The Sydney Coalfield.*

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In these notes nothing more is aimed at than to present a few facts of interest to members of the Mining Society unacquainted with the geology of the district. For fuller details reference may be made to Robb's reports for the Geological Survey from 1872 to 1875, from which they are a condensed abstract, to the "Coalfields of Cape Breton" by Mr. Richard Brown, one of the pioneer geologists of Nova Scotia, formerly manager of the Sydney mines and father of the present manager and of the Government Geologist of New South Wales, to Rutherford's "Coalfields of Nova Scotia," Dawson's "Acadian Geology," How's "Mineralogy," Gilpin's "Mines of Nova Scotia," Bell's "Mining Manual," Reports of the Department of Mines for Nova Scotia, Church's Mineral Map, and to papers in the transactions of various mining and scientific societies by Professors Lesley, Lyman, Brown, Routledge and other observers who have described the production of coal from the yield in 1758, by the simpliest appliances, of 3000 chaldrons for the use of the garrisons at Louisburg and Halifax to the complex modern process described at this meeting of the Society.

This the most valuable and most extensive coal field in Nova Scotia, known and worked for more than two hundred years, extends from Mira Bay to Cape Dauphin, a distance of thirty two miles, being bounded on the north and east by the sea; it has been estimated to contain a land area of about fifty-seven square miles, colored as coal measures and embracing the 1838 feet of Mr. Robb's maps and reports, or about two hundred square miles with the lower seams of the millstone grit, some of which are in places of workable size, and a large sea area; but there is the usual uncertainty of such estimates.

The district is intersected by bays and harbors affording fine rock sections in cliffs which rise from twenty to one hundred feet above sea level. The coal seams lie in four basins—the Cow Bay, Glace Bay, Sydney Harbor and Bras d'Or basins—separated by three anticlinals. On the east they are lost in the sea, on the west, thrust against the Laurentian rocks of St. Ann's Mountain by a great fault. The carboniferous strata in these basins have been subdivided by Mr. Brown into four distinct formations—the carboniferous conglomerate, carboniferous limestone, millstone grit and productive coal measures.

The first includes the beds of *conglomerate*, usually red, found along the foot of the Coxheath Hills. The *carboniferous limestone*, well exposed at Sydney Point, Point Edward and Kelly Cove, comprises thick beds of red and gray argillaceous shale and micaceous sandstone, beds of black and gray limestone with traces of galena and copper pyrites, and layers of gypsum here not more than five feet thick and unimportant, but largely worked in other portions of the province. On the shore of Sydney Harbor, a little above the South Bar it underlies the millstone grit and terminates at a fault near the mouth of Freshwater Creek, assumed to be a downthrow to the southwest of about 900 feet. Trunks of trees, fish-remains and shells, indicating brackish water life, are found in a three-and-a-half feet bed of calcareo-bituminous shale near Sydney Point and Point Edward. These rocks with the conglomerate are estimated by Mr. Robb to have a thickness of 4637 feet. Beneath them lie the igneous and metamorphic rocks of the Coxheath Hills; above them, the millstone grit, separated by a band of siliceous hematite.

The Millstone Grit, about 4000 feet thick, is well exposed on the roads from Sydney to Cow Bay and Mira Bay on Boulardarie Island, along the shores of Sydney Harbor and elsewhere. In the western portion of the field it consists of an almost unbroken series of beds of gray and rusty coarse sandstone, with great quantities of vegetable fossils, with occasional irregular patches of argillaceous shale and coal; whereas in the east the formation contains thicker and more regular beds of argillaceous shale, with a marked predominance of red shale and sandstone, and seams of coal, one of which at least is of workable dimensions and quality. In this eastern section are the Coal Brook seam of 1 foot 6 inches, the Tracy seam of 4 feet 1 in. and the Round Island seam of 2 feet, with smaller layers. Among these beds on the section at Mira Bay are exhibited changes both in color and in essential mineral characteristics. A stratum consisting at one place of coarse gray sandstone is frequently found when followed to no great distance, either on the strike or to the dip, to be replaced by red sandstone or by red or gray argillaceous shale. Such replacements are frequent also in the beds of the coal measures. Trunks and roots of prostrate trees are sometimes found converted into black crystalline carbonate of iron. No beds of limestone were observed in the Mira Bay section and carbonaceous shales are extremely rare and where found consist like most of the coal seams of this formation of very thin beds composed almost entirely of the matted and pyritized leaves of *Cordaites*.

At the North Head of Cow Bay, the lowest rocks exposed by the anticlinal in bold cliffs upwards of one hundred feet high, resemble the red, purple and green shales and sandstones of Mira Bay. Some of the sandstones form conspicuous features in the physical geography of the district, constituting high ridges crowned with large loose blocks. Westward from this point the millstone grit rocks are no where found on the open Atlantic coast until reaching Cape Dauphin. They form the Bird Islands of the west as they form Flint Island at the eastern end of the district. The formation appears to thin to 1800 feet at Kelly Cove, while on Mira Bay it is 5707 feet. On the west side of Sydney Harbor it includes the Ingraham seam, two feet thick; on the east side is the Fraser or Mullins seam 6 ft. 4 in. thick, and near McPhee Brook a lenticular layer of argillaceous shale and underclay, nine feet high, constituting a miniature coal basin. To the eastward there are five seams from 1 ft. 7 in. to 2 ft. thick below the Lorway seam; on the Cow Bay road at the intersection of Fitzpatrick Brook, a seam 1 ft. 10 in. thick; while another, the LeCras seam has been worked on the Mira road by the Messrs. Cossitt and others.

The Coal Measures.—The boundary line between the millstone grit and the so-called productive measures, although important in an economic point of view, is a somewhat arbitrary one and may be regarded more as a matter of convenience than as of geological importance. As the upper beds are cut off by the sea, the entire thickness is nowhere represented. The productive coal measures, as defined by Mr. Brown and Mr. Robb, include argillaceous and arenaceous shales, for the most part gray, red and green marl, sandstone, underclay, limestone, black shales and coal, a thickness of about 1840 feet, of which from forty to fifty feet are coal and fifteen feet limestone, one set of seams running through the district. The coal contains more combustible matter than the Pictou coal and a smaller proportion of ash but a greater amount of sulphur, being at most of the collieries less inclined than at the Pictou and Cumberland mines, and therefore, as stated by Mr. Poole, not subject to the same proportionate waste in working and screening.

Shales constitute more than one half of the total thickness of the coal measures. The argillaceous shales no doubt originally consisted of fine mud, the darker shades being due to the presence of carbonized vegetable remains; some of the beds contain much pyrite and nearly all are charged with clay ironstone in thin regular layers or in spherical or ellipsoidal nodules or concretions. The shales contain a vast variety of fossil plants, chiefly ferns, their most delicate and fragile fronds and stems being beautifully preserved between the laminæ. Many trunks of erect and prostrate *sigillariæ* with their *stigmaria* roots attached and growing into the coal seams are also found, the largest nearly five feet in diameter, the bark being converted into coaly matter and the interior now consisting of sandstone, carbonate of iron or argillaceous shale. The fluting of the stems is often beautifully preserved and frequently the leaf scars are visible. Occasionally the change of argillaceous shale into arenaceous shale or sandstone is so sudden as to give the beds the appearance of being faulted.

The red and green marls are argillaceous, of considerable thickness, distributed throughout all parts of the carboniferous series, seldom containing fossils.

Numerous beds of sandstone constitute the most prominent, thickest and most persistent members of this series of strata and sometimes form the roof of the coal seams. They are usually of considerable thickness up to forty or fifty feet, coarse and pebbly towards their base and sometimes assume the character of conglomerates, false bedding being prevalent in the thicker and coarser grained strata which are generally charged with casts of plants and much carbonized vegetable matter in conditions which point to deposition in troubled waters, the trunks, stems and leaves having evidently been drifted from a distance, and confusedly mixed together. Many of the sandstone beds are calcareous; a bed of this description at Lloyd Cove near Sydney Mines, furnished specimens of the footprints of a land animal, proving that it was deposited in a flat tidal estuary.

Underclays occur immediately beneath every coal seam and bed of carbonaceous shale. They are for the most part aluminous and siliceous, form good fireclays and are copiously charged with the roots and innumerable rootlets of *stigmaria ficoides* which constitute the most distinctive feature of these beds; they merge by insensible gradations into the beds upon which they rest and are generally full of ironstone nodules. They vary in thickness from a few inches to eight or ten feet, but their size and richness in vegetable remains, appears to bear no proportion to the size or purity of the accompanying coal seams. The roots spread themselves horizontally in the beds and sometimes intertwine; they are often flattened and converted into sandstone. The rootlets are generally in a carbonized state and penetrate the bed in all directions, but chiefly downwards, as if to prove that they occupy the positions in which they originally grew.

The limestones are dark-gray or black, vary from half an inch to two feet and aggregate about fifteen feet in thickness, are remarkably persistent but disappear or thin out towards the eastern and western extremities of the field. They occupy a definite horizon and are rich in fossils identical with those found at the Joggins, consisting of *Naiadites, Spirorbis, Cythere*, with scales, teeth, spines and coprolites of ganoid fishes. The fish remains are generally coated with and sometimes entirely replaced by iron pyrites, and the limestone shows cone-in-cone structure.

The black shales are sometimes of the nature of cannel or pass into bituminous limestone charged with fossil shells and plants; more frequently, however, they are soft and laminated, seem to be entirely made up of the matted leaves of *Cordaites* converted into mineral charcoal and may be regarded as coarse coals. Many of the workable coal seams enclose layers or bands of such shale, and also sometimes pyritous bands which tend to deteriorate the coal.

Taking the average of all the sections measured, the total number of seams in the productive measures is twenty-four, of which six are three feet or upwards in thickness; and the total average thickness of coal may be stated at forty-six feet. The similarity and persistency of the seams over great areas is very remarkable although local variations are frequent. There is, therefore, no great uncertainty in regard to the equivalency of the various seams at different points. In establishing this there have to be taken into account the quality of the coal, the position and character of the various partings or bands of shaly matter, the mineral and fossil characteristics and the thickness of the strata between the seams, as well as the manner in which the folds and undulations have affected the general structure.

In a few instances the coal seams are split by the gradual thickening of their argillaceous partings. Sometimes seams which are of workable thickness and good quality at one place become unavailable at no great distance. In the Blockhouse seam at Cow Bay and the Victoria seam at Sydney Harbor, curious wedge-shaped masses of rock similar to that overlying the coal interrupt the continuity of the coal, as described by Mr. John Rutherford.

The cleat or cleavage of the coal coincides with the joints of the accompanying sandstones and is most prominent where the strata have been subjected to the greatest pressure. The coal seams are for the most part overlaid by a stratum of argillaceous shale, very frequently characterized by the occurrence of erect stems of *Sigillaria*, often from two to three feet in diameter and in one case nearly five feet, the spreading roots of the trees resting upon the upper surface of the coal. Instead of the usual roof shales, the coal is often followed by sandstone and a bed of sandstone is almost invariably found to overlie the roof shales at no great distance above the coal. Many interesting details in regard to the occurrence of fossil trees in these strata are to be found in Mr. Brown's writings and in Dawson's Acadian Geology.

Subordinate Basins in the Coalfield.—Along the sea coast the three anticlinal and four synclinal folds are well exposed; but the upward slope of the strata from the sea causes the coal measures in the latter to rapidly run out inland, leaving large portions of the coal seams to be worked beneath the sea, as at the Sydney and Victoria mines.

The Cow Bay Basin.—The seams of this basin have been exposed both by natural and artificial means on both sides of Cow Bay. The average breadth of the basin at the shore, between the outcrops of the lowest seam, does not exceed two miles and one third and it diminishes gradually inland until it terminates at a point about six miles from the shore, as proved by several crop-pits and boreholes on the various seams. The coal seams of this and the following basins are given in the tabular view. On the South Head some of the lower seams crop out and are cut off by the ocean, thus constituting the eastern extremity of the coalfield as exposed on land. In all the sections at Cow Bay calcareous matter is very sparingly distributed, a remarkable exception to the general rule in this coalfield. On the South Head the coal seams are much more split up by clay and shale bands, yet the total quantity of coal, the approximate distances between the seams and their geographical position in relation to their strike appear to justify the equivalency noted in Mr. Robb's sections. The rocks underlying the Long Beach seam belong to the millstone grit. In the centre of the basin are the Blockhouse and Gowrie mines, on the south side the South Head colliery.

The Glace Bay Basin.—The axis separating this from the Cow Bay basin skirts the northern shore of Cow Bay at Cape Percy or North Head, the opposite dips being visible in the precipitous cliffs. In striking contrast to the Cow Bay basin that of Glace Bay is wide and has uniformly gentle dips on both sides; and includes 610 feet of strata overlying the highest beds of that basin, among which occurs the Hub seam, the highest workable coal seam in this district. The attitude of all the seams in the Glace Bay basin, extending for a length of about twelve miles, is a striking proof of the general regularity of deposit and absence of faults which characterize this district; but the section shows considerable thinning of the beds between the several coal seams as they are traced westward. The most important cannel coal found in this field lies twenty-five feet beneath the Hub seam, is 1 ft. 2 in. thick, underlined by 9 inches of ordinary bituminous coal and by 1 ft. 9 inches of coal, clay and carbonaceous shale in eleven bands; attempts have been made to work it as it contains 30.07 per cent. of volatile combustible matter, 44.42 fixed carbon and 24.68 ash. In the Phelan seam, at a distance of half a mile from the shore, in the main level of the old Bridgeport mine, a shale parting has increased to twenty-eight feet. The Ross seam at and near the Bridgeport shore is only 1 ft. 8 in. in thickness, while at the Emery mine, not quite two miles and a half to the eastward, it averages 5 ft. 3 in.

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