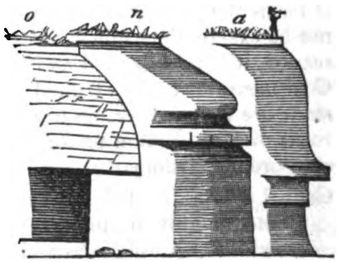
ART. XVII.—*On the Coal Measures of Cape Breton, N. B., with a Section;* by J. P. LESLEY.[1] (Communicated by the author.)

THE following section was obtained in August, 1862, from the cliffs between Lingan and Great Glace Bays, on the east coast of Cape Breton, from sixteen to twenty miles east of Sydney. Part of it was made out by means of a rope and ladder let down from the upper edge of the cliffs, where these overhung the sea, or occupied intervals between the short sand and gravel beaches. At the upper limit, which is also the northwestern end of the section, a square headland projects into the Gulf of St. Lawrence, along the axis of a synclinal basin with sloping sides of 4° or 5° dip. From this headland southeastward, the section was made out by an examination of each layer as it emerged from the sea, past the mouth of Little Glace Bay (where the new harbor is constructing, under the skillful and energetic direction of Captain William P. Parrot, Civil Engineer, of Boston, Mass.) and as far as to the mouth of Great Glace Bay.

| | Feet. |
|---|---|
| Soft shales with a hard belt at the bottom, - - - - - | 20 |

These rocks cap the square headland projecting into the Gulf of St. Lawrence between the Burnt Head and Little Glace Bay. They are the highest Coal-measure rocks of this basin, and perhaps the highest Coal-measures south of Sydney Bay. The cliffs are about forty feet high, and exhibit a remarkable contour, caricaturing the human face in profile, by means of the overhanging ledge of hard sandrock at the bottom of the mass, and about half-way of the height of the cliff. See woodcut (*a*).




| | Feet. |
|---|---|
| Red shale belt: red and green 10; red 10; green 2; red 1½; green ½; red 1½; green 1½, - - - - - - - - - - | 27 |
| Fire clay, the upper 5 feet crowded with small nodules of carbonate of iron; middle 2 feet sandy; lower 5 pure, - - - - - | 12 |
| Red shale 2 feet, over 2 feet of fire-clay, under which runs the outcrop of a plate of carbonate of iron, from 4 to 8 inches thick, for hundreds of yards along the face of the cliff, - - - | 4 |
| Shales, with three black streaks, like the outcrops of coal beds, but mere discolorations of the shale: layers of small nodules of iron occur in the lower 10 feet; the lowest 2 feet are fire-clay, - | 22 |
| Sandstone cliffs 8 feet, over sandy shales 6 feet, - - - | 14 |
| Coal; good; on fire-clay passing down into, - - - - - | 1 |
| Sandstone 6 feet; genuine black slate 2; fire-clay 8, - - | 16 |

[1] Reprinted (with many changes and additions by the author) from the *Proceedings of the American Philosophical Society.*

Slate cliffs; the top rock of the great coal bed; varying in compactness, but essentially a homogeneous mass of finely levigated and foliated sandy mud, - - - - - - - - - - 40
Coal; the Hub Vein; slate 1½, soft coal 1½, solid 4, hard 1, - 8

Of this, only six feet is good workable coal, on the coast; but it increases westward, and with the omission of eighteen inches poorer top coal, yields from six to seven feet of good body coal. It is on this bed that the principal mines of the Glace Bay Company are situated, shipments, until lately, having been made from a long pier projecting into the sea, or in an open roadstead by lighters. Now, a railroad a mile long, on a sixty foot summit, lands the coal upon a long wharf occupying the north side of an artificial harbor, constructed out of the shallow Little Glace Bay. The old drift-works into the bed have been abandoned on account of the inflowing of the tide, and new works by a slope have been commenced a quarter of a mile inland.—The floor of the bed is not well seen, being covered by the ruins occasioned by the firing of the cliff coal, in the last century, by the French, after the fall of Louisburg, and the cession of Acadia to the British government. The miners report the sandstone, next to be described, as lying immediately beneath the coal.

Sandrock full of the moulds of plants, mostly stems, only occasionally blackened, - - - - - - - - - - - 20

This mass of building stone is a rare exhibition for these Coal-measures. It forms the long point on which the pier is built. Its thickness could not be exactly determined, because, like all the very sandy deposits of the section, it is false-bedded and variable. It is as true here as in the great Coal-measures of the United States that the principal masses of sandstone are reserved for the lowest parts of the formation. The great sandrocks of Cape Breton underlie all the productive Coal-measures, and are seen around Sydney.

Cannel coal bed. This is no true cannel but a coal shale, compactly foliated, highly bituminous, burning well, but with much ash, and crowded with fish-scales and minute shells. It varies, and sometimes reads thus; cannel, 8 inches; bituminous coal, 8 inches; clay, 1½ inch; bituminous coal, 3 inches, - - - - 1½
Fire-clay, - - - - - - - - - - - 6
Cannel coal, as above, - - - - - - - - - - ½
Fire-clay, - - - - - - - - - - - 2½
Sandstone cliff rocks 8 feet, over sandy shales 11 feet, - - 25
Cannel coal, or jet black slate; sometimes growing compact like cannel, but nowhere seen as a true coal, but rather a black fireclay, one inch thick, with a few inches of black slate above and below it; plenty of fish scales, but no ferns, - - - - ½
Fire-clay 3; sandy clay 3, shaly 3, pure clay 4, blackish shales 8½, soft clay 2,—clay full of balls passing an eight inch plate of iron ore,—sandy shales 6, soft 3½, dark soft 1½, soft gray 8, - - 45
Sandstone shales 2, gray shales 5, blackish 1, gray 6, massive weathering flaky 2, sandy flaky 9, sandy cliff shales 11, blackish 10, sandy cliff shales 5, sandy shales 20, clay descending into sandstone 21. In this last occurs half an inch of coal, - - 92

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Top slate, - - - - - - - - - - - - - 6
Coal; sometimes black slate with two inches of coal, - - ½
Fire-clay, - - - - - - - - - - - - - 5
Shales: blackish soft 4, gray 2, with poor sandy ball ore ½, gray 4, sandstone flinty 1, fire-clay, compact below, 6, sandy shales 6, yellow 6, gray 6, soft sandy gray 12, soft shales (nipped out) 5, false-bedded sandy shales, hard at top, soft at bottom, 17, - - 69½

This great mass of sandstone, thrown up at a steep angle, not by any general structural movement, but by original oblique deposition, has here resisted the wearing action of the waves, and left a curious and instructive promontory. The mass begins at the bottom with 3 inches of pure clay, under which is an inch of

Cannel coal which burns well and is full of fish scales.
Shales, soft yellow, concretionary, clay slates 7, harder 1, gray 2½, with iron nodules along its base, gray 4, soft blackish band ¼, sandy foliated 3, top clay 1, gray, blackish ½ foot, - - - 19½
Cannel coal, or flaming slate ½, - - - - - - - 1
Hard shale ⅔, coaly matter half an inch, hard sandy shales 3, compact fire-clay 8, - - - - - - - - - - 11

These are the lowest rocks seen before reaching Little Glace Bay entrance, in the low banks, which fall off suddenly into the deep channel of the bay. A slight break in the section takes place here; it cannot be more than a few feet. The section commences again at the summit of the headland projecting from the south side of the bay, and runs thence uninterruptedly to the mouth of Great Glace Bay.

Soft measures under the soil, - - - - - - - - - 10
Coaly top slate 4 inches, bituminous coal 4 inches, - - - - ⅔
Sandrock variable 1, green clay with horses of sand ½, fire-clay 2, more compact 2, more sandy, becoming sandstone, 2, compact sandrock with thin flag-courses 7, - - - - - - - 14½
Shale fire clay 3, in pencils 4, sandy compact 3½, in pencils 6, sandy 15, crumbling 4, - - - - - - - - - - - 35½

The profile of this mass is one of singular architectural beauty. See woodcut (p. 179). (*n*).

Sandrock 8, blackish shales and fire-clays 4, sandrock massive 10, sandy fire-clay 2, shaly sandstone with six inch courses 7½, dark shales 7½, flags 3, gray top shales 1½, - - - - - - 43½
Bituminous slates with one inch of cannel in the midst, - - 1
Shale fire-clay 1, sandy 1, sandstone 2, sandy 11, fire-clay 5; the whole forming cliffs beetling over the breakers (woodcut *o*), - 20½
Coal. Harbor vein, - - - - - - - - - - - 5

Wrought by the inhabitants for many years in an entry from the beach. A new opening has been made on the outcrop where it crosses to the northwest side of the harbor below the new bridge.

Shales foliated, under which lies a plate of carbonate of iron three inches thick, sometimes breaking up into balls, - - - 8¼
Coals, with a centre streak of jet, perhaps characteristic of the bed, for it appears again in it at the new bridge, - - - - ⅔
Shales, red, green, yellow 7½, hard clay sandstone 2, clay shale 5, 14½

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| | |
|---|---|
| Coal. Regular bed of bituminous coal, - - - - - - | 2 |
| Sandy shales, foliated; then compact; then in half inch layers 26, sandstone then sandy shales 10, - - - - - - - | 36 |
| Shales, gray, blackish outside, 5, shaly fire-clay 10, - - - | 15 |
| Sandstone, greenish, 6, contorted 8; the local false-bedding has formed the point, and, like one or two other exposures along this coast, would throw a geologist completely off the track, leading him to suppose the country infested with high dips and faults; whereas, careful instrumentation has demonstrated an extraordinarily quiet and regular condition of things, - - - - - | 14 |
| Fire-clay 2, shales gray, green, harsh 4, gray, green 5, soft gray 20, | 31 |
| Sandrock in three equal layers, - - - - - - - | 6 |
| Soft fire-clay; top slate with nodules of ore, - - - - - | 10 |
| Coal half an inch, black slate six inches, - - - - - - | ½ |
| Fire-clay, passing further on into red, green and yellow shales; then sandy 6, false-bedded shales 12, ferruginous fire-clay 2, hard blackish slates 8, - - - - - - - - - - | 28 |
| Sandstone, green, rough, shaly, passing into dark shales 12, beautifully false-bedded, scalloped in all directions like the blocks and faces of No. X (Upper Devonian) at the viaduct of the Conemaugh, in Cambria County, Pennsylvania;—thin massive sandstone 6 feet, - - - - - - - - - - - | 18 |
| Shales, yellow sandstone at top, becoming yellow shales and then at bottom black, - - - - - - - - - - - | 20 |
| Carbonate of lime and iron, a tight blue bed, - - - - - | 5 |

Sometimes 1½ feet thick, but will not average more than 10 or 11 inches. It forms a long reef into the sea, in the exact line of the distant headland. As a solitary specimen of this kind of rock in this section, it is all the more important to have it carefully traced inland. It rests on a green fire-clay full of nodules of ore, as large as filberts and walnuts, oxydized on the surface.

| | |
|---|---|
| Blackish top slate, under which is a carbonaceous streak, - - | 3 |
| Shales (at the top sandstone balls a foot thick), yellow, then green and full of nodules of ore 11, soft fire-clay 1, yellow, then sandy, then clayey, then fire-clay 8, blackish fire-clay, then gray 10, - | 30 |
| Coal, - - - - - - - - - - - - - - | 2 |
| Fire-clay 2, with nodules of ore 2, blue shales 6, fire-clay full of nodules as large as chestnuts; the appearance of these fire-clays, crowded with nodules of iron ore, is very striking; their gnarly, knobby outcrops form long reefs visible by lines of breakers far out to sea.—Clays of various shades 12, blue black ½, red, yellow and green, - - - - - - - - - - - - | 25½ |
| Sandstone, false-bedded, then in layers 12, becoming clayey 4, blue fire-clay 5, - - - - - - - - - - - - | 21 |

These are the last rocks seen at the north side of the mouth of Great Glace Bay. The whole thickness of rocks measured is as follows:—

North of Little Glace Bay, 471 feet }
South " " " " 436 " } in all 907.

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Beneath these rocks lie formations of clay (including coal beds, one seven or eight feet in thickness), which form the west end of the long line of sea cliffs running out eastward from the Great Glace Bay bar. A measured section was made of these cliff-rocks also, which I propose to give at another time. It repeats a certain portion of the section given above, with interesting variations.

Our section of 907 feet of rock, commences at the headland in the centre of the synclinal and runs along the coast southward. Commencing at the same headland and running along the coast westward, a similar section may be obtained of the same rocks as they rise from the synclinal in that direction at the same low dip. Such a section would be from Cadougan's Creek, which corresponds to Little Glace Bay, to the mouth of Lingan Bay, which in like manner corresponds to Great Glace Bay. Many interesting variations in the metals would appear from such a comparison. While the general regularity and parallelism is remarkable, there are numerous minor irregularities; some fine instances of false bedding and local deposition; lenticular masses of sand separating adjacent mud-rocks; passages of shales into sandstones, and *vice versa;* gradual coalescing of scattered nodules of clay iron-stone into solid plates, or their gradual pervading of a thick bed of fire-clay, hardening it into so refractory a rock, that its outcrop forms a reef far out to sea. Instances occur of of the splitting of coal-beds. The Lingan bed, for example, has, on the sea-shore, a clay parting of half an inch, which in a quarter of a mile inland, thickens to nine inches; and then, in four hundred yards of gangway continued inland, thickens to nine feet, throwing the upper member of the bed entirely beyond the workings.[3] In this we have probably the explanation of the difference between the abandoned Bridgeport bed, on the south shore of Lingan Bay, and the Lingan bed on the north shore, separated by a wide and gentle anticlinal; the Bridgeport bed being but 7 feet thick, while the Lingan bed is 9.

The described section embodies the productive Coal-measures of the east end of Cape Breton, with five workable beds of coal, one of which can hardly be called workable in this area, whatever may be its character in others. In Mr. Brown's section of the North Sydney Coal-measures, there are enumerated, indeed, thirty-four coal-seams; but only four are said to be of workable thickness: Cranberry Head, 3·8 feet; interval (measuring downwards) 280 feet; Lloyd's Cove, 5·0; interval 730 feet; Main

[3] The *Cook Vein*, at Broad Top City in Pennsylvania, has a sandrock parting two feet thick, between two 2 foot beds of coal. At the present heading of the long drift, this rock, after first disappearing, leaving the bed of coal 6 feet thick, has increased to ten feet of tough rock, between two 6 inch beds of coal. This increase of ten feet takes place without crush in a distance of only three or four yards.

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Seam, 6·9; interval 450 feet; Indian Cove, 4·8. Mr. Brown's whole section extends to a depth of 1860 feet, or along 5000 yards at a dip of 7° to the N. 60° E.

Mr. Brown "concludes from the best information in his possession that the *productive* Coal-measures exceed 10,000 feet," but I saw nothing in Cape Breton to justify the supposition. He grants that, "owing to several extensive dislocations, it is impossible to ascertion their total thickness with any degree of accuracy." I can only suggest, with deference to his long experience and acknowledged skill, that the structure of the east coast of Cape Breton has not been regarded from a right point of view, inasmuch as the coal-beds have been represented as members of one area, dipping broadside into the waters of the gulf; whereas, in fact, along that coast, they occur with alternate northeast and southeast dips, forming a series of basin-ends, the bodies of which lie side by side submerged beneath the gulf. The same four or five workable beds, inclosed in the same one or two thousand feet of *productive* measures, appear on shore at the west end of each of these basins. As the dip is commonly gentle, viz: from 4° to 8°, the basins sometimes coalesce; but in one instance at least, that of Cow Bay, the *south* dips are 45°, and the basin is sharp and narrow, greatly resembling the end of one of the anthracite basins of Pennsylvania. As at Sydney, and again at Glace Bay, so here at Cow Bay there are but four workable coal-beds in about 1500 feet of *productive* measures, and they are, no doubt, the Glace Bay beds.[*]

Sir William Logan, Sir Charles Lyell, Prof. Dawson, and other geologists who have described the Coal-measures of Nova Scotia and New Brunswick, agree in assigning to them an almost incredible thickness. "The entire section of the Joggins," writes Sir William Logan, "contains 76 beds of coal and 90 distinct Stigmaria underclays," with "24 bituminous limestones," in "a vertical thickness of 14,570 feet."

When we analyze the eight divisions into which this immense mass has been distinguished, we find them thus constituted:

| | |
|---|---|
| Nos. 1, 2. Sandstones and shales; drift-trees and erect calamites, - - - - - - - - - | 2267 feet. |
| No. 3. Sandstones; coal shales; underclays; 22 coal-beds, | 2134 " |
| No. 4. Sandstones and shales, gray; bituminous limestones; 45 coal-beds; shells and fish-scales, - - - | 2539 " |
| No. 5. Sandstones and shales, red; carbonized plants, - | 2082 " |

[*] The combined thickness of the Lower, Middle, and Upper Coal-measures, as determined by Mr. Jukes, in South Staffordshire, England, is 1810 feet. The thickness of the productive Coal-measures of Leicestershire does not exceed 2500 feet. In most parts of the deep anthracite basins, 2000 feet would be a fair average. In Western Virginia and Pennsylvania, and in the deepest parts of the Mississippi Valley areas, 1500 feet.

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| | |
|---|---|
| No. 6. Sandstones, ¾; shales; bituminous limestone; 9 coal-beds; shells and fish-scales, - - - - - - | 2240 feet. |
| Nos. 7, 8. Sandstones, conglomerates, shales, nodular limestones, two beds of gypsum; remains of plants, - | 2308 " |
| Interval, - - - - - - - - - - - | 300 " |
| Massive limestone with *Prod. Lyelli* and other Lower Carboniferous fossils. | |

It is very evident that the Sydney, Glace Bay, or Cow Bay section of less than 2000 feet of productive Coal-measures, can represent but barely one of these divisions, and that it must be either No. 3, or No. 4, or No. 6. Sir William Logan adds, in his resumé, that "Nos, 3, 4, 5, and 6,[4] contain the equivalents of the productive Coal-measures of Pictou and Sydney, and, in part, of the sandstones which separate them from the Lower Carboniferous series." Prof. Dawson describes minutely his own section of "2819 feet of the central part of the Coal Formation,"[5] in approaching which, after describing the lower parts,[6] he says: "We have now, after passing over beds amounting altogether to the enormous thickness of 7636 feet, reached the commencement of the true Coal-measures."[7] By the *true Coal-measures* he means, therefore, Division No. 4 and the lower part of Division No. 3, embracing less than 3000 feet of measures and containing but four coal-beds which can be called workable, the rest being from one inch to eighteen inches thick. In descending order we have:

| | | |
|---|---|---|
| Nine small seams in a thickness of measures of - - | 536 feet. | |
| Main coal seam, 3·6; parting, 1·6; coal, 1·6, - - | | 5. |
| Three minute seams in an interval of - - - | 75 feet. | |
| Coal, ·3; clay, ·5; Queen's vein, 1·9; shale, 4·4; coal, 1·0, | | 3. |
| Ten small seams (largest 1·2) in an interval of - - | 762 feet. | |
| Coal, with three clay partings, - - - - - - | | 2¾. |
| Three small seams in an interval of - - - - | 206 feet. | |
| Coal, - - - - - - - - - - - | | 5. |
| Three small seams in an interval of - - - - | 17 feet. | |
| Coal, - - - - - - - - - - - | | 4. |
| Interval of - - - - - - - - - - | 32 feet. | |
| Coal and bituminous shale, - - - - - - - | | 5. |
| Eleven small seams in an interval of - - - - | 1153 feet. | |

The aspect of this section resembles those on the east coast of Cape Breton, where Modiolæ and fish-scales are also abundant.

The Albert or Pictou section is said also to contain but five or six seams of coal, two of which are of unusual thickness, as follows; From the surface, down the Success Pit, 73 feet; Main Coal, 39·11 feet thick; Interval, 157 feet; Deep seam, 24·9. Both these coal-beds, however, are far from presenting solid faces

[4] Dawson's Acadia, p. 178. [5] p. 177. [6] p. 127.
[7] Described in Proc. Geol. Soc., x, 1–42.



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of coal. On the contrary, they are built up, like the 30 and 60 foot coal-beds of the Anthracite region of Pennsylvania, of many layers separated by underminings. The peculiarity here is that these separations are plates of ironstone, not more than six inches thick, instead of being layers of fire-clay, coal-slate, or sandstone. The structure is certainly peculiar, and convinces us of the quietness of deposit and of the long-continued stability of the sea-level.

But inasmuch as the 60 foot coal at Mauch Chunk, on the Lehigh, is identifiable with the Low Main or Mammoth bed of the Pottsville Basin to the west, and of the Beaver Meadow, Hazleton, Buck Mountain, and Wyoming Basins to the north of it, and through them with still smaller and separated beds further off in the Mahanoy and Shamokin Basins, and even with the bituminous basins of the Alleghany Mountains,—there can not be, *a priori*, a reasonable ground for doubt, that the 25 and 40 foot beds of Pictou are identifiable with 5 and 6 foot beds of New Brunswick on the one side, and with the 8 and 9 foot beds of Sydney on the other.[*] The paleontological unity of the Low Main coal of the Pittsburg region with the Low Main coal of Eastern Pennsylvania is no longer a matter of discussion. The structural evidence also is coincident and precise. Yet, wider intervals of Devonian and Silurian denudation are to be bridged by the theoretical connection *there*, than are called for between the coal areas of the British Provinces. The general bordering of the sea-coast with coal-beds, and the long and parallel stretches of Carboniferous rocks through the interior, are all cogent arguments for the continuity of the original coal areas, and therefore for the contemporaneity of the remaining portions of the coal-beds. As the same coal-beds which now cap the highest mountains of the Alleghanies in Northern Pennsylvania, and have been swept away over wide intervals of Devonian valleys between them, descend also into the depths beneath the beds of the lowest valleys drained by the Swatara, the Schuylkill, the Lehigh, and the Susquehanna North Branch, so I have no doubt the coal-beds, whose edges we now see only

[*] To illustrate in a still more striking manner this separation of a large bed into several smaller ones, one has only to examine Mr. Jukes's description of the Thick coal of Dudley, in England, "which, forming at that place *one* solid seam ten yards in thickness, becomes split up into *nine* distinct seams by the intercalation of 420 feet of strata over the northern area of the coal-field." The Main coal of the Warwickshire area is split up, according to Mr. Howell, into *five* beds by 120 feet of intervening strata. The Main coal of Moira is noticed by Mr. Hull as a third instance. (See Hull's Paper on the Carboniferous Strata of England, vol. xviii, No. 70, *Quar. Jour. Geol. Soc.*, p. 189.) Mr. Lesquereux, in his Report on the East Kentucky Coal Field, in the fourth volume of Owen's State Reports, p. 360, gives what he considers sufficient evidence of a similar breaking up of the Low Main Coal of the Pittsburg area into three. This is precisely the normal number of large beds into which the great Mauch Chunk or Mammoth Bed separates throughout the Pottsville-Tamaqua Basin.

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along the sea-shore of Nova Scotia, or on the sides of the interior low lands, did once ride over the tops of its metamorphic Devonian mountains, whose summits, crowned with cliffs, opposing anticlinal and synclinal dips, remind the Pennsylvanian geologist, at every view he takes of them, of those mountains on which the coal still lies in fragmentary patches in his native State.

What, then, are the thousands of feet of rocks included in Divisions Nos. 5, 6, 7, and 8 of Logan's great section? In other words, the 7630 feet over which Dawson climbed to reach the bottom of his "true Coal-measures?"

What, I ask in reply, are those wide stretches of low, rolling, arable country, with a red shale soil, which the traveller sees spreading around all the productive coal areas of Cape Breton and Nova Scotia, especially the latter? To the geologist from the West they afford familiar scenery. He can hardly persuade himself, sometimes, that he is not riding through Lykens or Locust or Catawissa or Trough Creek Valleys in Pennsylvania, over the chocolate-colored soils of No. XI.* This formation, 5000 feet thick around the southern Anthracite coal-fields, becomes, indeed, thinner and thinner northwestward, until it is but 500 in the Alleghany Mountains, and not more than 50 beneath Pittsburg. But along its thickest line it extends from Alabama to New Jersey, a good thousand miles. It would not be surprising, then, to see it stretching another thousand miles further in the same direction, and spreading undiminished around the coal areas of Nova Scotia.

Division No. 5 of Logan's section consists of red shales and sandstones chiefly, 2012 feet thick. There is no reason why this should not be the representative of Formation No. XI, or of its upper part.

If it be objected that Division No. 6 is in fact a coal system with nine beds of coal and numerous bituminous limestones, the objection becomes an additional argument for the identification. For we see in this No. 6 the reproduction, at this immense distance, of the Lower or False Coal-measures of Virginia, where a *productive* coal system underlies the chocolate shales of Formation No. XI, and not only reappears, with workable beds, in Eastern Kentucky and Middle Tennessee, but projects itself, in a recognizable shape, through Western Indiana nearly to Chicago, and through Middle Pennsylvania nearly to the Delaware River. In fact, Lesquereux pronounces the whole coal of Arkansas to belong to this lower system. It may therefore, very well be found in force in Nova Scotia. Throughout Division No. 6 no bed of respectable size is mentioned. It is an early and imperfect system.

* The numbers of Formations, used in these pages, are those originally used in the Reports of the Geological surveys of Pennsylvania and Virginia. Prof. Rogers has since then given them.

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The chief objections to the hypothesis above sustained will come (1) from the absence of any general representative for the Millstone grit or Great Basal conglomerate of the True Coal-measures; (2) from the sub-position of Divisions 7 and 8, 2308 feet of sands, pebble-rocks, and limestones; and (3) from the presence at a still lower depth of what seems to be the genuine, massive, Subcarboniferous limestone. To break the full force of these objections, I can only remark, (1) that the Pictou coal-basin *has* a massive conglomerate under its productive Coal-measures, while elsewhere no one formation of the whole Palæozoic System is so variable and unreliable and unidentifiable as Formation XII, the Great conglomerate, technically so called; (2) that Nos. 7 and 8 may be identified with Formation X; and (3) that the Subcarboniferous or Archimedes limestones of the Western United States not only have been subdivided into five separate formations in the Valley of the Mississippi, but wholly thin away and disappear before crossing the Schuylkill and Lehigh Rivers on their way to Nova Scotia. Therefore, although the False or Lower Coal-measures of Virginia and Southwestern Pennsylvania are *overlaid* by limestones with Subcarboniferous fossils, the connection, *as to limestone*, is entirely cut away between them and the Nova Scotia deposits, so that the massive gypseous limestones of Nova Scotia may be at any assignable lower level. This argument is rendered all the more forcible by the fact that gypsum is unknown in the United States, except in one or two anomalous positions, apparently connected with the Lower Silurian limestones, and in the closed basin of Michigan.

Beneath the red shale Formation No. XI, we have, in the southeastern ranges of the Appalachians, nearly three miles' thickness of sedimentary deposits, separable everywhere into three great formations: No. X, white sandstone, 2000 feet, No. IX, red sandstone, 5000 feet, No. VIII, green and olive shale, 8000 feet; the white sandstone including rarely a thin bed of conglomerate here and there, and traces of coal-plants and even thin coal-beds; the red sandstone passing downwards into red shale, and often alternating flinty sandrock with massive mud-rocks even in the upper part; and the olive shale becoming near the base of it rocky, and even mountainous in the region of the Juniata, where a system of thin coal-beds was also developed in the midst of the sandstone and shale. The white sandstone of No. X becomes, in the Alleghany Mountain belt, less than 800 feet thick, and is there characterized by thin-bedded and very irregularly cross-bedded sandstones of a peculiar greenish tint and harsh, rough fracture, weathering to a surface sprinkled with small red dots of peroxyd of iron.

It is not too much to say that a geologist well accustomed to these formations, along their great Appalachian belts of moun-

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tain and valley, stretching from the Appalachicola and Alabama Rivers in the South, to the Delaware and Hudson in the North, cannot fail to recognize them and distinguish them anywhere. The *tout ensemble* or *facies* of each is *sui generis*. Fossils may come in afterwards as a satisfactory confirmation; but the eye has already determined the respective formations. Even in the West, where Formation IX has dwindled, like Formation XI, to an insignificant one or two hundred feet, and scarcely separates the green sands of X from the green shales of VIII, the characteristic features of the three formations, although modified and harmonized by the preponderance of the argillaceous element, are still in sufficient contrast to be recognized when fairly seen.

To an eye thus trained among the broad outcrops of the Lower, Middle, and Upper Devonian of the Appalachians, it is evident that the mountains of Cape Breton and the hills of Northern Nova Scotia, surrounding or intervening between the already-mentioned red shale borders of the coal areas, are composed of these formations. True, the anticipation of finding these formations has a tendency to warp the judgment and delude the eye, especially when that anticipation is based upon such a probability as this: that a mass, three miles thick and a thousand miles long, will maintain its thickness (and of course its topographical height and geographical breadth) at least as far along the prolongation of its isometric axis (to use Mr. Hull's new and much-needed term), as will such minor formations as the Coal over it or the Upper Silurian limestones under it. In other words, if analogies between the Nova Scotia and the United States coals compel us to consider them synchronic, if not originally conterminous; and if the Clinton fossils of New York, and even the Dyestone[10] iron ore of Pennsylvania, Tennessee, and Wisconsin, be found at Arisaig, and along a well-defined outcrop in the direction of Truro; surely the Second Mountain, Little Mountain, Orwigsburg Mountain, and Summer Hill, upon the Schuylkill River, must be represented by the Antigonish Mountains of Nova Scotia, and by the Sydney and St. Peter's Range in Cape Breton: and this, whether the Nova Scotia Carboniferous rocks or Subcarboniferous limestones be deposited upon the Devonian conformably or unconformably. The Province is in fact a wide belt of mountains partially submerged; and may have been to some extent in the same condition at the beginning of the Coal era. In the Antigonish Hills we may have principally Formation VIII, while in the country south of the Lake Bras d'Or we may have the full series of VIII, IX, and X. The Arisaig formation, with fossils once thought by Hall and Lyell to be Hamilton and Chemung, and now consid-

[10] Described by Dawson, p. 58, supplementary chapter to *Acadian Geology*, August, 1860.

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ered by Hall and Dawson to be indisputably Clinton, although overlaid and concealed along most of its extent by apparently nonconformable Coal measures, gives us a fixed lower limit for the so-called metamorphic hill country of the Province, which makes this hill country necessarily Devonian, or Formations VIII, IX, and X. Even if we object to the term Devonian, and permit the paleontologists to carry down the term Carboniferous, or the term Subcarboniferous, step by step, so as to include first, Formation X, perhaps rightly, and then the genuine Old Red IX, and even, as the effort is in the Western States, to include Formation VIII down to its black shale beds with coal, the change of term will not change the lithology,—the mountains of Nova Scotia must still be the representatives of the Catskill, Mohantongo, Terrace, and Alleghany Mountains of New York and Pennsylvania.

The eye can hardly be mistaken in the features of the roadside banks between Antigonish and Merigonish; the road defiles through hills of VIII. Equally certain is it that the outcrops on the road from St. Peter's to Sydney are of the reddish and greenish rocks of IX and X. The road for forty miles winds along the lake shore, and in and out of ravines descending from a group of parallel mountains of these formations, made parallel by a system of parallel anticlinal and synclinal curves which issue from the lake and throw the mountain dips to the north and to the south alternately, at angles from 5° to 45°. Great rib-plates of flinty sandrock rise to the summit and form tablets with broken cliffs upon the outcrop side, fine objects seen thus against the sky. The mountains at the head of the east arm of the lake, and those on its northern side forming the peninsula, come down upon the shore in the same style, and belong to the same system. On the south side of Miré Bay, in the ravines east of the Gabarus road bridge, there is no mistaking the aspect of masses of slates of No. VIII standing at 45°; nor can one be convinced that he is not riding through a forest grown on a soil of IX, as he is whirled over the fine old road from Miré bridge to Louisburg, although the highest elevation of the plateau is but 350 feet.

Whatever impression the Devonian and Subcarboniferous sediments of Nova Scotia and Cape Breton may make upon a geologist from the Middle States, certainly his wonder will be piqued by striking analogies between the exhibitions of the workable Coal-measures at two such distant places as Sydney and Pittsburg. The resemblance is more than general; it has special points.

At Pittsburg there are about a thousand feet of Coal-measures (to the top coal), with a great bed 8 or 10 feet thick near the top, a 6 foot bed half way down, two small workable beds in

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the lower half of the column, and a large bed (4 to 8 feet) at the bottom.

At Sydney (Glace Bay), in like manner, there are about a thousand feet of Coal-measures, with an 8 or 9 foot bed towards the top, a 6 foot bed half way down, two smaller beds in the lower half of the column, and a 7 or 8 foot bed near the bottom.

At Pittsburg, as at Glace Bay, the upper 18 inches or 2 foot of the high Main coal is rejected.

At Pittsburg, as at Glace Bay, the middle 6 foot coal (Upper Freeport of the Alleghany River and Cook Vein of Six Mile Run) is famous for its solid face and excellent quality.

No one should admit that such coincidences furnish a demonstration of identity. But it must not be overlooked that the beds of the Pittsburg area have been traced and identified from end to end of areas with a diameter, in all, of over a thousand miles, even across the denuded interval of Central Kentucky. The expectation may, therefore, be pardoned, not as an amiable enthusiasm, but as a logical inference, that when the fossil groups of the individual beds of Cape Breton shall have been thoroughly studied by Lesquereux and other competent botanists, their identification with the beds of the West may be made somewhat more than possible. The zone of sediment, when taken along its isometric axis, is equal enough over *a priori* incredible distances. Logan and Hunt and Murchison are finding the Quebec group and the Huronian and Laurentian systems in Scotland and Scandinavia, not by fossils, but by aspect. No one doubts the extension of the Millstone grit and the Mountain limestone of England to Pennsylvania. Why should the remarkably homogeneous and continuous Flora of any one of the immensely outspread beds of the United States not be homogeneously continuous to Rhode Island, New Brunswick, and Cape Breton?

One remarkable feature, however, in this resemblance of the two coal columns at Pittsburg and Sydney, must not be forgotten. I refer to the mass of red shales which cap the Glace Bay section. A similar deposit occurs, at a fixed horizon, widely spread over Western Pennsylvania, but *beneath*, not *above*, the High Main coal.

*Note on Mr. Lesley's Paper on the Coal-measures of Cape Breton;* by J. W. Dawson, Principal of McGill College, Montreal.[11]

The new facts and general considerations on the Nova Scotia coal-field contained in Mr. Lesley's paper, are of the highest interest to all who have worked at the geology of Nova Scotia. I think itmy duty, however, to take exception to some of the statements, which, I think, a larger collection of facts would have induced

[11] This note was read by Professor Lesley before the American Philosophical Society, and is published in the same number of its Proceedings.

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Mr. Lesley himself to modify. My objections may be stated under the following heads.

(1.) It is scarcely safe to institute minute comparisons between the enormously developed Coal-measures of Nova Scotia, and the thinner contemporary deposits of the West, any more than it would be to compare the great marine limestones of the period at the West, with the slender representatives of the part of the group to the eastward.

(2.) There is the best evidence that the Coal-measures of Nova Scotia never mantled over the Devonian and Silurian hills of the Province, but were, on the contrary, deposited in more or less separate areas on their sides.

(3.) Any one, who has carefully compared the Coal-measures of the Joggins with those of Wallace and Pictou, must be convinced of the hopelessness of comparing individual beds, even at this comparatively small distance. *A fortiori*, detailed comparisons with Pennsylvania and more distant localities must fail.

(4.) I do not think that any previous observer has supposed that the coal-measures of Eastern Cape Breton represent the whole of the coal formation of Nova Scotia. The "Upper Coal-measures" of my paper on Nova Scotia are certainly wanting, and probably the Sydney coal-field exhibits no beds higher than the middle of No. 4 of Logan's section at the Joggins.

(5.) The whole of the coal-beds at the Joggins belong to the *Upper* and *Middle* Coal-measures. It is quite incorrect to identify No. 6 of Logan's section with the *Lower* Coal-measures. These do not occur at the Joggins, but are found in Nova Scotia, as in Virginia and Southern Pennsylvania, at the base of the system under the marine limestones. The Albert beds are the equivalents of these Lower measures, and not of the Pictou coal. In my paper on the Lower Carboniferous Coal-measures (*Journal of Geological Society of London*, 1858), will be found a summary of the structure of the Lower Coal-measures, as shown at Horton Bluff, and elsewhere. The term "true-Coal-measures," quoted by Mr. Lesley, does not mean in my description, the Middle Coal-measures, but merely that part of them holding the workable coal-seams.

(6.) Whatever may be the value of Mr. Lesquereux's applications of the fossil flora to the identification of coal-seams in the West, I am prepared to state, as the result of an extensive series of observations, still for the most part unpublished, that in Nova Scotia, the flora is identical throughout the whole enormous thickness of the Middle Coal-measures, and that the differences observable between different seams are attributable rather to difference of station and conditions of preservation, than to lapse of time. It is, indeed, true, as I have elsewhere explained, that the assemblages of species in the Lower, Middle, and Upper

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Coal-measures may be distinguished; but within these groups the differences are purely local, and afford no means for the identification of beds in distant places.

(7.) I do not desire to offer any opinion on the questions raised by some American geologists, as to the extension of the term Carboniferous to the Chemung group; but I know as certain facts, that the flora of the Lower Coal-measures, under the marine limestones and gypsums of Nova Scotia, is wholly Carboniferous, and that the *flora*, on which alone I consider myself competent to decide, of the Chemung of New York, as now understood by Professor Hall and others, and also of the groups in Pennsylvania named, by Rogers, Vergent, and Ponent (? IX and X of Mr. Lesley), is as decidedly Devonian, and quite distinct from that of the Carboniferous period.[12]

For Mr. Lesley's ability as a stratigraphical geologist, I have the highest respect; and, with reference to the present subject, would merely desire to point out that he may not have possessed a sufficient number of facts to warrant some of his generalizations, on which in the meantime I would, for the reasons above stated, desire geologists to suspend their judgment.

J. W. DAWSON.

**McGill College, Montreal, February 18th, 1863."**

Mr. Lesley remarked that he read this communication of his friend, Dr. J. W. Dawson, with great pleasure, as it would prevent any mistake about the nature and importance of the discussion, and any undue weight being attached to his own suggestions; that no one was more convinced than himself that there could be no excuse for dogmatism where so little was known, and, therefore, that he had intended rather to suggest than to defend those opinions expressed in his paper, which had drawn down so earnest and valuable a caveat from so high a source. To defend them would require long and systematic researches on the ground, if, even then, the too easily accepted present standpoint of paleontology would not hide the truth from view behind immovable obstacles. So long as apparent specific identity in organic forms continues to be accepted as the supreme test of stratigraphical horizon, discord is inevitable. When paleontology is prepared to return under the mild dominion of her mother, lithology, which she has at least one-half repudiated, geology will advance more rapidly in her work.

Dr. Dawson's first objection is a begging of the very question, whether the Coal-measures of Nova Scotia *are* "enormously developed." That, in one spot of the earth's surface like Nova

[12] See paper on Devonian Flora of Eastern America, *Quar. Jour. Geol. Soc. Lond.*, November, 1862. Also *this Journal*, May, 1863.



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Scotia, and that too midway between the great coal areas of America and those of Europe, wherein the thickness of Coal-measures proper range from 2000 to 5000 feet, if they even attain the latter size, there should be an anomalous deposit of 25,000 feet, is incredible."[13] What the great Bohemian paleontologist, by unerring instinct, said to us after our thirty years' war over the Taconic system, *there must be a mistake somewhere*, I must repeat to those who so "enormously develop" the Nova Scotia Coal-measures. And my intention in the paper on Nova Scotia coal was only to suggest one formula on which the error might be discussed. I distinctly repudiated the safety of instituting "minute comparisons." My comparison of the Cape Breton coals and the column at Pittsburg was carefully made in the most general manner, and the resemblance called a coincidence. But the value of the comparison remains; for it affords a new argument in favor of the *family likeness* of those parts of the general Coal-measures of different countries, which have a right to the specific title of "productive coals." The argument also remains good, that, if 2000 feet of Coal-measures in Missouri can be recognized in 2000 feet of Coal-measures in Kentucky, Virginia, and Eastern Pennsylvania, the very same system of beds, bed for bed, being demonstrated first by stratigraphy, and then by paleontology (and such is the fact), why not in Nova Scotia? Even granting (3) that sufficient skill and care and opportunity combined have hitherto failed to identify the coals of the Joggins with those of Wallace and Pictou, there is still hope at the bottom of the box. Before Lesquereux undertook the study of the slack-heap at the mine's mouth, our own identification of individual beds was very imperfect, and the search for a complete system of identification had been abandoned with the same sense of hopelessness. But how is it now? There certainly may be special difficulties in Nova Scotia; there are such at Pottsville, and in Michigan; but they are exceptions which prove the rule, instead of affording an *a fortiori* argument against it.

I have no doubt that some of the Coal-measures of the British Provinces may have been "deposited in more or less separated areas on the sides of the Devonian and Silurian hills," as Dr. Dawson says (2). But I confess to a complete scepticism of the great extent which has been assigned to this unconformability of the Coal-measures upon the lower rocks; first, because most of the Island of Cape Breton, and much of the

[13] We have received a note from Dr. Dawson, written after he had seen the above remarks of Prof. Lesley, in which he says he never claimed any such thickness as 25,000 feet for the Coal-measures proper of Nova Scotia, but that the actual measurements of Sir Wm. Logan, carefully revised by himself, gave at one place the truly enormous thickness of nearly 10,000 feet, and that it is to this that his remarks apply. See Dawson's *Acadian Geology*, pp. 117 and 177.—Eds.

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surface of Nova Scotia and New Brunswick are confessedly unstudied and almost unknown; secondly, because the incredible thickness assigned to the Coal-measures throws doubt upon the positions assigned to the non-conformable horizons; thirdly, because the coal-beds themselves stand almost vertical in many places round the shores; fourthly, because the mountains of Nova Scotia, with apparently conformable Carboniferous limestones, have apparently an Appalachian structure and aspect, have suffered vast denudation, exhibit cliff outcrops and section ravines, and may just as well have carried coal upon their original backs, as we can prove that our Tussey, Black Log, Nescopec, Mahoning, Buffalo, Tuscarora, Brush, and other Silurian and Devonian mountains did. There is an immense non-conformable chasm in the column west of the Hudson River, and the Catskill Mountains over it have no coal upon their backs; but the coal comes in regularly enough on them at the Lehigh, (a less distance than from Sydney to St. Peters, or from Pictou to Windsor,) and the unconformability in the Upper Silurian and Devonian has already disappeared.

Dr. Dawson's fourth objection would be good, if I had really "supposed the Coal-measures of eastern Cape Breton to represent the whole of the Coal-measures of Nova Scotia." But I only suggested that they may be the equivalents of the system of *productive Coal-measures*; that is all. Between the Monongahela and the Ohio, our column of productive coals is capped by another of barren shales and soft sandstones of unknown height, by one estimate 3000 feet thick; and part of this column may represent the so-called Permian measures, which, in Kansas, cap conformably the Coal-measures. Having no knowledge of the fossils, I have no desire to oppose the conclusions of Professor Dawson, as to the part of the column of the Joggins to which the Glace Bay coals apply, but hope that his accurate handling of them will secure some certainty about it. It was the grouping of the beds, and not the fossils, which I wished to bring into prominent notice; because the doctrine of isolated basins, when unfounded, or overapplied, is as injurious to lithological truth, as the careless identification of surface aspect may at any moment prove to paleontology. I willingly leave to accomplished paleontologists, like Professor Dawson, the discussion of the grand generalization embodied in his sixth objection; but I may be permitted to believe that it has had its birth in the doctrine of isolated basins, and that the two must stand or fall together. It also seems to me to involve radical inconsistencies; for, if I comprehend it, it asserts, 1. That the flora of the whole coal-measures (25,000 feet?) is identical; that is, the vertical distribution of each and all the plants is complete from the bottom to the top. 2. That, nevertheless, there are differences observa-

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ble between different coal-beds. 3. That these are attributable rather to difference of station and conditions of preservation, than to lapse of time; that is, if we could take the beds, each one in its whole extent, and its fossils in their original condition, there would, after all, be no differences observable between different seams. 4. That groups or assemblages of species in the Lower, Middle, and Upper Coal-measures may nevertheless be distinguished; that is, while each and every species may be found occasionally in all parts of the column from bottom to top, yet this happens in such a manner as to group some of them more abundantly, or in certain peculiar proportions in the Lower, others in the Middle, and others in the Upper portions of it. 5. That, after all, however, these groups are not persistent, but differ at different localities, and are as worthless as the specific forms themselves for the identification of a single bed in more than one place.—Is it possible that all this has been made out, or *can* be made out, except in a country of *horizontal* Coal-measures, well opened for study, where the stratification can be established beforehand, and the range of the fossils be made certain?

In conclusion, I would say, that the want of clearly defined and applied names is a drawback to such a discussion. The discussion is, in fact, *initially* one of names, viz: how far down the name Carboniferous must be carried; what are the Lower Coal-measures, &c. But, *in the end*, it is a question of vital importance to the value of the paleontological *imprimatur* upon stratigraphical and structural deductions from field work. Is the discovery of specific forms to keep all our geological *niveaux* in a perpetual mirage-flicker? Are we never to know, from day to day, whether we are at work in Devonian or Carboniferous, in Trias, or Lias? Why not at once obey the marriage law of the weaker sex, and give up our names for our lords? Let geology forget the virgin nomenclature of her youth, and rewrite her books with such titles for her chapters as these: "The Spiriferiferous formation; The Lepidodendriferous formation; The Lower Thecodont; The Middle Baculite; The Upper Pterodactylian formation. Why has this not already been done? Simply because it cannot be done. No paleontologist has yet been bold enough even to propose it. Yet, as I believe, the 25,000 feet of Coal-measures in the British Provinces will be found to be one of the many unconscious *realizations* of this idea, when no one can be found to *nominate* it openly. The whole Paleozoic system, at its thickest place, in southeast Pennsylvania and middle Virginia, is but 35,000 feet. It is not unreasonable then to *suggest*, if not to affirm, that the vast column of so-called Coal-measures in Nova Scotia will take in all that part of the Paleozoic column which has furnished coal, and that is from the top downwards nearly to the Upper Silurian.

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