.

† Quarterly Journal of the Geological Society, vol. v. p. 45.