ART. VII —THE CARBONIFEROUS OF CAPE BRETON.—BY EDWIN GILPIN, JR., *A. M., F. G S., F. R. S. C., Inspector of Mines.*

(PART I.)

THIS formation is conspicuously developed in Cape Breton, and, apart from the fisheries, to its presence is due what measure of prosperity the Island enjoys. Its soils in the limestone districts are very fertile, and the poverty of the clays overlying the coal measures and the Millstone Grit is counterbalanced by the stores of coal which have been extensively worked. Surrounding great part of the Western and Southern shores, and fringing the Bras D'Or Lake, it is accessible to the farmer and the miner, and ready outlets are afforded for its productions.

Sir William Dawson, in his Acadian Geology, divides the formation, as met in the Lower Provinces, into five subdivisions:

I. Upper Coal Formation.
II. Productive Coal Measures.
III. Millstone Grit.
IV. Marine Limestone Series.
V. Lower Coal Measures.

Some districts do not present all these sub-divisions, the lowest one being frequently wanting or sparingly represented; and in many cases no division line can be drawn between the Millstone Grit in its passage upward into the Productive Measures or downward into the Marine Limestones. The most instructive section is that presented in Cumberland County, where all the subdivisions can be recognised in passing from Hillsboro, in New Brunswick, to the Joggins, in Cumberland Co. In Cape Breton this gradual passage of the subdivisions is strongly marked in several cases.

Here the Carboniferous measures may be said, roughly speaking, to occupy three principal districts. The Western District, with the exposures of Bay St. George and Port *à* Port, in Newfoundland, forms the Eastern rim of the great Carboniferous

basin of the Gulf of St. Lawrence. Its former immense extent is marked by the Bonaventure series of Gaspe and the Carboniferous Limestone, etc., of the Magdalen Islands, north of Prince Edward Island, and of Pictou and Antigonish Counties. Beginning at Cheticamp, this division extends along the North-Western shore of the Island, gradually widening, until at Lake Ainslie it is about fifteen miles wide; it then narrows, until at the Northern entrance to the Strait of Canso it appears connected with the Carboniferous of Nova Scotia proper.

Another district, beginning at the southern end of the Strait of Canso, spreads out in two arms, one running between Lennox Passage and the Sporting Mountains, passes to the North of St. Peter's and terminates at Cape George; the other, continuing up the River Inhabitants, crosses into the water-shed of the River Dennys, and passing along both sides of St. Patrick's Channel, finally terminates at St. Anne's Harbour. Along its northern edge, from Whyhogomah to St. Anne's, it projects in long narrow tongues among the crystalline rocks.

This district connects through Boularderie Island with the third or eastern district, which extends from Cape Dauphin through Sydney to the Mira River. Connecting with this district is a long irregular band of the same measures, extending along the Salmon and Grand Rivers.

In addition to these principal divisions there are numerous small isolated patches of carboniferous measures along the south-eastern shore of the Island, which, taken in connection with the exposures of Guysboro, St. Margaret's Bay and Chester, in Nova Scotia proper, would show that once the Atlantic front of the Province was covered by the lower measures at least of the Carboniferous system. The pre-cambrian rocks of the Bras d'Or Lake are generally flanked by narrow fringes of the Marine Limestone and Lower Coal Measures.

At St. Lawrence Bay, in the extreme North of the Island, is a considerable area of Lower Carboniferous Measures, as is also the case at Aspy and Ingonish Bays. Between these points the pre-cambrian felsites and syenites either come boldly to the sea or have a narrow fringe of these measures.

The general arrangement of the Carboniferous of the Island

is that of valleys between the ridges of the older rocks, and their softer strata have been worn into broad river valleys and rolling hills of inconsiderable altitude. When they rest on the flanks of the pre-carboniferous hills they present charming and picturesque gorges worn by the brooks which are long nourished by the accumulated winter snows.

The Eastern or Sydney district presents unusually fine natural sections, and has received much attention owing to the extensive mining operations which have been carried on during the past century. Its structure has been carefully worked out, and as it is a typically well developed carboniferous district a brief description of the various subdivisions will serve in great measure as a guide to these in other parts of the island.

In the Sydney or Eastern district the following subdivisions are recognised:—

Productive Coal Measures.

Millstone Grit.

Marine Limestone Formation.

Lower or Basal Coal Measures.

The upper subdivision, that of the upper Coal Measures, being absent, unless represented by the beds at Low Point, overlying the Carr Seam.

The shore from Cape Dauphin to Mira Bay is occupied by the productive measures, which are folded in three undulations having a general East and West course. As the measures are interrupted at the anticlinals the exact identification of the seams has not been made out.

The following section, taken in the Lingan district, will serve to show the thickness and relative positions of the best known seams:—

Seam.	Strata and Coal. ft.	in.
Seam A	3	..
"	306	..
Carr	6	5
"	190	..
Barrasois, Hub or Block House	12	1
"	379	3

Seam.	Strata and Coal ft.	in.
Harbor, Victoria or Sydney	8	..
" "	234	..
Seam D	3	..
"	78	..
North Head	4	..
"	75	..
McAuley, Phelan, or Lingan.....	8	..
" "	95	..
Ross, or Emery	4	6
"	340	..
Gardener.....	4	9

A somewhat different arrangement is suggested by Mr. P. Neville, Deputy Inspector of Mines, who has had much experience in tracing the seams of this district, and he correlates those of the districts South of Lingan as follows:—

Cow Bay.	Schooner Pond.	Big Glace Bay.	Little G. Bay.	Bridgeport.
Block House Seam, 9 ft.	.....	.....	Hub Seam, 9 ft. 10 in.	.....
Gowrie Seam, 5 ft.	.....	.....	Harbor Seam, 5 ft. 6 in.	International Seam, 5 ft. 6 in.
Big Seam, 8 ft.	.....	Ontario Seam, 8 ft. 6 in.	Caledonia Seam, 9 ft. 6 in.	Reserve Seam, 9 ft. 6 in.
Seam, 5 ft.	McPhail Ross Seam, 5 ft. 6 in.	Seam, 5 ft. 10 in.	Seam, 5 ft. 8 in.	Emery Seam, 5 ft.
Long Beach Seam, 3.2 ft.	Seam, 3 ft. 4 in.	Seam, 3 ft.	.....	Lorway or Gardner Seam, 4 ft.

The coal field is remarkably free from disturbances, etc., and Professor Lesley, in a report, dwells strongly on this point.

Nearly all the seams lie at easy angles, yield little water, and owing to the generally firm character of the roof, they can be mined with unusual cheapness and safety. So strongly marked is the impermeable nature of the strata, that at a moderate depth the submarine workings are perfectly dry.

Shales, arenaceous and argillaceous, with red and green marls, make up about one-half the total thickness of this section. The shales pass into sandstones and frequently carry ironstone

nodules, and the more argillaceous beds are crowded with fossils, chiefly ferns. Many trunks of erect and prostrate sigillariæ, with roots attached and grown into the coal, are seen in these shales; they have been observed nearly five feet in thickness, but those which have come under my notice have not usually exceeded two feet in diameter. The term marl is applied here to beds not necessarily calcareous, but to red and green shales which crumble readily on exposure. Sandstone beds, gray and white in colour, and often fifty feet in thickness, are met at frequent intervals, and nearly always occur a few feet above a coal bed. Many of the sandstone beds are calcareous, and are then flaggy micaceous, and sometimes ripple-marked.

Almost invariably underclays highly charged with stigmariæ roots and rootlets, and from a few inches to eight feet in thickness, form the floor of the Coal seams. In a few instances Coal seams rest directly on thin beds of fossiliferous limestone, and in one instance the floor is sandstone. Beds of black bituminous limestone, from a few inches to three feet in thickness, have been observed about the middle of the section. The physical characters of the coal beds will be referred to in connection with the analyses to be given in the appendix, and it may be remarked here that they resemble in many points those of the Durham district in England.

The division line between the Millstone Grit and the Productive Measures is an arbitrary one, and, as marked on the Geological Survey maps, is considered by many as encroaching on measures which may fairly, so far as their coal contents are concerned, be considered productive. This opinion is strengthened by the fact that a large collection of plants from the Cossit pits, a short distance east of Sydney town, at a horizon considered low down in the Millstone Grit, were reported on by Sir William Dawson as distinctly marking the productive horizon. Further investigations may show that the distinctions at present laid down as separating the upper part of the Millstone Grit from the Coal Measures are due more to local conditions of deposition, which have modified the Coal Seams and their encasing strata, than to any change of the distinctive features of the preceding horizon.

As compared with the productive measures, these strata show a much larger percentage of sandstones, frequently coarse and sometimes conglomeritic. There are fewer argillaceous layers and much false bedding. Near the old syenitic and felsitic rocks the prevailing color is red; further away, where the material has been derived from the preceding Carboniferous horizons, gray shades are met. The formation is also distinguished from the Productive and the Marine Limestone series by the absence of calcareous matter. Numerous coal seams are met, some of which are persistent over long distances and of workable dimensions. Others are not at present considered of value in the presence of the large seams now worked, but will prove in the future an important source of coal. This series stretches from the Mira River to the Eastern shore of Sydney harbour, and then widens until it occupies nearly all Boularderie Island. The maximum thickness in this district is 5,700 feet, but it rapidly diminishes to the Northward, until at Cape Dauphin only 500 feet is exposed.

A long arm of millstone grit extends up the Salmon and Mira Rivers and overlaps unconformably the marine limestone and basal conglomerates, and rests against the Mira and East Bay felsites. The underlying divisions of the carboniferous crop at various points throughout the district, and extend irregularly through Loch Lomond and Grand River to St. Peter's.

This outlier presents the outcrops of several small seams of coal apparently underlying a large extent of ground. There has not been any attempt made to find other seams, or even to test the value and extent of these outcrops. The measures including the coal seams possibly represent the upper part of the millstone grit as exposed to the eastward of the Productive Measures of the Sydney Coal Field, and are on a horizon corresponding to that of part of the millstone grit lying south of Sydney town, where similar outcrops of coal are found.

The Marine Limestone formation occupies a triangular tract of ground between the arms of Sydney harbor, and attains a thickness of about 2,000 feet. It is composed principally of red and gray shales, sometimes approaching marls in aggregation,

argillaceous and calcareous, and frequently carrying nodules of limestone and iron ore. Numerous beds of limestone are met, compact, laminated, or concretionary, usually gray and blue, sometimes black and bituminous. These are frequently associated with beds of gypsum and anhydrite, sometimes over 100 feet in thickness. Beds of red and gray Sandstone, usually laminated, often micaceous and ripple-marked, are frequently met. The limestones generally carry the fossils characterising the formation, and are frequently charged with galena and copper pyrites, celestine, manganese ores, etc.

The following section, taken from the report of H. Fletcher, Esq., of the Geological Survey, for the years 1875-76, gives a good idea of the conditions under which the limestones and gypsum are usually presented:—

	ft.	in.
Bluish gray columnar limestone	136	0
Measures concealed	50	0
Green marl	9	0
Black bituminous nodular, gray and mottled compact limestone	55	0
Gray compact and variegated limestone, with fossils and layers of marl	40	0
White crumbling gypsum	15	0
Green gypseous marl	0	7
Greenish gypseous marl, with streaks of pink gypsum	1	6
Red micaceous marl, with green blotches and thin wavey layers of gypsum	7	0
White gypsum in nodules with marl	1	0
Gypsum and marl, with veins of white and pink gypsum	1	6
Nodular gypsum, with emerald green blotches and a pink layer	1	0
Nodular gypsum, and red arenaceous marl, and blue thick-bedded limestone	—	—

The gypsum varies greatly in appearance and quality, and the following description of an immense cliff of it on the Bras d'Or Lake will serve to show its characteristic features:—

It is essentially white, but tinted and spotted with many colours. It occurs in beds, often massive but frequently jointed in every direction. It is compact, or granular, minutely crystalline, or fibrous and radiating. Crystals of selenite of a brownish or white colour frequently occur in it; they are isolated, or arranged in radiating groups, and sometimes give the rock a porphyritic appearance. The rock is frequently traversed by veins filled with fibrous gypsum of various colours, or by large plates of transparent selenite. Layers and nodules of anhydrite and of limestone frequently occur in the beds or divide them. Long-continued weathering roughens the surface of the gypsum, owing to the presence of silica as sand.

These beds of gypsum are sometimes presented as immense lenticular masses, but they often extend for miles as an irregular cliff, reminding the tourist of a ruined marble wall. The vicinity of their outcrops is marked by the luxuriance of the grass, and by the vigorous growth of the evergreens which mask the conical holes formed by the removal of the gypsum through the action of the water drainage of the district. It may be remarked here that possibly some of the irregularities characterizing the outcrop of this rock may be due to the washing away of masses of salt. It is true that at present there is no evidence to show that such deposits existed, but the numerous brine springs issuing from this formation, and the common association of gypsum and salt, afford reasonable ground for anticipating valuable discoveries of rock salt in Nova Scotia in the vicinity of the gypsum beds.

Lower Coal Measures.

This term, as used by Sir William Dawson in describing measures such as those of Horton and Hillsboro, is applied, in speaking of this district, to strata of a quite different character. This, the lowest member of the carboniferous group, corresponds with the Bonaventure formation of Gaspe, and the basal conglomerate of New Brunswick and Newfoundland is in this district of variable volume, and cannot be separated by any strict line from the overlying limestone formation, and it is Mr. Fletcher's opinion that in the districts surrounding the Bras d'Or Lake

much of it must be considered contemporaneous with the limestone formation. In the Sydney district, near the Coxheath Hills, it has a thickness of 2,525 feet, which rapidly diminishes as its strike is followed to the North and the South.

This formation in the Sydney or Eastern district presents itself generally as a friable reddish conglomerate, the pebbles varying in size up to a diameter of three feet. The masses are frequently of little coherence, in some cases the matrix is calc-spar, hematite, or quartz. The conglomerates, the distinguishing feature of the formation, alternate with masses and beds of reddish, coarse and fine grained, friable sandstones, and with beds of red and green marl and an occasional bed of limestone. Usually the upper beds are finer than those near the base of the formation, and the line between it and the succeeding horizon may be said to be drawn at the first plainly marked calcareous deposit, which is not unfrequently a coarse arenaceous limestone obscurely fossiliferous.

Passing to the westward we meet the Carboniferous of St. Peter's Bay and the River Inhabitants. The marine limestones and some beds of the lower horizons border St. Peter's Inlet and Bay and the northern shores of Isle Madame, and passing to the north under the higher measures skirt the Sporting Mountains, and passing round the head of West Bay fill the valley of the River Inhabitants and are exposed on the shore of the Strait of Canso at Plaster Cove. These strata show at several points sections more closely resembling the typical lower coal measures of Nova Scotia than any met in the Eastern district. The colouring of the geological maps of the Canadian Survey does not separate these two subdivisions. They extend northward until they reach the River Denny's Basin, and stretch to the Grand Narrows and the Little Bras d'Or.

The officers of the Geological Survey have grouped the Carboniferous measures overlying these strata, in the district we are now considering, under the term "Middle Carboniferous," including millstone grit, productive measures, and some beds referred with doubt to the upper coal formation, as the dividing lines are obscure, and the structure not yet fully worked out.

The problem presented by the Carboniferous of the River Inhabitants is a difficult one, and complicated by the apparent anomaly of part of the coal horizon being connected with gypsum and limestone. Mr. Fletcher estimates the total thickness of the Carboniferous rocks at 21,960 feet, which probably embraces all the divisions already described in the Eastern district, and the 1,350 feet of strata referred to by him as overlying the Little River Coal Series (8,926 feet thick) may represent part of the Upper Coal Division (No. 1) of Sir J. W. Dawson.

The measures of the district do not present features calling for special notice, and the description of the various subdivisions of the Eastern district may be applied here. Some of the sandstones and shales of the River Inhabitants are little more than compact sand and mud, while at other points they present the normal hardness of the carboniferous strata.

But little is yet known about the extent and value of the River Inhabitants coal fields. A very considerable area of coal-bearing strata is indicated by the widely-separated coal crops at the mouth of the River and around the Basin. The paucity of outcrops, coupled with the presence of several large faults ranging through the district, have discouraged prospecting in the face of a dull coal trade. In the future the advantage of an all-winter shipping port, like that of Carribacou Cove, will no doubt stimulate the development of coal mines here, when the export of coal to the United States begins again.

In order not to unduly extend this paper, I will on another occasion give a brief description of the carboniferous districts of the Western shore of the Island, and of their coal fields, with analyses of the coal and other economic minerals found in them.