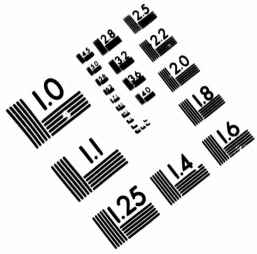

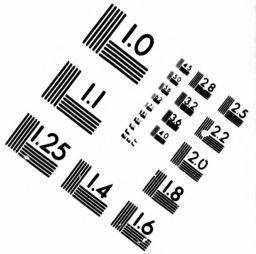

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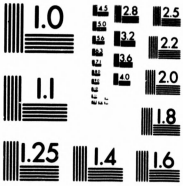

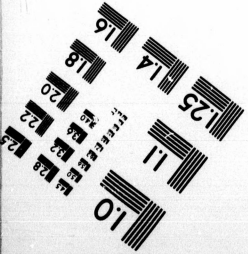

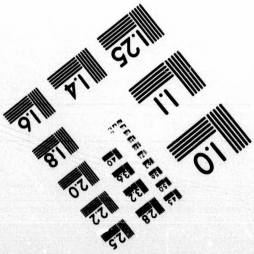

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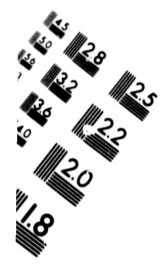

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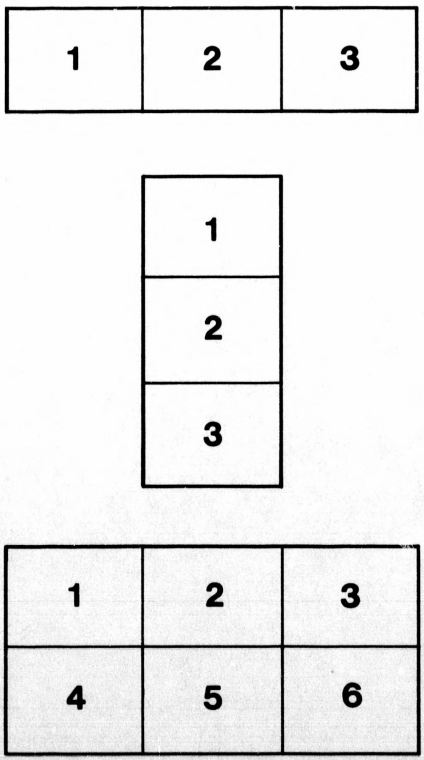

CHAPMAN'S OUTLINE

OF THE

GEOLOGY OF CANADA:

INCLUDING

ALL THE PROVINCES OF THE DOMINION.

AN OUTLINE

OF THE

GEOLOGY OF CANADA:

BASED ON A SUBDIVISION OF THE PROVINCES

INTO NATURAL AREAS.

BY

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AND CONSULTING MINING ENGINEER.

WITH 12 PLATES AND MAPS.

TORONTO:
COPP, CLARK & CO., 47 FRONT STREET EAST.
1876.

PREFACE.

THIS work was drawn up, in the first instance, to serve as an index or extended syllabus to the author's Lectures on the Geology of Canada, in connection with the Natural Science Department of the University of Toronto It has been thought, however, that the work may prove acceptable to a wider circle of readers—to all, indeed, who may desire to obtain a general knowledge of the leading geological features of the Dominion, without caring to incur the labour and trouble of gleaning this from the able but necessarily complicated and somewhat fragmentary Reports of our Geological Survey and other detached sources of information. The present essay is, in fact, the only work in which a condensed and systematic view of the geology of the entire Dominion has been attempted. In order to render it more useful to the general reader, the main portion of the work is preceded by a brief geological introduction; and twelve lithographed plates, containing figures of the more common or characteristic fossils of our Silurian and Devonian formations, with outline maps of the Provinces, have been added. These maps are, of course, on too small a scale to admit of detailed information, but they serve to show with sufficient accuracy the various subdivisions adopted in the text.

Many of the statements embodied in this outline have been taken, necessarily, from the Geological Reports and from other published sources of information enumerated on pages ix-xi; but these details, carefully sifted from extraneous matter, have been compared in numerous instances with the author's own observations, and have been grouped after his own views. For the generalizations and leading geological subdivisions, adopted in the book, he is, therefore, alone responsible.

UNIVERSITY COLLEGE, TORONTO,
September 30, 1876.

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INTRODUCTION.

OUTLINE OF GEOLOGY OF CANADA.

GEOLOGICAL LITERATURE OF CANADA.

The chief sources of information on the geology of Canada are indicated under the separate Provinces, in the annexed list. In addition to the leading authorities, the titles of older works now out of date, and the names of contributors to scientific journals, authors of mining reports, &c., so far as known to the author, are also given; but although no name possessing the slightest claim to recognition has been intentionally omitted, the list has no pretension to be exhaustive.

PROVINCE OF ONTARIO.—The leading works on the geology of this Province comprise the various Reports of the Geological Survey, and more especially the Revised Report of 1863—a volume of 1,000 pages—bearing on its title-page the names of Sir W. E. Logan, Alexander Murray, T. Sterry Hunt, and E. Billings. Also the subsequent Reports and other publications of the Survey (1866-69-70-72-73-74) containing important contributions by (as regards the geology of Ontario) Sir W. E. Logan, Dr. Hunt, Mr. Billings, Prof. Robert Bell, Mr. James Richardson, Mr. Andrew Macfarlane, Mr. Vennor and Mr. Gordon Broome.

Various papers in scientific journals (*Journal of the Geol. Society of London; Annals of Nat. History; Philosophical Magazine; American Journal of Science; Canadian Journal; Canadian Naturalist*, &c.), Notices of Fossils, Reports on Mineral Lands, and other contributions to a knowledge of the geology of this Province, have likewise been published by Dr. Bigsby, Captain Bonnycastle, Mr. Roy, Sir W. E. Logan, Dr. Dawson (Principal of McGill College, Montreal), Dr. Sterry Hunt, Prof. James Hall, of Albany, Mr. Billings, Prof. Robert Bell, Mr. J. F. Whiteaves, Dr. Lawson, Mr. Macfarlane, Mr. Charles Robb, Mr. Sandford Fleming, Prof. H. Y. Hind, Mr. De Cew, Mr. T. C. Wallbridge, Mr. John Gibson, Prof. Nicholson, Mr. J. G. Hinde, Mr. James Smith, Major C. Grant, Mr. J. W. Spencer, Mr. D. Wilkins, Mr. Peter McKellar, Mr. William Plummer, Captain John Plummer, Mr. Walter Dickson, Mr. Hugh Wilson, Mr. S. J. Dawson, M.P., and Mr. R. H. Fletcher. Also by the author of the present work.

PROVINCE OF MANITOBA AND NORTH-WEST TERRITORY.—The more important geological literature of these regions is comprised in the Report of the Assiniboine and Saskatchewan Expedition (1859) by Prof. H. Y. Hind; the Reports (1872-4) of Mr. Selwyn, the present Director of the Geological Survey of Canada, and Prof. Bell; the very able Report (1875) on the Geology and Resources of the Region in the vicinity of the Forty-ninth Parallel, by Mr. George Mercer Dawson; and the Report of Dr. Hector, issued by the English Government in 1863. The Road Report and map of Mr. S. J. Dawson, M.P., and the various Reports of Mr. Sandford Fleming, likewise afford useful information.

Valuable contributions have also been published by Prof. F. B. Meek (1860), Dr. Bigsby, Sir James Richardson (1851), and Mr. Isbister (1855).

PROVINCE OF BRITISH COLUMBIA.—The principal geological notices of this Province comprise: the Reports of Mr. James Richardson, of the Canadian Survey (1871-72-73), with Addenda by Dr. Dawson, Mr. Billings, Mr. J. F. Whiteaves, and Dr. Harrington; and Mr. Selwyn's Report of 1871-72. Communications on the geology of portions of the Province have also been published in the *Journal of the Geological Society of London*, by Mr. Bauerman, Dr. Brown, and Mr. Begbie.

PROVINCE OF QUEBEC. — The geology of this Province—so far as then worked out—is described in detail in the "Revised Report of the Geological

Survey for 1863," by Sir W. E. Logan, Alexander Murray, T. Sterry Hunt and E. Billings; and also by the same observers (with the exception of Mr. Murray, who had previously left the Canadian Survey to undertake the direction of that of Newfoundland) in several subsequent Reports (1866-74). These later Reports of Progress contain, in addition, communications on portions of the Province by Mr. Charles Robb, Mr. James Richardson, Mr. Michel and Mr. Walter McOuat.

Early notices and memoirs on the geology of Quebec were contributed by Dr. Bigsby, Admiral Bayfield and General Baddeley; and important communications, chiefly on the Eozoon localities of the lower rocks, the occurrence of the Lower Helderberg formation near Montreal, the plant remains of the Upper Silurian and Devonian strata of Gaspé, and the subdivisions of the Post-Cainozoic deposits of the Province, have been published of late years by Dr. Dawson. A notice of some new trilobites from the Quebec group has been communicated by Mr. Thomas Devine; and the graptolites of these strata have been described with much amplitude of detail by Professor James Hall, in Decade II. of the Survey publications. Mr. J. F. Whiteaves has likewise published valuable palæontological papers in reference to this Province.

Various Mining Reports, and analyses of iron ores and other minerals of the Province, have also been contributed by Dr. Sterry Hunt, Mr. Herbert Williams, Mr. Robb, Dr. Harrington, Mr. Hoffmann, and the writer of the present essay.

PROVINCE OF NEW BRUNSWICK.—Apart from the earlier publications of Dr. A. Gesner and Dr. Robb, the principal sources of information on the geology of this Province comprise: The "Acadian Geology" of Dr. Dawson, and various communications on the Devonian Flora, &c., of New Brunswick, published by Dr. Dawson before the appearance of the second edition of the above work; also various communications by Mr. Hartt, Prof. Hind, Mr. G. F. Mathew, Prof. L. W. Bailey, Mr. Charles Robb, and the Rev. Dr. Honeyman. Of these latter, the more important are contained in the Reports of Progress issued by the Canadian Survey in 1869-70-71-72 and '73.

Mineral Reports have likewise been published by Dr. Jackson, on the Albert mine; by Mr. Selwyn, on the Acadia Iron Ore Deposits (1872); and by the writer, on the Copper Ore of the Grand Manan (1870). Mineral analyses also have been communicated by Dr. Hunt, Prof. How, Dr. Harrington, Mr. Hoffmann, Dr. Dawson, and the writer.

PROVINCE OF NOVA SCOTIA.—The "Acadian Geology" of Dr. Dawson (second edition, 1868) is the great work of reference on the geology of this Province, although some of its views may require slight modification to harmonize with facts brought to light by later researches. Other works of importance comprise: Professor How's "Mineralogy of Nova Scotia, 1869;" Mr. R. Brown's "Coal Fields of Cape Breton, 1871;" Mr. John Rutherford's "Coal Fields of Nova Scotia, 1871;" and Mr. Heatherington's "Guide to the Gold Fields of Nova Scotia, 1868."

Much valuable information is also afforded by the Canadian Survey Reports, especially those by Dr. Sterry Hunt (1868) and Mr. Selwyn (1871), on the gold districts; and the reports of Sir. W. E. Logan and Mr. E. Hartley (1869), with those of Mr. C. Robb (1873), and Messrs. Robb and H. Fletcher (1874) on the coal regions of the Province. The annual reports of the Government Inspector of Mines, Mr. John Rutherford, are also valuable contributions to our knowledge of the mineral resources of the country.

Various reports and other communications relating to the geology or mineral locations of the Province, have likewise been published by Prof. Silliman, Mr. T. Creelman, Mr. P. T. Hamilton, Prof. Hind, Prof. How, Mr. Heatherington, Mr. H. Poole, Mr. John Campbell, the Rev. D. Honeyman, Mr. E. Gilpin, Dr. Bernard Gilpin, Mr. W. Barnes, Mr. Hicks, the writer, and others.

PROVINCE OF PRINCE EDWARD ISLAND.—A very complete report on the geological features of this Province, by Dr. Dawson, with the co-operation of Mr. Harrington, was published by the Canadian Survey in 1870. Other sources of information comprise: Dr. Dawson's "Acadian Geology," and the older Report (1846) on the Geology of the Island, by Dr. A. Gesner.

ADDENDA: MAPS:—A geological map of Ontario was published by Sir William Logan in 1853; and another, including the Province of Quebec, but on a very small scale, was attached to a little brochure—"Esquisse géologique du Canada, par W. E. Logan et T. Sterry Hunt"—issued in connection with the Paris Exhibition of 1855. Another map (on a scale of 125 miles to the inch) embracing a wider area, appeared in the collection of maps and sections, published with the Revised Report on the Geology of Ontario and Quebec, in 1863. This was followed a year or two later by the publication of the great geological map, on a scale of 25 miles to the inch, embracing the larger portion of British North America and the adjacent districts of the United States. Many other maps and plans of detached areas, by Mr. Murray, Prof. Robert Bell, Mr. Richardson, Mr. Robb, Mr. Vennor, and other officers of the Survey, including the present Director, Mr. Selwyn, are scattered through the various Reports of Progress. Valuable maps are also attached to many of the other publications cited above: as the map of Nova Scotia, &c., in Dawson's "Acadian Geology;" that of the Saskatchewan region in Hind's Report; and numerous others. A useful reproduction, in separate sheets, of the large map of the Survey, has been given in the Atlas of Tackabury, compiled chiefly by Mr. H. F. Walling, and in the New Standard Atlas of Walker and Miles. These atlases contain also brief notices of the Natural History, Geology, and Mineral Resources of the Dominion, contributed mostly by officers of the Geological Survey.

GEOLOGY OF CANADA.

INTRODUCTION.

I.

ROCK FORMATIONS GENERALLY—GEOLOGICAL PERIODS.

1.—Apart from the primary origin of their materials, of which nothing certain is known, the rock-masses which make up the solid portion of the earth have been formed by the same natural forces or agencies as those by which similar or closely related rocks are now being formed at various localities.

2.—These forces are of two general kinds: SURFACE FORCES—seen in the action of rain, frost, streams and rivers, moving ice-masses, sea-waves and currents, organic growth and decay, &c.—in operation at the earth's surface; and SUBTERRANEAN FORCES—amongst which heat undoubtedly plays the chief part—acting beneath the surface of the earth at unknown depths.

3.—The rock masses, thus produced, are consequently of two general kinds also: SURFACE-FORMED or EXOGYNOUS ROCKS, and SUBTERRANEAN-FORMED or ENDOGYNOUS ROCKS.*

4.—The surface-formed rocks are essentially *stratified rocks*, although in some of their representatives, as in the Lower Drift-clays more especially, distinct marks of stratification may be wanting or obscure. They are also essentially *sedimentary rocks*, made up for the greater part of sediments produced by the mechanical action of surface-forces on other rock-matters; but consisting in some cases of matters produced by chemical precipitation, or derived from animal or vegetable structures. As these sedimentary matters, moreover, are obtained or at least collected together and deposited by the action of water, the resulting rocks are also frequently known as *aqueous rocks*.

5.—The subterranean-formed rocks are essentially *unstratified rocks*—occurring in irregular masses, veins and dykes. They have been driven upwards for the greater part in a fused or more or less heated condition, through cracks and fissures in overlying rocks, and they are thus often known as *eruptive* or

* The terms *Exogynous* and *Endogynous* were first applied to these classes of rocks by HUMBOLDT. The term "Subterranean-formed" simply implies that the rocks of this class have been brought into their present form by the action of subterranean forces.

igneous rocks. Whilst the igneous origin, however, of many eruptive rocks, ordinary lavas for example, is undoubted, the actual mode of formation of other rocks of the eruptive series is altogether unknown. Hence the term "igneous," formerly applied to all unstratified rocks, is now but little used.

6.—In both the stratified and unstratified classes of rocks, two distinct conditions are present: a *normal* and a *crystalline* condition. The latter in some instances, and very probably in all, is not an original condition, but the effect of alteration or "metamorphism." This latter condition connects the two classes of rocks, as shewn in the annexed table:

Surface-formed Rocks	*Normal* (*e.g.*, sandstones, ordinary limestones, &c.)
	Crystalline or *Altered* (*e.g.*, gneiss, mica-schists, crystalline limestones, &c.)
Subterranean-formed Rocks	*Crystalline* (*e.g.*, granites, syenites, &c.)
	Normal (*e.g.*, traps, trachytes, lavas, &c.)

7.—The outer portion of the earth is principally made up of surface-formed rocks. These, viewed generally, have been originally deposited (in the condition of detrital, chemical, or organic sediments) in regular beds or layers in river estuaries, or over the floors of lakes and seas. Hardened or consolidated by the slow lapse of time, by the binding effect of their ferruginous or calcareous components, by pressure or other agencies, the strata thus formed have been subsequently elevated, by subterranean forces, above the level of the sea. The formation of rocks of this kind is seen, at present, in the enormous delta-accumulations under continuous increase at the mouths of many rivers; in the constant wasting of many sea-coasts by the action of the waves, and the deposition of the detritus, so obtained, over the adjacent sea-floor; and in the calcareous-mud deposits forming by organic agencies over vast areas of the open ocean. Also in the daily formation of bog ores, peat, calcareous tufas, salt deposits &c. With regard to the conversion of sub-aqueous deposits into dry land, it is now a well established fact that parts of the earth's surface are undergoing slow movements of elevation, whilst a gradual depression is taking place at other spots. At many localities, the land must have been elevated to considerable heights within a comparatively recent period. Shells of marine mollusca of existing species (evidently in their original beds or sandy burrows) are thus found at various elevations above the present sea-level—as on the Montreal Mountain, and at hundreds of other spots in widely separated regions.

8.—Stratified rocks have not only been elevated above the seas, estuaries, or lakes, in which, in the form of sediments, they were originally deposited, but in many cases they have been subjected to repetitions of upheaval and depression. In many cases also, they have been thrown out of their original horizontality, and have been fractured and displaced, and also folded or corrugated, by disturbing forces.* Partly also, during their elevation above the waters, or their

* For technical details of this kind, see the ordinary text-books. Also Part III. (pages 152 to 168) of the writer's "Minerals and Geology of Canada."

subsequent depression, and partly by the slow but continuous action of meteoric agencies, their surfaces have been more or less denuded and worn away ; and, in this manner most of the valleys and lesser inequalities of the earth have been produced.

9.—In the sedimentary accumulations now forming at river mouths and in lakes and seas, the shells of mollusca, bones of vertebrates, and hard parts generally of other animals—together with many sea-weeds, and the leaves and stems of land plants—are constantly enclosed.

10.—The remains of many of the plants and animals which lived upon the earth or in its waters in former ages, became entombed, in like manner, in the sedimentary accumulations then under process of deposition ; and these remains have thus to a great extent been fossilized and preserved, although very commonly in the form of casts or impressions only.

11.—By reference partly to super-position and other characters, but chiefly by the aid of the organic remains thus preserved in many strata, the latter generally (with their associated eruptive-rocks) have been subdivided into groups or formations, representing successive periods in the history of the earth. The geological periods made known to us by these formations, however, must undoubtedly have been preceded by others belonging to the earth's azoic time (see sec. 16), although no indications of these have been preserved to us, unless we see them, as still very commonly assumed, in some of the crystalline strata referred to the Eozoic age. With this understanding, the ages and conventionally-adopted periods of the earth's history may be tabulated as follows :—

Androzoic Age.	Existing Period. Glacial Period.
Cainozoic Age.	Pliocene Period. Miocene Period. Eocene Period.
Mesozoic Age.	Cretaceous Period. Jurassic Period. Triassic Period.
Palæozoic Age.	Permian Period. Carboniferous Period. Devonian Period. Silurian Period. Cambrian Period.
Eozoic and Azoic Ages.	Huronian Period Laurentian Period. Azoic, or Pre-Laurentian Periods.

12.—As the collective thickness of the rock-formations visible to us in the outer portion of the earth, at different localities, exceeds many thousands of feet, it is evident that a complete series of these formations can never be

exhibited at any one locality. But their relative order of succession is known by their observation at various spots. No departure from this order is ever exhibited: that is to say, a formation of the Devonian period, for example, is never found to underlie one of the Silurian period, nor a set of Cretaceous strata to occur below beds containing Jurassic or Triassic fossils. Gaps in the sequence are of common occurrence, however. Thus, at many spots, particular sets of strata are altogether wanting, lower and higher formations alone appearing: the latter consequently resting directly on the former. Gaps or breaks of this kind may have been occasioned by the elevation of the spot above the sea-level during the period to which the absent strata belong; or the missing beds may have been removed by denudation; or the spot may have been situated beyond the area of deposition to which the sediments then forming, extended.

13.—The strata of a given period necessarily vary, as regards mineral characters, in different localities. At one spot, the period may be represented by limestones, and at another by sandstones or beds of shale, &c., or by alternations of strata of different composition: just as in the seas of the present period calcareous sediments are being deposited in some localities, whilst accumulations of sand and mud are forming at other places. The names by which certain geological periods are unfortunately known, are thus, strictly considered, of local application only. The latter portion of the Mesozoic age is made known to us over a large portion of Europe and Asia by strata of chalk, whence the term "Cretaceous," bestowed upon the period generally. But chalk beds, even in Europe, do not make up the entire series of the known strata of the period; and on this continent, although "cretaceous strata" (as recognized by their fossil forms) occupy comparatively wide areas, no true chalk is found among them.

14.—Although each group of fossiliferous strata is characterized by special forms—*i.e.*, by organisms which do not appear in either lower or higher groups—no strict lines of demarcation can be drawn between the periods which these strata represent. The strata themselves are often separated by abrupt transitions, both physical and organic; but phenomena of this kind are purely local. Each period evidently merged gradually into that which followed it, as an ordinary historic or literary epoch is found to blend insensibly with preceding and succeeding times. The extinction of successive groups of organic forms, although partly to be accounted for by physical causes, is probably in chief part due to the slow action of a law of change and decay inherent in the type—as in the individual—at its birth or earliest origin.

15.—Regarded broadly, the higher strata contain the higher organisms; and many structural conditions, present as adult or permanent characters in early organic types, become embryonic or transitory in later forms, or are retained only in a rudimentary, useless condition. These and other concurrent facts point incontestibly to a progressive outcome or evolution from lower to higher

forms—arrested at many stages, but continuing in unbroken development along divergent lines.

16.—It is very generally assumed that the component matters of the earth and other cosmical bodies existed originally in a diffused nebulous condition, and gradually became condensed or solidified after passing through a state of igneous fluidity. And it is assumed, further, that this early molten condition of the earth is still retained in subterranean depths. This view—proposed by IMMANUEL KANT and maintained by LAPLACE—is necessarily hypothetical, but it is supported by many collateral facts, and has been very generally admitted.* If it be in the main correct, the rock-matters resulting from the first consolidation of the earth's surface must have been more or less akin to lavas and other volcanic products, although probably of a somewhat denser character from the greater density of the atmosphere then existing. No traces of these early lava-like rocks are now, however, visible. They must have been converted, long since, into other products, or have been re-melted and re-consolidated, probably time after time, beneath increasing thicknesses of superincumbent deposits. Sooner or later, after the first process of consolidation had set in, the continued radiation of terrestrial heat would allow the condensation of water to take place on the cooling surface of the earth. Then, a new set of phenomena would arise. The more exposed rock-surfaces would be worn down by aqueous and atmospheric agencies, and the materials thus obtained would form over the sea-bed a gradually increasing thickness of stratified deposits—most of which would undoubtedly be converted by subterranean agencies into crystalline or metamorphic formations. The earliest known rocks—those which underlie all other strata—are of this metamorphic character. They form vast beds of gneiss, mica-slate, hornblende-rock, chlorite-slate, quartzite, and other crystalline rocks, interstratified here and there with beds of crystalline limestone and dolomite. In some of these limestones, within the last few years, some obscure and fragmentary examples of a supposed Protozoan, belonging or related to the Foraminifera, have been discovered in Canada and at several European sites. A special genus has been framed for their reception under the name of Eozoon†; and the crystal-

*"There are the strongest grounds for believing that during a certain period of its history the earth was not, nor was it fit to be, the theatre of life. Whether this was ever a nebulous period, or merely a molten period, does not much matter: and if we refer to the nebulous condition it is because the probabilities are really on its side."—PROFESSOR TYNDALL: *Address before the British Association: Liverpool, 1870.*

†Examples of the *Eozoon Canadense* were first discovered in the Laurentian strata of Ontario by the late DR. WILSON, of Perth, and others were subsequently found in the crystalline limestone of Grand Calumet Island on the Upper Ottawa, by the officers of the Canadian Survey. Although their organic origin was strongly suspected at the time by SIR WILLIAM LOGAN, it was not definitely admitted until the publication of DR. DAWSON'S microscopic researches, followed by those of DR. CARPENTER in England. By many observers, however, the organic nature of these remains is still contested, and it cannot certainly be regarded as fully proved. One point, and a great point, in its favour, is the undoubted resemblance of the better preserved Eozoon structures to examples of Palæozoic *Stromatopora*. On the other hand, it is somewhat remarkable that no other form, with any pretensions to be considered organic, should as yet have been discovered in these Laurentian strata or in the less crystalline limestones of the succeeding Huronian series.

line strata in which they occur, and which were formerly classed as formations of the Azoic age, are now very generally known as "Eozoic strata."

17.—Viewed broadly, the rock-representatives of the earlier portion of the Palæozoic age—comprising ordinary slates, sandstones, limestones, &c.—are characterized, more especially, by the presence of graptolites, cystideans, and trilobites, associated with tabulated corals, a great abundance of brachiopods (including species of the still surviving genus *lingula*), and many examples of orthoceras—an extinct cephalopod with straight shell, and simple, unlobed septa. These earlier Palæozoic formations are also distinguished, negatively, by the general absence or extreme rarity of land plants and vertebrated animal remains. The middle and higher portions of the Palæozoic series—including the Upper Devonian, Carboniferous and Permian formations—contain, on the other hand, the remains of an abundant terrestrial vegetation, especially characterized by the presence of ferns and large equiseta (*calamites*), accompanied by peculiar types (*lepidodendra, sigillariæ*, &c.), some of which apparently indicate extinct transition groups between the higher acrogens and the gymnosperms of existing nature. In these higher Palæozoic strata also, the remains of cuirassed and other ganoid fishes, all of heterocercal type, occur more or less commonly; together with numerous tabulated-corals, crinoids, brachiopods, and cephalopods, related generally to earlier or lower forms—whilst graptolites and cystideans are no longer met with, and trilobites die out at the base of the Carboniferous beds. Among the cephalopods, however, genera with angulated septa (*bactrites, goniatites*) make their appearance, and thus foreshadow the advent of the more elaborately-lobed types of the succeeding age. Of the higher vertebrates, mammalia and birds are entirely unknown, and reptiles all but absent—the only undoubted examples of the latter occurring in Permian strata. The remains of labyrinthodont amphibians, on the other hand, occur throughout the Carboniferous and Permian formations.

18.—The succeeding strata, of Mesozoic age, are characterized essentially by the remains of numerous extinct types of reptilia of remarkable organization, including the paddle-footed Ichthyosaurians and Plesiosaurians, the winged Pterodactyls, the Dinosaurs, and many others. These strata are also especially distinguished by the ammonites and other genera of tetrabranchiate cephalopods with highly-lobed or foliated septa, which first appear in them, and which are altogether unknown in higher formations. Of these, the *ammonite* (as a genus) ranges throughout the entire Mesozoic series; the *ceratite* is confined to Triassic strata; and the *baculite, scaphite, ancyloceras, crioceras, turrilite*, &c., are entirely Cretaceous forms. The *belemnite*, a genus of the dibranchiate cephalopoda, known by its conical (internal) shell, is also especially characteristic of Mesozoic strata. Among the representatives of fish-life, homocercal forms appear; and in the higher or Cretaceous portions of the series the rapidly-diminishing ganoids become almost entirely replaced by teleosteans of modern type. Vertebrates, higher than reptiles, are exceedingly rare; but some bird remains of apparently reptilian character, referred to the

extinct genus *Archæopteryx* (distinguished by an elongated series of caudal vertebræ : an embryonic type of structure as regards existing birds), have been found of late years in Jurassic strata ; and a few small jaws and teeth, belonging most probably to marsupial mammals, are also known as Mesozoic forms. In the vegetation of the age, cycads and conifers stand out as dominant types—especially in its earlier and middle periods ; but monocotyledons are also represented throughout its series of strata, and dicotyledons appeared abundantly before its close.

19.—The organic remains entombed in Cainozoic strata present, collectively, a marked resemblance to those of the existing epoch. Angiosperms, except under local conditions, evidently formed, as now, the prevailing vegetation of the age ; but among the dicotyledonous types, gamopetala, as compared with polypetala and apetala, were apparently less numerous than at present. In the animal world, the crinoids, brachiopods, chambered cephalopods, ganoid fishes, and other types eminently characteristic of Mesozoic and Palæozoic periods, were no longer predominating forms, but were reduced to a few comparatively unimportant representatives. The reptilian characteristics of the Mesozoic age had also given place to higher modifications of vertebrate structure and organization. Placental mammals formed the leading or more characteristic types, and were abundantly represented. All Cainozoic orders still offer representatives : but many Cainozoic genera, and practically all the species, have become extinct ; and two orders at least, the Edentata and Proboscidea, exhibit marked decadency.

20.—During the Palæozoic and Mesozoic ages, and the earlier epochs of the Cainozoic age, the entire surface of the globe appears to have possessed a warm and comparatively uniform temperature, resembling that which now prevails in intertropical regions. This view is amply sustained by fossil evidence. The remarkable plant-remains, so abundant in the middle or higher Palæozoic strata, exhibit in widely separated regions the same aspect and characters. Those of Mesozoic formations, and also the characteristic reptilian and other types of the Mesozoic periods, exhibit the same law. The broad distinctions, due to geographical position, which now prevail, were absent also throughout the greater portion of the Cainozoic age, or only became indicated towards its close. Not only do we find, for example, in the Cainozoic strata of Northern Europe, and other comparatively high latitudes, the shells of conulariæ, nautili, and similar warm-sea mollusca, but these strata contain also many palm-fruits, with the remains of large ophidians, and the teeth and bones of mammals allied to the existing tapir, rhinoceros, hippopotamus, giraffe and other genera, now limited, or nearly so, to intertropical habitation. As time passed on, however, a great climatic change appears to have crept slowly over all the northern portions of both the eastern and western continents, and to have been experienced also in the extreme south. Under its influence, the once warm climate gradually gave place to all the rigours of an arctic winter. This remarkable change was evidently accompanied, and probably in chief part produced, by great alterations in the previously-existing

levels of land and sea. All the higher lands appear to have been covered by broadly-extended glaciers, whilst the seas were traversed by floating icebergs, bearing southwards the boulders and detritus of northern rocks. This condition of things was undoubtedly of long duration. Between its close and the actual commencement of the natural conditions now existing, no strict line of demarcation can be drawn. The one period merged slowly into the other, as the glacial manifestations were gradually beaten back to within the higher latitudes and alpine elevations in which they still prevail.

At some remote epoch of this later time, Man appeared upon the scene. His advent preceded the extinction of several important species and even genera of mammals: a fact which in itself goes far to prove the high antiquity of our race. The extinction of these types cannot be supposed to have taken place in any sudden manner, but was undoubtedly the result of slow organic and physical changes, proceeding continuously throughout long intervals of time. All the earlier tokens of man's presence on the earth—the rude flint and bone implements found in certain gravel-beds, associated in places with extinct mammalian remains—indicate a low state of civilization: a deduction sustained to some extent by the characters of certain human crania found in similar deposits. In later accumulations of detrital matter, as well as in many peat-morasses, etc., somewhat more finished types of stone utensils and weapons make their appearance; and these become replaced, in higher portions of the same deposits, by characteristic memorials of the so-called bronze and iron periods.

II.

ROCK FORMATIONS PRESENT IN CANADA.

21.—All the geological ages, enumerated above, are represented by rock-groups within the limits of the Canadian Dominion—the older formations appearing in some of the Provinces, the more recent in others. In the "Geological Outline" which follows this "Introduction," the rock-formations of the separate Provinces are described in reference to their more special characters and topographical relations, and the physical features of the districts in which they prevail are briefly given. In the present place—and chiefly to avoid the necessity of encumbering the Outline proper with general statements and details—it has been thought advisable to pass these formations under a preliminary review, with brief reference to their leading mineral characters and recognized subdivisions, their more characteristic fossils (where organic bodies are present in them), and the Provinces or regions in which they are principally seen. They comprise, in ascending order (see the Table of Geological Ages and Periods on a preceding page), the Laurentian, Huronian, Cambrian and Silurian, Devonian, Carboniferous, Permian (?), Triassic, Jurassic (?), Cretaceous, Cainozoic, Glacial, and Recent series.

LAURENTIAN SERIES.

22.—This series comprises two subdivisions: the *Laurentian (proper)*, below; and the *Labrador*, or *Upper Laurentian*, above.

23.—*Laurentian Formation.*—This is the oldest known formation on the surface of the globe. It is composed essentially of metamorphic or crystalline strata, comprising vast beds of micaceous and hornblendic (or syenitic) gneiss,* mica-schist, quartzite, and other siliceous and feldspathic rocks of allied character, with subordinate strata of crystalline limestone and dolomite, and beds of magnetic and specular iron-ore. Masses of unstratified granite and syenite occur amongst these in many places, and the strata generally present a granitic aspect. They occur, moreover, for the greater part in highly inclined and often contorted beds. The formation extends over all the northern portions of Quebec and Ontario, and is prolonged through the north-west to the Arctic Ocean. It is probable also, that extensive tracts in the eastern or maritime provinces are occupied by this formation.†

24.—*Labrador or Upper Laurentian Formation.*—This is represented chiefly by beds (more or less obscurely stratified) of feldspathic and augito-feldspathic rock,‡ associated in several places with large deposits of titaniferous iron ore. It has been hitherto only recognized in detached areas in the Province of Quebec, north of the St. Lawrence, where it overlies the Laurentian formation, proper. (See under the "Laurentide District," in the description of that Province.)

HURONIAN SERIES.

25.—The strata of this series, although presenting in places an estimated thickness of over 18,000 feet, are referred to a single group or formation. It is even probable that eventually they will be regarded as forming merely the higher portion of the Laurentian series; but at present their true position, in relation to the so-called Labrador or Upper Laurentian formation, is not positively known. The *Huronian formation*, viewed generally, is made up of evidently altered strata, but these present on the whole a less crystalline condition than the underlying Laurentian representatives. They consist, for the greater part, of hard siliceous slates and slate-conglomerates, commonly of a dark green or gray colour and occasionally striped; quartzites and quartz- or jasper-conglomerates; and beds of limestone, mostly of semi-crystalline aspect. No traces of fossils have hitherto been discovered in Huronian strata. In some localities the formation is broken through by vast dykes of trap or greenstone,

* In most of the Reports of the Geological Survey of Canada, crystalline hornblendic rocks, whether stratified or unstratified, are commonly referred to as "syenites." This term should properly be restricted to an eruptive or unstratified rock of essentially hornblendic composition and granitic aspect; but in many cases the stratification of these crystalline metamorphic rocks is exceedingly obscure, and the true nature of the rock, in consequence, becomes somewhat doubtful. In cases of this kind, however, it would be better to use the term "syenitic rock" than that of syenite, alone. Much of the so-called "syenite" of Nova Scotia is undoubtedly a syenitic gneiss, or a related hornblendic-rock of non-eruptive origin.

† For fuller descriptions, see under the respective Provinces in the "Geological Outline" following this "Introduction." See also, as regards the discovery of the *Eozoon* (a supposed Foraminifera or related Protozoan type), the note to sec. 16.

These rocks are often known as "anorthosites," from the character of their component feldspar. The latter is chiefly the triclinic lime-species or Labradorite, but it sometimes consists of a mixture of various triclinic species.

and its beds are interstratified also with trappean bands. They are likewise traversed by quartz-veins carrying copper pyrites and other metallic ores. The formation is chiefly developed on the north-west shore of Lake Huron, and over a large extent of country between Lake Huron and Hudson's Bay; but it occurs also in belts and patches about Thunder Bay and elsewhere in the Lake Superior region; and doubtfully in New Brunswick and Nova Scotia. (See the geology of these Provinces in the succeeding "Outline.")

SILURIAN (OR CAMBRIO-SILURIAN) SERIES.

26.—This group of strata is largely developed in Ontario and Quebec, and partially in Manitoba and in the Maritime Provinces. Its lower portion is separated, by many geologists, under the term of the Cambrian series; but the limits of this division are still undefined, and hence in the present work—in conformity with the practice of the Canadian Survey—the entire group is regarded as Silurian only. Its subdivisions, as recognized in Canada, are as follows :*

Upper Silurian Series.	Lower Helderberg or Eurypterus formation.	
	Onondaga or Gypsiferous formation.	
Middle Silurian Series.	Guelph formation.	
	Niagara formation.	
	Clinton formation.	
	Medina formation.	
Lower Silurian Series.	Hudson River formation.	
	Utica formation.	
	Trenton (including Black River and Bird's Eye) formation.	
	Chazy formation.	
	Sillery formation	Quebec group.
	Lauzun formation	
	Lévis formation	
	Calciferous formation.	
	Potsdam formation.	
	St. John's formation.	

27.—*The St. John's formation* consists essentially of black slates with some interstratified sandstones. These contain fossils of "primordial" type—species of *Agnostus*, *Paradoxides*, *Conocephalites* and other related trilobites, with various *lingulæ*, *discinæ*, &c.; but the formation has only been recognized, with certainty, in Southern New Brunswick (and in Newfoundland).

28.—*The Potsdam formation* is represented typically by fine or coarse quartzose sandstones, the latter passing into conglomerates. Fossils, as a rule, are not abundant in its strata. The more characteristic comprise: The brachiopod, *lingula antiqua* (distinguished by the triangular outline and broad margin of the shell); and certain supposed crustacean tracks, but some of

* Many of these subdivisions, it should be understood, are little more than groups of convenience, of local value only. But as they have been adopted by the Canadian Survey and by Canadian geologists generally, they are necessarily retained in the present "Outline." For topographical details, economic products, and other local characteristics in connection with these conventionally-adopted formations, the reader is referred to the descriptions of the separate Provinces in the body of the work.

the latter are probably the impressions of long sea-weeds, in part resembling the *arthrophycus* of higher strata. On their assumed crustacean origin, they are known as *Protichnites* and *Climactichnites* impressions. (*See* Plate I.) These Potsdam beds are developed chiefly in the Province of Quebec and eastern part of Ontario, as explained under these Provinces.

29.—*The Calciferous formation* is composed essentially of sandy and dolomitic limestones. In many places it can scarcely be separated from the underlying Potsdam beds. It is chiefly developed, with the latter, in the upper St. Lawrence district of Quebec, and in the lower Ottawa district of Ontario. Characteristic exposures, &c., are given in the description of these districts under the Provinces in question. Some of the more common fossils comprise: *Lingula Mantelli*, distinguished by its narrow uniformly-oval shell; *Ophileta compacta*; and *Orthoceras Lamarcki*, especially characterized by the salient bands or ridges around its shell. (*See* Plate I.)

30.—*The Lévis, Lauzun, and Sillery formations* comprise, collectively, a series of more or less altered and disturbed strata, known as the *Quebec Group*. They occur principally in the Eastern Townships, and on both sides of the St. Lawrence around Quebec, as described under the "Appalachian District" of that region. The Lévis formation is composed mostly of black slates containing numerous graptolites, as *Graptolithus Logani*, *G. flexilis*, &c., and species of the leaf-like genus *Phyllograptus*, as *P. typus* and others. (*See* Plate I.) Various brachiopods, and trilobites of somewhat "primordial" aspect are also present in these Lévis slates. The Lauzun, or middle formation, is chiefly made up of altered strata, amongst which magnesian-schists and serpentines predominate. It is essentially a metalliferous formation, and is especially characterized by its copper ores and chromic iron ore. The Sillery formation is mainly composed of red and greenish shales and dolomitic beds; but is represented by altered strata in some places—being at these spots scarcely separable from the Lauzun division—and by dark (Lévis-like) slates in others.* It is comparatively destitute of fossils.

31.—*The Chazy formation* is represented for the greater part by thin-bedded sandstones and hydraulic and other limestones, some of the latter yielding ornamental marbles of good quality. Many of these strata are highly fossiliferous. Some of the more characteristic forms comprise: *Lingula Lyelli*, distinguished by the comparatively quadrate shape of its shell; *Rhynconella plena*, a small species, exceedingly abundant; and *Camerella varians*, with ribbed markings on the lower portion, only, of its shell. (*See* Plate I.) The coral *Stenopora fibrosa*, so abundant in the Trenton and higher strata, with species

* If a separation of Cambrian from Silurian formations be desirable, the separating line should apparently be drawn here, and the St. John's, Potsdam, Calciferous, and Quebec formations be given to the Cambrian series. With regard to the divisions of the Quebec Group, something has yet to be learnt. The metalliferous Lauzun strata form undoubtedly the middle portion of the group, but owing to the disturbed and complicated character of the district in which these rocks chiefly occur, the relative positions of the other strata—or of some of the beds referred to them—seem somewhat questionable.

of *pleurotomaria*, &c., and various trilobites belonging to *Illænus*, *Ampyx*, *Asaphus* and other genera, occur also in those beds. The formation appears chiefly in the Lower Ottawa district of Ontario, and in the Upper St. Lawrence district of Quebec.

32.—*The Trenton formation* is made up essentially of both thick-bedded and thin-bedded or shaly limestones, mostly of a dark-gray colour, and highly fossiliferous. It is often subdivided into three series or so-called formations, comprising (in ascending order) the Bird's Eye and Black River formations, and the Trenton division, proper. Certain fossils are more abundant in the lower, and others in the higher portions of these strata; but the subdivision of the latter into distinct formations is quite arbitrary, and practically unnecessary. In its typical condition, the Trenton formation is largely developed in the region north of Lake Ontario and around the city of Ottawa; and also in various parts of Quebec, as around Montreal, &c. (For instructive exposures, &c., see the Lake Ontario and Lower Ottawa districts in the "Outline of the Geology of Ontario," and the Upper St. Lawrence district in the "Geology of Quebec.") Some of the more abundant or characteristic fossils comprise: The *Stromatopora rugosa*,* probably an extinct foraminiferous type, allied to the Laurentian Eozoon(?); the Corals: *Tetradium fibratum*, *Columnaria alveolata*,* *Favistella stellata*, *Stenopora fibrosa*, *S. petropolitana*, and *Petraia corniculum*; the Brachiopods: *Lingula quadrata*, *Orthis testudinaria*, *O. pectinella*, *O. tricenaria*, *O. lynx*, *Strophomena alternata*, *Leptæna sericea*, and *Rhynconella increbescens*; the Pteropod: *Conularia Trentonensis*; the Gasteropods: *Murchisonia gracilis*, *M. bellicincta*, *Subulites elongatus*, and others; the Heteropods: *Maclurea Logani**, and species of *Bellerophon*, as *B. bilobatus*, &c.; the Cephalopods: *Orthoceras bilineatum*, *O. proteiforme*, *O. Bigsbyi**, &c.; and the Trilobites: *Trinucleus concentricus*, *Asaphus platycephalus*, *A. megistos*, and *Ceraurus pleurexanthemus*. (*See* Plates II. and III.)

33.—*The Utica formation* is made up almost entirely of black or dark-brown bituminous shales. It occurs in the Lake Ontario district in the form of a narrow band running from Whitby to the vicinity of Collingwood on Georgian Bay, and from thence through the Great Manitoulin Island. It outcrops also, here and there, around Ottawa. In the Province of Quebec it is seen around Montreal, Longueuil, Lachine, &c., as well as at Beauport, and elsewhere below Quebec city. Its most characteristic fossils comprise: *Graptolithus pristis*: *Lingula obtusa* (distinguished by the rounded outline of its shell); and the trilobites, *Asaphus Canadensis* and *Triarthrus Beckii*. (*See* Plate III.)

34.—*The Hudson River formation* consists essentially of shaly thin-bedded sandstones, mostly of a greenish-gray or light-brown colour, but weathering rusty-brown. It occurs around Toronto on Lake Ontario, and largely on Georgian Bay, west of Collingwood; also in the Lower Ottawa district, as

* The species distinguished by an asterisk are more especially abundant in the lower (or Black River) portion of the formation. The list in the text does not of course give a tenth part of the species recognized in the Trenton strata of Canada, but it includes all the common or generally occurring forms.

described under the "Geology of Ontario;" and on both sides of the St. Lawrence in the Province of Quebec. Many of its fossils are identical with those of the Utica and Trenton strata, these three formations constituting, properly, a single group. The more common comprise: *Graptolithus bicornis; Stenopora fibrosa; Leptæna sericea; Strophomena alternata; Ambonychia radiata, Modiolopsis modiolaris; Cyrtolites ornatus; Orthoceras crebriseptum* (with beaded siphuncle); *Trinucleus concentricus, Asaphus platycephalus* (the *Isoteles gigas* of early American publications), and *Calymene Blumenbachii* (= *C. senaria* of some authors). (*See* Plate IV.)

35.—*The Medina formation*, with which the Middle Silurian series commences, is made up chiefly of red marls and soft red sandstones with some interstratified green shales, the whole capped by a bed of fine-grained sandstone known as the "gray band." Fossils are of rare occurrence in this formation. The principal comprise: a cuniform *lingula, L. cuneata;* and a transversely-ribbed fucoid, the *Arthrophycus Harlani* (=*Harlania Hallii* of Gœppert. *See* Plate IV.) The formation is largely developed at the mouth of the Niagara River and along the western side of Lake Ontario, from whence it extends in a north-westerly direction to Georgian Bay.

36.—*The Clinton formation* consists, at its lower part, of green and red, more or less ferruginous, shales; and at its upper part, of grayish dolomitic limestones. The lower beds might be referred legitimately to the Medina, and the upper beds to the Niagara formation. Fossils occur chiefly in the latter, and agree generally with Niagara species. In the lower shales the fucoid, *Arthrophycus Harlani*, and a small coral, *Heliopora fragilis*, are not uncommon. (*See* Plate IV.) The formation runs, in a comparatively narrow band between the Niagara River and Georgian Bay, along the line of the great Niagara escarpment (see under the "Geology of Ontario"), and from thence through the Manitoulin Islands.

37.—*The Niagara formation* is composed essentially of dark-gray dolomitic limestones and limestone shales. It forms the chief part of the abrupt cliff which runs uninterruptedly from the Niagara River to Georgian Bay and through the Manitoulin Islands, and it extends for some distance to the west and south of this escarpment, as described fully in the "Geology of Ontario" on a succeeding page. In the east, it appears to occupy the central and southern portions of the Island of Anticosti; and it probably forms part of the more or less altered Silurian strata of New Brunswick and Nova Scotia. In these eastern districts, however, it is not possible to partition off the Middle Silurian series into the conventional subdivisions adopted in the west. Many of the Niagara beds are rich in fossils. The more common species comprise: The corals: *Favosites Gothlandica* (=*F. Niagarensis*), and *Halysites catenulatus* (the so-called "chain coral"); the Bryozoon, *Fenestella elegans;* the Brachiopods: *Pentamerus oblongus, Orthis elegantula, Spirifer Niagarensis,* and *S. radiata;* and the Trilobites, *Calymene Blumenbachii* (ranging upwards from earlier strata), *Homalonotus delphinocephalus,* and *Dalmannites caudatus.*

38.—*The Guelph formation* consists of white or light-coloured dolomites of a peculiar sub-crystalline or granular texture. Most of its fossils are identical with those of the Niagara formation, but casts of a large lamellibranchiate, the *Megalomus Canadensis* (Plate V.), are highly characteristic. The Guelph dolomites occupy a considerable extent of country in the Erie and Huron district of Ontario. (For exposures, &c., see the "Geology" of this Province, in the body of the work.)

39.—*The Onondaga or Gypsiferous formation* is made up chiefly of yellowish dolomitic beds and greenish calcareous shales, enclosing in many places large lenticular deposits of gypsum. These strata appear to have originated in great part from chemical deposits thrown down in salt lakes or inlets of the sea in which rapid evaporation was going on, and they are practically destitute of fossils. They contain, however, many casts derived from crystals of common salt, prismatic sulphates, and other soluble bodies. The formation, as regards Canada, is confined to Ontario. It ranges from Grand Island, on the Niagara River, in a general north-westerly direction to the vicinity of the Saugeen on Lake Huron. (See under the Erie and Huron district, in the "Geology of Ontario.")

40.—*The Lower Helderberg or Eurypterus formation*, in Canada, occurs only in limited patches. One of these, in the form of thin-bedded dolomites and brecciated shales, outcrops near the eastern extremity of Lake Erie (see the "Geology of Ontario"); and others, mostly in the form of conglomerates of slight thickness, occur in small detached areas at St. Helen's Island and elsewhere in the neighbourhood of Montreal. Some of the "Gaspé limestones" appear also to belong to the same geological horizon. In the west, fragmentary examples of the extinct crustacean, *Eurypterus remipes* (Plate V.), characterize the formation.

DEVONIAN SERIES.

41.—This series of strata is developed somewhat largely in the Erie and Huron district of Ontario, and also in Manitoba. It has been recognized, likewise, in the North-west Territory and British Columbia; and eastwards, in the Eastern Townships of Quebec and Gaspé, New Brunswick and Nova Scotia (?). In the latter provinces, the strata occur in a more or less altered condition. In Ontario they are subdivided (in descending order) as follows:

Portage and Chemung formation.
Hamilton or Lambton formation.
Corniferous formation.
Oriskany formation.

42—*The Oriskany formation*, at the base of the Devonian series, is very slightly developed in Canada. It is composed essentially of beds of chert and sandstone. These, collectively, do not exceed eight or ten feet in thickness. The principal exposures occur in Bertie, Dunn, Cayuga, and adjacent townships, on Lake Erie. The Cayuga beds yield good mill-stones. Fossils are somewhat abundant. They comprise many well-known Middle and Upper

Silurian species, associated with Corniferous and other essentially Devonian types. *Favosites Gothlandica*, *Zaphrentis prolifica*, *Strophomena rhomboidalis*, *Atrypa reticularis*, and *Calymene Blumenbachii*, are some of the more common forms.

43.—*The Corniferous formation* is mainly composed of granular dolomitic limestones, interstratified with layers of chert or hornstone and some bituminous shales. Fossils are very abundant in these beds, and they are mostly in a silicified condition. The more common forms comprise: The Corals: *Michelinea convexa*, *Syringopora Maclurei* (with coarse cell-tubes), *S. Hisingeri* (with tubes of narrow diameter), and the simple horn-shaped types, *Zaphrentis prolifica*, and *Z. gigantea;* the Brachiopods: *Strophomena rhomboidalis*, *Atrypa reticularis*, *Spirifer gregarius*, *S. mucronatus*, *Spirigera concentrica*, and *Stricklandia elongata*—most of which occur also in higher Devonian strata. The trilobite *Phacops bufo* is also a common Corniferous type. (*See* Plate VI.) The formation occupies two extensive areas in the country between Lake Erie and the more southern portion of Lake Huron. Certain altered strata in the Appalachian region of Eastern Canada, and some of the "Gaspé sandstones" are probably also of the same age.

44.—*The Hamilton (or Lambton) formation* is named from Hamilton in the State of New York. It occupies a much higher geological position than that of the strata around Hamilton in Canada.* With us, the formation is made up of calcareous shales and beds of encrinal limestone. It fills a broad depression between the two Corniferous areas mentioned above, and is principally exposed in Lambton and adjacent counties. The main fissures or subterranean reservoirs from which the petroleum of Western Ontario is derived, appear to lie near the base of this formation, or in the still lower Corniferous strata, as described under the Erie and Huron district, in the "Geology of Ontario," in the body of the present work. Fossils are abundant in the Hamilton shale beds, but are identical for the greater part with Corniferous species. The following brachiopods, however, are met with more especially in this formation: *Spirifer mucronatus*, *Spirigera concentrica*, *Atrypa reticularis* (running upwards from the Middle Silurian series), and *Orthis Vanuxemi*. (*See* Plate VI.)

45.—*The Portage-Chemung formation* is represented in Western Ontario by dark, bituminous shales, holding large calcareous concretions and much iron pyrites, in places. It appears to extend over the country adjacent to Lake St. Clair and the southern extremity of Lake Huron, but is almost entirely concealed by over-lying Drift and superficial deposits. The only exposures are at Cape Ipperwash or Kettle Point, and at one of two spots in the town-

* When the geological formations of Canada were first traced out, the names bestowed on the same formations in the States were naturally adopted. Hence the "Hamilton formation," from Hamilton village, in Maddison county, New York. This name, however, as applied to our Canadian formation of the same horizon, has occasioned much misconception. It is constantly supposed to refer to our city of Hamilton, at the head of Lake Ontario. The writer has therefore been accustomed for some years to designate these strata as the Lambton formation, after the county of that name, in which they are largely developed, in Western Ontario.

ships of Brooke and Warwick. At these localities, the shales contain impressions of a long narrow calamite (*C. inornatus*), and some indistinct fish-scales.

CARBONIFEROUS SERIES.

46.—Strata of Carboniferous age are unknown within the Province of Ontario; and in Quebec they are seen only in the form of a partial development in Eastern Gaspé, where some of their lower beds, under the name of the *Bonaventure formation*, extend for considerable distances along the coast. In New Brunswick and Nova Scotia, on the other hand, the series is largely developed. Carboniferous strata appear also to occur within the Rocky Mountain ranges, but the great coal deposits of our Western Provinces belong to a much higher geological horizon. In the Eastern Maritime Provinces the series presents three more or less distinct divisions, comprising (in ascending order) the Lower, Middle and Upper Carboniferous formations.

47.—*The Lower Carboniferous formation* consists very generally of thick strata of limestone with associated beds of gypsum, interstratified with conglomerates, red and gray sandstones and argillaceous shales; but in some localities the limestone and gypsum beds are either absent or but sparingly represented. The calcareous strata contain many corals, brachiopods and other marine fossils of well-known Carboniferous genera; and the shells and sandstones contain ganoid-scales and coal-plants generally. Beyond a few unimportant traces, however, this Lower Carboniferous group is destitute of coal; but in some localities it contains workable beds of highly bituminous shale, known as "oil shale;" and in Southern New Brunswick (see under the "Geology" of this Province) a remarkable deposit of a similar bituminous character, but compact in texture and of vitreous aspect, fills a broad fissure in strata of Lower Carboniferous age. This substance, under the name of "Albertite," is largely worked as a gas-material.

48.—*The Middle Carboniferous formation* includes the coal-measures proper, and is thus commonly known as the productive portion of the Carboniferous series. In many localities its lower strata consist of thick beds of conglomerate, sometimes classed apart as the "Millstone-grit formation." This is succeeded by other conglomerates, sandstones, and argillaceous shales, interstratified with seams of coal and fire-clay, and containing numerous plant-remains. The fire-clay layers are commonly known as "underclays"—a layer being found under almost every seam of coal. The coal seams of this division in New Brunswick are of comparatively slight thickness, one only, of those at present discovered, averaging eighteen or twenty inches. But in Nova Scotia many seams exceed five and a half or six feet; and in the Pictou district two are of great thickness, one averaging over thirty, and the other over twenty feet. The principal coal areas of the latter province, as described in the body of the work, comprise the Cumberland and Pictou areas of Nova Scotia proper, and the Sydney area of Cape Breton.

49.—*The Upper Carboniferous formation* is made up essentially of sandstones, conglomerates and shales, and thus closely resembles in its component

strata the Middle formation, but it is practically destitute of coal. It occurs both in New Brunswick and Nova Scotia, and is seen also in some slight exposures on Prince Edward's Island. In the great central and eastern carboniferous area of New Brunswick, the unproductive lower and upper divisions, as pointed out by Professor Bailey and Mr. Mathew ("Geological Survey of Canada : 1870-71"), are very generally characterized by the red or purplish colour of their strata, whilst the productive beds of the middle division are for the greater part of a gray colour. These distinctions, however, are of local application only.

PERMIAN SERIES.

50.—Permian strata are of very doubtful occurrence within the limits of the Dominion ; but it has been conjectured that some of the red sandstones of the Bay of Fundy and Prince Edward's Island may perhaps belong to the series.

TRIASSIC SERIES.

51.—The strata of this series consist essentially of soft red sandstones, associated in places with a few thin beds of limestone and some calcareous conglomerates. They make up almost the entire surface-area of Prince Edward's Island, and occur also on the shores and some of the islands of the Bay of Fundy, where they are overlaid, for the greater part, by enormous masses of columnar and amygdaloidal trap. These Triassic strata are practically destitute of fossils ; but a few coniferous and other plant remains—with the lower jaw and teeth of a Dinosaurian (*Bathygnathus borealis*, Leidy)—have been found in the red sandstones of Prince Edward's Island.

JURASSIC SERIES.

52.—This series is also of doubtful representation in Canada, but the fossils of some of the coal-bearing strata of Queen Charlotte Islands (British Columbia) are apparently related to Jurassic types, whilst other fossils from the same strata are regarded as Lower Cretaceous forms. These strata are thus looked upon as probably indicating beds of passage between the Jurassic and Cretaceous series. (See Appendix II., by E. Billings and J. F. Whiteaves, to W. Richardson's "Report on the Coal Fields of Queen Charlotte and Vancouver's Island : Geological Survey of Canada, 1872-73.")

CRETACEOUS SERIES.

53.—Strata of Cretaceous age are largely represented in the North-west Territory, and in the Pacific Islands of British Columbia, but under a somewhat abnormal form as compared with the typical Cretaceous strata of Europe. Nothing in the shape of ordinary chalk occurs amongst them, but they consist mainly of sandstones and marly clays (with occasional beds of lignite-coal), as regards the North-west Territory ; and of sandstones, shales, and conglomerates, with coal seams and ironstones, in Vancouver and Queen Charlotte Islands. At the latter localities, consequently, these western Cretaceous strata present a very close resemblance to the ordinary coal measures ; but their Cretaceous age is rendered manifest by the presence in them of species of

Ammonites, Baculites, Belemnites, Inoceramus, and other characteristic types of Cretaceous or Upper Mesozoic character, together with examples of angiosperms and other plants unknown in lower strata.

CAINOZOIC SERIES.

54.—This series, like the last, is confined to the more western regions of the Dominion. It has been recognized, principally, as underlying a large portion of the central prairie lands of the North-west Territory, and the adjacent country along the eastern slopes or foot-hills of the Rocky Mountains. In this region, it is represented, generally, by horizontal or nearly horizontal beds of sandy clay, with interstratified layers of ironstone and lignite, much of the latter being of a comparatively dense and compact quality, and thus closely resembling ordinary coal. These beds rest conformably on the underlying cretaceous strata, and the two series appear to merge into each other, both stratigraphically and palæontologically, without the occurrence of any intervening break or strict line of demarcation. These lignite-bearing beds would thus seem to belong essentially to the Eocene or lower boundary of the Cainozoic series; but the subdivisions of the latter, as recognized elsewhere, are probably of very obscure separation in this region, and they have not yet been definitely traced out.

GLACIAL SERIES.

55.—This series, originating at the close of the Cainozoic age, or commencement of the present period, subdivides itself, although with no sharply-defined line of separation, into two sub-series or groups of formations, comprising the Drift or Glacial formation proper; and the Post-Glacial deposits.

56.—*The Drift or Glacial formation*, properly so-called, consists essentially of beds of clay and gravel, with boulders of crystalline and other rocks. These deposits extend, more or less generally, over the entire Dominion. They form two sub-formations: the *Lower or Unstratified Drift*, made up of beds of boulder-holding clay, devoid of any clearly marked stratification, and the *Upper or Stratified Drift*, also consisting of boulder clays and gravels, but occurring in distinctly stratified beds or layers. The harder rocks beneath these Drift accumulations are very commonly found to present a smoothed or even polished surface, crossed by fine lines or grooves, running, in the great majority of cases, in a direction not far removed from north and south. The associated boulders have also been derived, with few exceptions, from northern sources. They consist of rounded masses and pebbles of gneissoid and other rocks; and they are often smoothed and striated, like the rock surfaces on which they rest. They are regarded as having been transported southwards by the agency of ice; in some cases by floating icebergs, during the general submergence of the land; and in others, by glaciers. The Upper or Stratified Drift—the "Erie Clay formation" of the Geological Survey—has been extensively denuded in many places before the more recent Post-Glacial beds were deposited upon it. During the glacial epoch, generally, a great elevation of Arctic lands appears to have taken place, with a corresponding depression of adjacent regions to the south, by

which the latter became covered for the greater part by ice-laden seas, whilst huge glaciers formed around their higher points. Subsequently, the more northern lands appear to have been again lowered, whilst the ground with its scattered boulders and other Drift accumulations rose gradually in the south. During this latter time, the materials of the older Drift beds became partially stratified and re-arranged; various Post-Glacial deposits were accumulated upon them; and the arctic conditions, previously prevailing, receded slowly to the higher latitudes and alpine elevations in which they still exist.

57.—*The Post-Glacial deposits* consist essentially of stratified clays, sands, and gravels, which appear to have been derived in great part from the waste of the older Drift accumulations. Boulders are thus occasionally present in these deposits. In many cases the line of demarcation between Glacial and Post-Glacial formations is exceedingly obscure; but in some localities the higher deposits rest on the denuded surfaces of the Drift beds proper. (See under the Huron and Erie District, in the "Geology of Ontario.") In the Province of Quebec, and in the Eastern Maritime Provinces, these Post-Glacial deposits contain numerous shells of existing species of marine mollusca; and they have been sub-divided by Dr. Dawson into two formations: the *Leda Clay formation*, below; and the *Saxicava Sand formation*, above. The lower of these divisions is regarded as a comparatively deep-sea formation. It consists, essentially, of beds of more or less calcareous clay, containing shells of *Leda truncata* (= *L. Portlandica*), *Astarte Laurentina*, *Rhynconella psittacea*, and some other marine forms. The higher division, in its typical aspect, is a sandy deposit holding numerous shells of *Saxicava rugosa*, *Mya truncata*, *Tellina Grœnlandica*, *Buccinum undatum*, &c., together with fragmentary examples of a large Balanus (*B. Hameri*) and other littoral types. It is apparently, therefore, a shallow-sea deposit, formed in close proximity to the shore.

In Ontario, or rather in that portion of the Province lying west of the gneissoid belt which crosses the St. Lawrence between Brockville and Kingston, the Post-Glacial representatives appear to consist entirely of fresh-water deposits. These were formed, there is reason to assume, at a period when the western lakes stood at higher levels, and were united for the greater part into a single body of water—a vast inland, fresh-water lake—held up on the west by a greater elevation of the belt of rocky country referred to above, or perhaps by an enormous glacier or system of glaciers, radiating from the Adirondack mountain-district of New York. These deposits consist of clays, sands and gravels, mingled in many places with crystalline and other boulders, derived mostly, if not entirely, from older Drift accumulations. They belong to the Saugeen, Artemisia, and Algoma formations of the Geological Survey. The shells seen in them at various elevations, and in widely separated localities, are referrible to species of *unio*, *cyclas*, *amnicola*, *valvata*, *melania*, *planorbis*, *limnea*, *physa*, *helix*, and other fresh-water and terrestrial types. With these, the bones and teeth of the common beaver (*castor fiber*), wapiti (*Elaphus Canadensis*), black bear (*Ursus Americanus*), and other existing mammals are occasionally found, together with the remains of at least two

extinct proboscidians : the mammoth (*Elephas primigenius*), and the mastodon (*M. Ohioticus*).

RECENT SERIES.

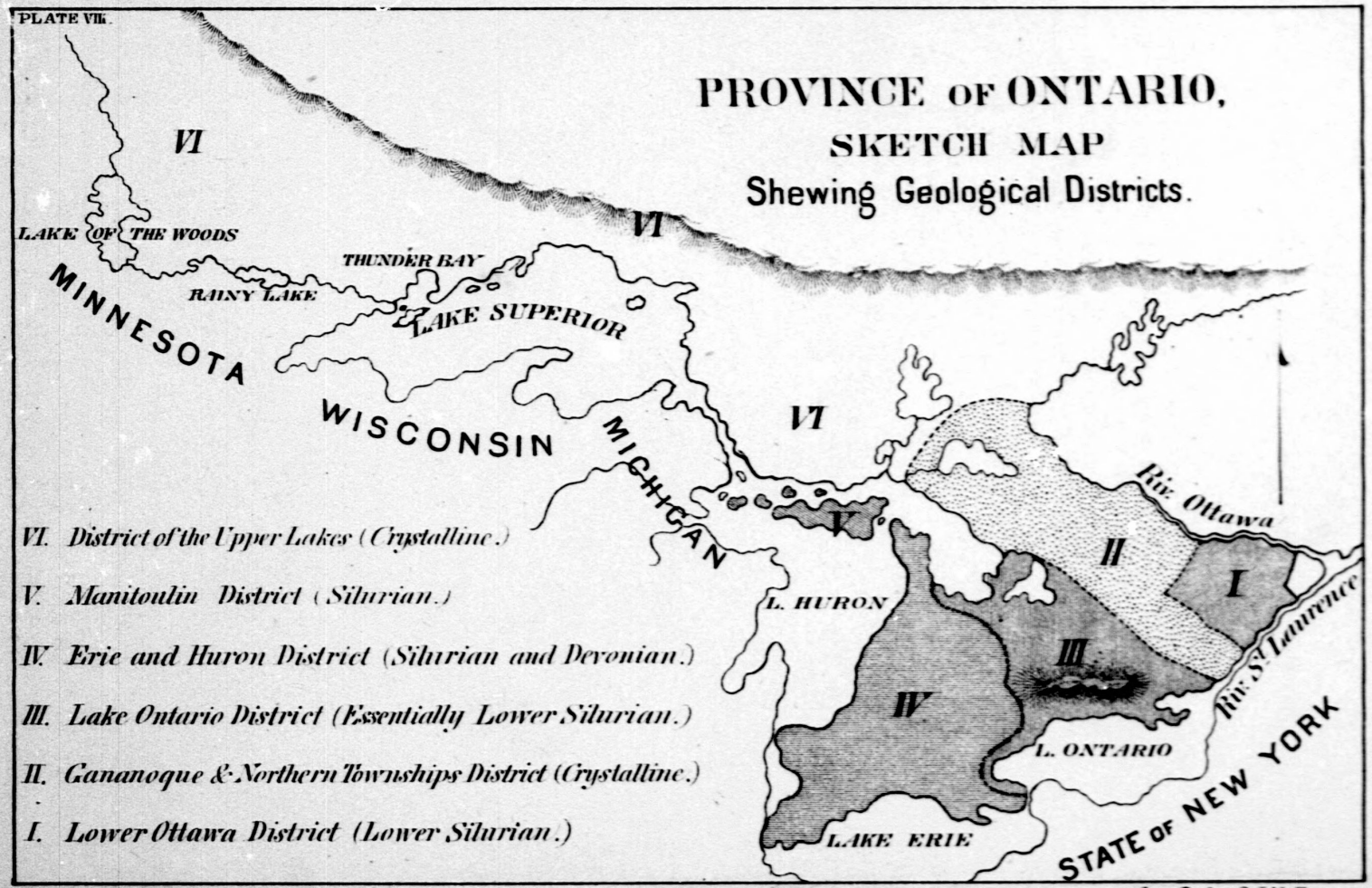
58.—This series includes a number of mineral deposits—with some deposits of organic origin—formed in recent times, or now under process of formation. As regards Canada, the principal comprise : Bog iron ores and ochres ; calcareous tufas and shell marls ; alluvial sands of river flats, &c. ; marine dunes and sand ridges ; shell-mud deposits ; and peat beds. These are referred to, in the body of the present work, under the Provinces in which they occur.

PLATE VII.

PROVINCE OF ONTARIO,

SKETCH MAP

Shewing Geological Districts.



VI. District of the Upper Lakes (Crystalline.)

V. Manitoulin District (Silurian.)

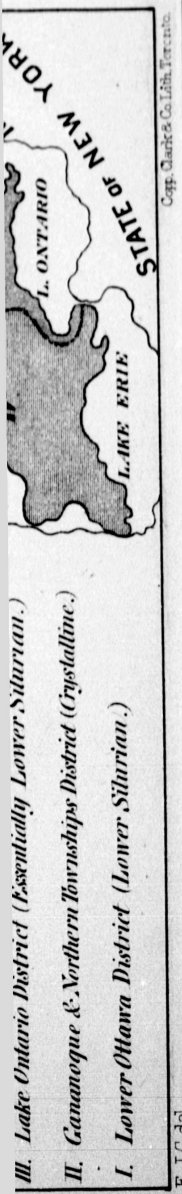
IV. Erie and Huron District (Silurian and Devonian.)

III. Lake Ontario District (Essentially Lower Silurian.)

II. Gananoque & Northern Townships District (Crystalline.)

I. Lower Ottawa District (Lower Silurian.)

E. J. C. del.



AN OUTLINE

OF THE

GEOLOGY OF CANADA,

INCLUDING ALL THE PROVINCES OF THE DOMINION.

The Dominion of Canada may be regarded as practically identical with the wide domain of British North America, although the Island of Newfoundland and some of the unsettled portions of this vast territory have not yet been formally included within its rule. It may thus be viewed as extending, in a general east and west direction, from the Atlantic to the Pacific Oceans; and northwards—from about the parallel of 45° in the east, 42° in the centre, and 49° in the west—to the shores and islands of the Arctic Sea. Upwards of three millions of square miles are comprised within these limits—an area nearly equal to that of Europe. The Dominion contains at present seven Provinces: THREE WESTERN PROVINCES—Ontario, Manitoba, (with the North-west Territory provisionally attached) and British Columbia; and FOUR EASTERN PROVINCES—Quebec, New Brunswick, Nova Scotia, and Prince Edward Island. In the following summary of their leading geological features, these Provinces are taken in the above order.

PROVINCE OF ONTARIO.

This Province extends westward along the north shore of the St. Lawrence and great lakes, from within a few miles of the junction of the Ottawa and St. Lawrence Rivers, to about the meridian of 45° W.; and in a northerly direction, it ranges to the belt of high land which forms the water-shed between the lake regions to the south, and the streams which flow northwards into Hudson's Bay.* It admits of a subdivision into six natural areas, more or less distinct in their physical and geological characters. These areas or districts

* The actual limits of Ontario in the west and north-west are still undetermined.

succeed each other from east to west in the following order:—(1.) The Lower Ottawa District; (2.) The Gananoque and Northern Townships District; (3.) The Lake Ontario District; (4.) The Erie and Huron District; (5.) The Manitoulin District; and (6.) The District of the Upper Lakes.

(1.) *The Lower Ottawa District.*—This is essentially an agricultural area, underlaid by Lower Silurian formations in comparatively undisturbed stratification. It occupies the country between the right bank of the Ottawa and the left bank of the St. Lawrence, extending to the Province boundary near the junction of these rivers. On the west, it is bounded by a line extending roughly from Brockville to the vicinity of Perth, and from the latter point to the Ottawa a little north of the mouth of the Madawaska. It presents a generally level surface, although some bold escarpments, in part connected with faults, occur within its limits, especially around Ottawa city, and in the townships of Cumberland, Alfred, L'Orignal and Hawkesbury. The height above the sea at the junction of the Ottawa and St. Lawrence rivers, is about 60 feet; and at the foot of the Chaudiére Falls, about 118 feet. From these levels, the district rises near its north-west boundary to about 400 feet, and its average elevation may be placed at from 250 to 300 feet above the sea. In some parts of Cumberland and other townships, extensive swamps occur, but viewed generally, the district is well timbered and of good fertility. The Rideau Canal passes through its central portion, and a large part of its more southern area is drained by the South Nation River, which rises near the St. Lawrence in Edwardsburg, and flowing north-east, falls into the Ottawa, in the township of Plantagenet.

A broad synclinal, with an intermediate fold, forms the floor of the country between the main rivers. The strata of the district belong entirely to the Lower Silurian series, but they are overlaid in many places by Drift deposits and more recent accumulations. The Lower Silurian beds comprise representatives of the Potsdam, Calciferous, Chazy, Trenton, Utica, and Hudson River formations.* The Potsdam strata are mostly sandstones and quartzose conglomerates, with a few interstratified beds of dolomitic limestone. They form a more or less continuous belt, of no great width, curving from the St. Lawrence below Brockville, north-west to the township of Bedford, and from

* For characteristic fossils, &c., see the brief "Introduction" attached to this Outline.

thence, in a general north-easterly direction, to Packenham on the Ottawa. Instructive exposures may be seen between Prescott and Brockville; at Charleston Lake, in Escott township; in the vicinity of Perth, (where the *Protichnites* and *Climactichnites* impressions [see "Introduction"] occur); at Otty Lake, in Drummond, and in the township of Nepean. The calciferous strata, which consist chiefly of dolomitic and arenaceous limestones—the "bastard limestones" of the country parlance—extend over a considerable area along the inner edge of the Potsdam belt, more especially in the counties of Leeds, Grenville, Lanark, Carleton and Russell. Exposures occur near Prescott, on the bank of the St. Lawrence; at Smith's Falls, &c., on the Rideau Canal; and at various points in Packenham, Beckwith, and adjoining townships. The Chazy formation, which follows, is composed, in this district, for the greater part of light-coloured, thin-bedded, sandstones, succeeded in places by gray or dark-browu limestone, largely employed in the manufacture of hydraulic cement. The formation occupies a zone of several miles in width on the east or inner margin of the calciferous area, but it is much concealed by overlying Drift deposits. Some of the more characteristic exposures are seen in the vicinity of L'Orignal, on the Ottawa, and at points in Hawkesbury, Cornwall, Huntly, and Nepean. Outlying patches of small extent occur also in the county of Renfrew, as at Pembroke, &c., but these lie entirely within the gneissoid region of the Upper Ottawa, and are thus referred to under the next district. The succeeding Black River and Trenton strata consist essentially of thick and thin-bedded limestones, mostly of a dark gray colour, and very fossiliferous. They occur in force around the city of Ottawa, as well as in Gloucester, Russell, Clarence, and adjacent townships; and outlying patches, associated with Chazy sandstones, lie beyond the limits of the district, in the crystalline gneissoid country to the north. Characteristic exposures, within the present district, occur at Barrack Hill (Ottawa city); Green's Creek in East Gloucester; near Dunning's Mills in Cumberland; near McCaul's Mills in Clarence; at the High Falls of the South Nation River in Cambridge; and at various sites in Lochiel, Kennyon and Cornwall. The Utica formation, represented here as elsewhere by dark-brown or black bituminous shales, occurs only in small areas around Ottawa city, and in parts of Cumberland, Clarence, and Plantagenet. The Hudson River strata are also but slightly developed in this district. They consist essentially

of thin-bedded calcareous sandstones, seen here and there in the townships of Osgoode and Russell, and at points near Ottawa city.

These Silurian strata, as stated above, are overlaid very generally by Drift deposits and other superficial accumulations. The Drift formation is represented by boulder clays in some places, and by gravel heaps and scattered boulders in others. These latter are arranged here and there in long ridges which occasionally cause obstructions and rapids in the river courses, as at Green's Creek and L'Orignal on the Ottawa. At Barrack Hill and other places around Ottawa, and also in other parts of the district, the limestones beneath the boulder clay often shew ice-grooves and other signs of glacial action. The grooves and striæ have mostly a south-east direction, but some are only a few degrees east of south. To these Drift or Glacial deposits proper, succeed in many places beds of stratified clay, sand and gravel, as a rule free, or practically free, from boulders. They contain shells of marine or estuary species of mollusca now living in the St. Lawrence Gulf. At Green's Creek, and at spots on the Madawaska, 200 feet above the present sea-level, some of these later deposits contain also calcareous nodules inclosing well-preserved examples of the capelin *(Mallotus villosus)*, lump-sucker *(Cyclopterus lumpus)* and other small fishes of existing species, with occasional impressions of modern leaves, as those of the *populus balsamnifera*, &c. To still more recent formations belong the deposits of shell-marl and peat, indicating the sites of ancient ponds and swamps, which overlie the surface rocks of the district in Cumberland, Plantagenet, Clarence, Gloucester and other townships. Several of these peat deposits are of wide extent.

In addition to good building-stones, the more important economic products comprise: The white sandstone of the Potsdam formation of Nepean, available as a glass material; the dolomitic limestone of the Chazy formation of the same township, which furnishes the celebrated "Hull Cement;" the "shell limestone," also belonging to the Chazy strata, which is largely dressed at L'Orignal for mantel-tops, tombstones, &c.; and the great peat beds referred to above.

(2.) *The Gananoque and Northern Townships' District.*—This geological area, lying immediately west of that just described, is of a very different character. The limestones and other unaltered and more or less horizontal strata of the Lower Ottawa country, are here

replaced by hard crystalline rocks, inclined, for the greater part, at high angles, and contorted or otherwise disturbed. These rocks belong essentially to the Laurentian series, but at one or two localities (see below) they are overlaid by small outlying patches of Lower Silurian strata. The district forms a narrow belt of rocky land extending along the St. Lawrence between Brockville and the vicinity of Kingston, but in its northern and north-western extension it widens rapidly and covers a large area. In its southern prolongation beyond the Province boundary, it crosses the St. Lawrence River into the State of New York, and, again expanding, spreads over the wild region of the Adirondacks between Lake Ontario and Lake Champlain. North of the river, it extends over Leeds and Renfrew, and embraces the back townships of the counties of Frontenac, Addington, Hastings, Peterborough, Victoria, and Simcoe—its southern boundary striking Georgian Bay near the mouth of the Severn. From this point it forms the shore of the bay to beyond French River. Its north-western boundary is to some extent a conventional line running from the latter spot to Lake Temiscamang. Strictly, perhaps, the district should not be separated from that of the Upper Lakes, but for descriptive purposes it is convenient to keep the two distinct. They present, moreover, certain points of difference. Both consist essentially of crystalline mineral regions; but in the lower district the gneissoid rocks are interstratified with many bands of crystalline limestone, containing various silicates and other minerals (apatite, graphite, &c.), whilst these limestone bands are apparently wanting in the more western country. In both regions iron ores abound; but those of the lower district are frequently titaniferous, whilst those of the upper district are as a rule practically free from titanium. Again, the overlying Huronian and Copper-Bearing rocks of Lake Huron and Lake Superior, with their associated beds and dykes of trappean rock, have not yet been definitely recognized within the present region, although some of the higher strata of North Hastings are thought to rest unconformably on the lower beds, and thus to represent Huronian equivalents.

The average elevation of the district is about 800 feet above the sea. Lake Nipissing, its highest body of water, lies at an elevation of 640 feet, but the ground to the south and east of the lake is considerably higher. The maximum elevation is probably about 1,000 feet. Numerous smaller lakes occur within its area; and an almost

continuous chain of these extends along its southern border. The surface generally is of a broken, hilly character, vast masses of gneissoid rock standing in many places high above the ground. The entire region, however, is more or less densely wooded.

The crystalline strata of the district, occupying practically its whole area, consist of micaceous and hornblendic gneiss, and various gneissoid rocks of allied character interstratified with subordinate beds of quartzite, crystalline limestone (or dolomite), and oxidized iron ore. These, as stated above, are mostly tilted at considerable angles, and are corrugated or contorted at many spots. The iron beds are occasionally in the condition of hematite, but consist generally of magnetic oxide. Gold-bearing pyrites and mispickel frequently occur in their vicinity. The crystalline limestones and dolomites are comparatively abundant. Some are of coarse, and others of fine granular texture, but their employment as marble is very commonly affected by the presence in them of crystallized silicates (pyroxene, phlogopite, tourmaline, zircon, wernerite, sphene, &c.), accompanied by other minerals, among which graphite in scales and plates, and apatite, in distinct crystals and crystalline masses, are especially frequent.* In some localities, however, these limestone bands are comparatively free from foreign substances.

At spots on the Bonnechere River in Renfrew, and around Pembroke, on the Upper Ottawa, in the same county, the gneissoid rocks of the district support small outlying patches of Chazy and Black River or Trenton strata. The Chazy beds are represented essentially by the light-coloured sandstone of the formation, and these, at Pembroke, furnish building stone of superior quality. The lower layers, which rest directly on gneiss, as seen especially at the Allumette Rapids, contain dark nodular masses of impure phosphate of lime mixed with shells of lingulæ, &c. These are thought to be coprolites. Black River limestones rest in places on the Chazy beds, and extend (in the Province of Quebec) over Allumette Island and across the river. At Paquette's Rapids they contain silicified fossils in great abundance. These Black River limestones appear also in

*The apatite crystals are of some interest in frequently presenting a complete terminal pyramid: the basal plane, so characteristic of apatite crystals generally, being entirely suppressed. Similar combinations occur in the crystals obtained from the phosphate beds and veins on the Quebec side of the Ottawa. Pointed apatites of this kind have hitherto been known only in the "moroxite" from Arendahl in Norway, and the "spargelstein" from the mountains near Jumilla in the south-east of Spain.

the outliers on the Bonnechere; and they occur in a few small patches near the southern border of the gneissoid region, in the vicinity of Madoc in North Hastings.

Over many portions of the district, unstratified clays with boulders, and higher or Post-Glacial stratified clays and sands, are distributed; and Glacial striæ are seen on exposed surfaces of many of the harder rocks. In some localities, as in most parts of Renfrew, the striæ have a very general south-easterly direction; whilst in more western sites, as about Lake Nipissing and Georgian Bay, and in the northern parts of Hastings, Peterborough, and Victoria, the prevalent direction is towards the south-west. Although not favourably adapted, as a rule, for agricultural occupation, the district contains valuable economic minerals. The principal of these comprise: The iron ores of McNabb, Bedford, Crosby, Sherbrook, Madoc, Marmora, Belmont, Limerick, Minden, Snowden, etc.; the auriferous mispickel of Marmora and adjacent townships; the galena of Frontenac, Galway, etc.; the apatites of Burgess, Elmsley, Bedford, Loughborough and Storrington; the mica of Burgess; and the marbles of McNabb, Fitzroy, Barrie and Elzevir.

(3.) *The Lake Ontario District.*—In this district we come again upon an agricultural area, underlaid by limestones, shales and other sedimentary rocks in comparatively undisturbed stratification. It ranges along the entire north and west sides of Lake Ontario. Its eastern and northern limits are bounded by the crystalline region described above. Its western boundary is the high escarpment which runs from the Niagara River near Queenston, at first in a general westerly direction to the back of Hamilton, then northwards by Dundas, Georgetown, Bellefontaine, and Orangeville, to the northern part of Nottawasaga, and from thence north-westerly by the "Blue Mountains," &c., to Cabot's Head on Georgian Bay. From the latter point eastward the district forms the shore of the bay to a short distance beyond the mouth of the River Severn. It thus includes portions of the counties of Frontenac, Addington, Hastings, Peterborough, Victoria, Simcoe, Peel, Halton, Wentworth, and Lincoln; with the whole of York, Ontario, Durham, Northumberland and Lennox. Numerous lakes, of which Lake Simcoe is the largest, lie within the district, and especially along its northern edge. The Trent, which rises in the Laurentian country to

the north, and flows through a series of small lakes into the Bay of Quinté, leading to Lake Ontario, is its most important river. Among other streams flowing into Lake Ontario, the principal comprise the Salmon, Moira, Humber, and Credit. In its surface features the district presents but few marked inequalities of level. The ground rises gradually from Lake Ontario (232 feet above the sea) in a series of ridges or terraces running in a general east and west direction. These ridges are composed of Drift materials, mostly sand and gravels filled with boulders of various kinds, brought down from northern sources during the Glacial and Post-Glacial epochs, probably by floating icebergs. The highest ridge in Albion and King townships has an elevation of from 700 to 750 feet above Lake Ontario, but becomes gradually lower in its eastern extension. Near the village of Stirling, in Hastings County, it averages 515 feet above the ordinary level of the lake; and a few miles east of this spot it merges into the general levels of the country. Lake Simcoe to the north is 704 feet above the sea, and Balsam Lake (the northern part of which lies within the crystalline area already described) is still higher, its elevation being 820 feet above the sea. Belmont Lake and Rice Lake are each nearly 600 feet, and Scugog Lake (in the midst of the Drift ridges) nearly 800 feet above the sea level.

The strata of the Lake Ontario District consist essentially of Lower Silurian formations, overlaid by Glacial and Post-Glacial deposits; but in its extreme western limits some of the lower beds of the Middle Silurian series, comprising the Medina and Clinton formations, occupy the ground. These strata, apart from a few subordinate anticlinals, exhibit a slight inclination only towards the west or south-west; and they are altogether free from intrusions of trappean or other eruptive rocks. In ascending order, and succeeding each other in successive outcrops from east to west, they comprise representatives of the Potsdam, Black River and Trenton, Utica, Hudson River, Medina, and Clinton formations.

The Potsdam formation is very sparingly represented. It occurs in the form of a thin band (or in broken patches) of sandstone and conglomerate lying along the south-western edge of the crystalline gneissoid region in the townships of Loughborough and Storrington. Exposures occur on Loughborough Lake and on Knowlton and Eel Lakes. Some of the beds in Storrington are readily friable, and yield a refractory sand employed as a lining for iron furnaces.

The Trenton formation (including its lower or "Black River" beds) is represented essentially by dark gray limestones and limestone shales, in places exceedingly fossiliferous.* Some of its beds yield excellent building stones; and towards its lower portion a band of lithographic stone runs from the vicinity of Kingston through Marmora, &c., to Georgian Bay. The thickness of the formation in this district averages about 700 or 750 feet. The northern boundary runs from the St. Lawrence, a little east of Kingston, through North Hastings, Peterborough, Victoria, Ontario, and Simcoe, to near the mouth of the River Severn in Georgian Bay—a chain of small lakes indicating its course throughout the greater part of the distance. North of these lakes gneissoid Laurentian rocks occur in highly tilted beds, whilst the Trenton (or Black River) strata, to the south, occupy a nearly horizontal position. The southern boundary of the formation constitutes the coast of Lake Ontario from Kingston to a little west of Cobourg; and from the latter point it turns towards the north-west, and passing across Durham, Ontario and Simcoe, comes out on Nottawasaga Bay a few miles west of Collingwood. The intermediate country, however, is more or less thickly overlaid by Drift and other superficial deposits. Characteristic exposures are seen at the following spots: Kingston city and environs, where the limestone beds contain in places crystallized examples of celestine, gypsum, &c.; Crow River, near Marmora; Shannonville; River Moira, near Belleville; Ox Point, Bay of Quinté; Rednersville, on the southern shore of the bay; Trenton, Healy's Falls, and other places on the Trent River; environs of Peterborough; lake shore at Cobourg; Balsam Lake, south shore; Fenelon's Falls; River Scugog near Lindsay; Lake St. John and north-east shore of Lake Couchiching.

The Utica formation is made up almost entirely of dark brown or black bituminous shales. These weather light gray, and yield by atmospheric disintegration a very fertile soil. The formation ranges along the lake shore from near Cobourg to the township of Pickering, and sweeps from these points towards the north-west, coming out on Nottawasaga Bay; but in the intervening district it is concealed by overlying Drift deposits. The best exposures occur near Whitby, and under the "Blue Mountains" west of Collingwood. The formation averages in thickness from 80 to 100 feet.

* For characteristic types, &c., see the "Introduction."

The Hudson River formation is essentially represented by greenish-gray and brown shaly sandstones. Its total thickness in the district is about 750 feet. It forms the shore line of Lake Ontario from the River Rouge to the River Credit. From these points, although much obscured by overlying Drift and more recent deposits, it extends to the north and north-west, and forms the shore of Nottawasaga Bay in the townships of Collingwood, St. Vincent, Keppel and Albemarle. Instructive exposures (from most of which fossils may be collected) occur on the banks of the Humber, Mimico, Etobicoke and Credit; also at Point Boucher on Nottawasaga Bay, and at Cape Rich, Point William, Cape Crocker, and Point Montresor, further west.

The Medina formation is chiefly made up of red marls and soft red sandstones, associated with some red and green arenaceous shales, and capped generally by a bed of gray sandstone. The latter, known as the "gray band," is extensively quarried for building purposes in Nottawasaga, and at Dundas, Hamilton and elsewhere. The formation extends westward from the River Credit to the escarpment at Hamilton, and forms (with the less developed Clinton beds) the strip of country lying between the escarpment and the lake as far as the Dominion boundary on the Niagara River. Northwards it passes through East and West Flamborough, Nelson, Caledon, Mono, Mulmur and Nottawasaga; from whence, turning westward, it continues along the base of the escarpment towards Cabot's Head. Good exposures occur at Queenston and in the vicinities of St. Catharines, Hamilton, Wellington Square, Dundas and Georgetown, and at the Dinnis quarries in Nottawasaga.

The Clinton formation is mostly represented by green, red and gray shales, highly ferruginous in places, with some interstratified dolomitic limestones. Its thickness varies from a few feet on the Niagara River, to about 180 feet on the south shore of Georgian Bay. It follows the general course of the great escarpment, as given above: and exposures occur more especially at the following places: on the Welland Canal near Thorold; in the vicinity of Hamilton; in road cuttings about Dundas; in the gorges of the Noisy and Mad Rivers in Nottawasaga; at spots on Beaver River; in the cliffs near Owen Sound and along the Sydenham River; and at Cape Commodore, Cape Chin, etc., on Georgian Bay. The celebrated Thorold cement is manufactured from a hydraulic limestone of the Clinton formation.

As already stated, the greater portion of the Lake Ontario District is overlaid by clays, sands, and gravels of the Glacial and Post-Glacial periods, by which the underlying rocks are much concealed. Beneath these deposits the limestone strata, especially, are found very generally to be striated and polished by glacial action. The striæ run in some places towards the south-west, and in others towards the south-east; and the same rock-surface frequently exhibits both S.W. and S.E. striations. Many fresh-water shells, identical in species with those now living in our lakes and streams, occur at various levels in the succeeding Post-Glacial accumulations; and their presence in these deposits apparently indicates the former union of our lake waters into one vast freshwater sea, held up on the east by a greater elevation of the gneissoid belt of rock which crosses the St. Lawrence between Brockville and Kingston, and expands into the wild district of the Adirondack Mountains in the State of New York; or perhaps by an enormous glacier descending from this elevated region and extending northwards into Canada. Bones and teeth of the beaver, wapiti, and other existing mammals are also occasionally found in these higher deposits, together with at least two extinct types: the mammoth, an extinct species of elephant; and the mastodon, a related, but entirely extinct, proboscidean genus. Both the Glacial and Post-Glacial accumulations are often overlaid in places by deposits of still more recent origin. The principal of these, in the Lake Ontario district, consist of beds of shell-marl, a white or light-coloured calcareous deposit containing minute shells of fresh-water mollusca. This substance occurs at numerous localities, mostly around small lakes and swamps. It consists entirely of carbonate of lime with intermixed sand in variable proportions.

(4.) *The Erie and Huron District.*—This section of country—occupied throughout by comparatively undisturbed limestones and other Silurian and Devonian strata, with overlying Drift clays and sands, and more recent superficial deposits—is essentially an agricultural area, and one of great fertility. It lies immediately west of the Lake Ontario District, and is separated from the latter by the edge of the great Niagara escarpment, which runs, as stated above, from the Niagara River—by Queenston, Thorold, Grimsby, Hamilton, Dundas, Georgetown, &c.—to Cabot's Head on Georgian Bay. On the south, the district is bounded by Lake Erie; and on the west,

by Lake Huron. The greater portion of its area forms an elevated table-land of from 1,000 to 1,200 feet above the sea. Along its north-eastern edge the ground rises in places to an altitude of nearly 1,600 feet; but it slopes gradually towards Lake Erie on the south (565 feet above the sea), and towards Lake Huron (578 feet above the sea-level) in the west. Its surface, except where cut by river-valleys, is generally even; and the district presents a marked contrast to the lower region of Lake Ontario by the almost total absence of inland bodies of water. It is traversed, however, by many important rivers, and especially by the Grand River, flowing into Lake Erie; the Thames, flowing into Lake St. Clair; and the Maitland and Saugeen, flowing into Lake Huron. The eastern and north-eastern boundary, along the great escarpment, is also cut through by numerous smaller streams. These enter the Lake Ontario District, consequently, through deep ravines, many of which are of a very wild and picturesque character.

The strata of the district consist, in its more eastern portions, of Middle and Upper Silurian representatives, with various Devonian formations in the west. They follow each other (in ascending order) from north-east to north-west, generally, and comprise: The Niagara formation (with some Upper Clinton beds) and the Guelph formation, of the Middle Silurian series; the Onondaga or Gypsiferous, and the Eurypterus or Lower Helderberg formations, of the Upper Silurian series; and the Oriskany, Corniferous, Hamilton or Lambton, and Chemung-Portage formations, of Devonian age. These strata, although practically undisturbed, are affected by several moderate anticlinals running across the more central part of the district in a general east and west or south-west direction; and it is thought that the petroleum of this part of the region has been brought towards the surface by fissures resulting from these anticlinals. A transverse or nearly north and south fold, forming a trough or synclinal filled with higher Devonian strata (of the Hamilton or Lambton formation), also occurs in the south-western portion of the district between Lake Erie and the south point of Lake Huron.

The Niagara formation, in this district, is made up of dark gray calcareous shales and thick-bedded limestones, both of which are more or less magnesian and bituminous. Its lower limit is regarded, conventionally, as indicated by a magnesian limestone holding shells of the

brachiopod *Pentamerus oblongus*;* but this "Pentamerus bed" is referred by the New York geologists to the upper part of the underlying Clinton formation. At Niagara Falls, the dark shales present a thickness of about 80 feet, and form the lower portion of the escarped face over which the cataract breaks, whilst the upper portion of the cliff is composed of thick-bedded limestones. Along the gorge, the shales are mostly concealed by the slope or talus of detrital matter which rests against the cliff face; but they may be seen on the side of the steep road which leads from the old ferry to the Clifton House, and at several other spots. Some of the beds of this formation yield excellent hydraulic lime, much of the "Thorold cement" being manufactured from the lime obtained from them. The formation extends a few miles westward from the edge of the great line of escarpment—already described as running from the Niagara River, by Hamilton, Georgetown, &c., to Cabot's Head on Georgian Bay—and then passes under the succeeding Guelph formation. It thus marks the eastern and northern limits of the table-land of which the Erie and Huron district largely consists. Good exposures occur more especially at the Niagara Falls and on the adjacent banks of the river (where the limestones are overlaid by terraces of fresh-water clay and sand of Post-Glacial age); also on the Welland Canal near Thorold; along the upper part of the escarpment or "mountain" by Grimsby, Hamilton, Dundas, Ancaster, Rockwood, &c.; on the River Credit in Caledon, as at Bellefontaine and elsewhere, and on the Nottawa and Beaver Rivers, where it forms high and precipitous cliffs; at various other points in Mulmur, Nottawasaga, Artemisia, and Euphrasia; about Owen's Sound; and at Cape Paulet, Cape Chin, and the upper part of Cabot's Head. In the immediate vicinity of Rockwood, some large caverns occur in a dolomitic limestone (thickly interspersed with crinoid stems) belonging to this formation; and deceptive veins and strings of galena have been noticed in the same township (Eramosa), as well as in the Niagara strata of Mulmur and Clinton.

The Guelph formation is represented for the greater part by white or light-coloured dolomites of a peculiar semi-crystalline or granular texture, containing, among other fossils, large casts of a lamellibran-

* See Figures 61 and 62. Lists of characteristic fossils, belonging to the various formations of the district, are given in the "Introduction."

chiate mollusc, the *Megalomus Canadensis*. (*See* Figure 68.) The formation extends over a considerable area, chiefly in the counties of Waterloo, Wellington, and Grey, but it is greatly concealed by overlying Drift and other superficial deposits. The principal exposures occur on the River Speed in the vicinity of Guelph; at Elora, near the junction of the Grand and Irvine Rivers, where the strata form high cliffs; also on other parts of the Grand River, as at Fergus, Preston, and Galt; near Hespeler, again, on the railway between Guelph and Brantford; and on the Rocky Saugeen River in Bentinck. At most of these localities excellent building-stones are obtained.

The Onondaga or Gypsiferous formation (with which the Upper Silurian series is assumed to commence) consists, in Canada, of thin-bedded dolomites of a yellowish or pale gray colour, associated with greenish calcareo-argillaceous shales, and with large masses or irregular beds of gypsum. These deposits appear to have been largely formed from precipitates thrown down in ancient salt-lakes or bays in which an active evaporation was going on. They contain only a few obscure traces of organic remains; but hopper-shaped and prismatic casts, derived from crystals of ordinary salt, soluble sulphates, &c., are not uncommon in some of their beds. The gypsum is mostly of an earthy or granular texture, and is always more or less mixed with carbonates. The formation enters Canada a short distance above the Falls on the Niagara River, and includes the whole of Grand Island in this portion of its area. From thence, it follows the general outcrop of the Guelph formation to the vicinity of the Saugeen River on Lake Huron. It thus includes portions of Welland, Haldimand, Brant, Oxford (north-east corner), Waterloo, Perth and Bruce; but throughout much of this area it is covered by Glacial and other superficial deposits. Exposures may be seen near Waterloo village, Bertie township, on the Niagara River; along the Grand River between Cayuga and Paris, and near the Don Mills; on the Upper Saugeen, near Ayton and Neustadt, in Normanby township; around Walkerton on the Saugeen, in Brant, and at various points down the river; as at the elbow in the south-west corner of Elderslie, a little below Paisley. The gypsum or "plaster" deposits are chiefly quarried at Cayuga, Indiana, and York, in the township of Seneca; at Mount Healy and elsewhere in Oneida; largely around Paris; and at various places in

Brantford township. Some of the dolomitic and argillaceous shales of the formation, as those which outcrop near Walkerton, &c., furnish valuable material for the manufacture of hydraulic cement; and it is apparently from this formation that the brine—obtained in the vicinities of Goderich, Seaforth and Clinton, by deep borings through overlying deposits—is essentially derived.

The Lower Helderberg or Eurypterus formation, as occurring in this district, represents merely a small portion of the "Lower Helderberg group" of New York. It is made up of a few thin-bedded dolomites, with some interstratified shales and a brecciated bed (composed chiefly of dolomite fragments) at its base. These strata, which collectively do not exceed fifty feet in thickness, appear to represent the lower portion—the "Water-lime" or "Tentaculite limestone"—of the Helderberg series proper. They are chiefly characterized by the presence of fragmentary examples of a peculiar crustacean, *Eurypterus remipes* (*see* Figure 69), belonging to the Merostomata, an almost extinct order, but represented in existing nature by the Limulus or Xiphosure. The formation probably extends as a thin band along the western border of the Onondaga formation between Lake Erie and Lake Huron, but the only known exposures are in the Lake Erie townships of Bertie and Cayuga.

The Oriskany formation, the first in ascending order of the Devonian series, is also but sparingly present in the district. It is represented chiefly by a layer of chert or hornstone (containing much iron pyrites) at the base, with a succeeding brecciated bed (made up in part of chert fragments), and some quartzose grits or sandstones: the entire thickness varying from about six to ten feet. Its fossils (see "Introduction") are chiefly identical with those of the overlying Corniferous strata, but are mixed in places with Middle and Upper Silurian types. The formation enters Canada in the township of Bertie in the north-east corner of Lake Erie, and appears to run as a thin band along the southern edge of the Eurypterus or Onondaga formation at least as far as the county of Norfolk; but the only known exposures occur in Bertie, Dunn, North Cayuga, Oneida, and Windham. From the exposure in North Cayuga, a little north of the Talbot Road, good millstones have been quarried.

The Corniferous formation, as recognized in Western Canada, includes the "Onondaga limestone" and "Corniferous limestone" of New York geologists. It is made up essentially of more or less

bituminous limestones, containing, in places, nodular masses of chert, or interstratified with bands of that substance, and associated here and there with beds of calcareous sandstone and bituminous shale. The thickness of these strata, collectively, is estimated at about 200 feet. The limestones contain, as a rule, a great abundance of silicified fossils, mostly brachiopods, corals, and crinoidal stems. (See "Introduction;" also Plate VI.) In the district under review, the formation occupies two large areas, separated by a broad intervening belt of the succeeding Hamilton or Lambton formation. The more eastern of these areas extends over portions of Welland, Haldimand, Norfolk, Brant, Oxford, Perth, Huron and Bruce; and the western area occupies parts of Lambton, Kent and Essex. Exposures occur more particularly on or near the shore of Lake Erie in the following townships: Bertie, Humberstone (as at Rama's farm, near Port Colborne, a noted fossil locality), Dunn, Rainham, Walpole and Woodhouse. Also in North and South Cayuga; near Woodstock village; and at St. Mary's (another locality especially rich in fossils). The formation outcrops likewise at various places in Carrick, Brant, Bruce and Kincardine; and again, farther south, as near Port Albert and Goderich, and in the vicinity of Amherstburg in Malden. At many of these localities, and especially at the large exposure in Malden, building stones of very superior quality are obtained.

The Hamilton or Lambton formation,* as defined in Canada, represents merely the middle portion of the "Hamilton formation" of the New York geologists. It consists mainly of soft calcareous shales associated with some beds of encrinal limestone. The fossils are identical for the greater part with those of the Corniferous formation. (See "Introduction.") The formation in this district is estimated at about 250 feet in thickness. It extends across the counties of Norfolk, Elgin, Kent, Middlesex and Lambton, and also the south part of Huron, but is much obscured throughout this area by overlying clays, sands, and other Drift and superficial deposits. The best exposures occur in the township of Bosanquet, in the north-west

* The name by which this formation is commonly known, is derived from the village of Hamilton, in Madison county, New York. It is often supposed, in Canada, to refer to our city of Hamilton, on the western extremity of Lake Ontario, where the strata belong to a much lower horizon—that of the Medina formation, lying at the base of the Middle Silurian series. In consequence of this very prevalent misconception (of which some curious instances might be given), the writer proposed some years ago to call this group of strata, as occurring in Canada, the *Lambton formation*, after the county in which it is principally developed in Western Ontario.

Hamilton
Spirifer Macronalis
Spirifera Concentrica
Atrypa Reticularis

corner of Lambton. The formation is chiefly of interest as constituting the essential petroleum area or *oil district* of Western Canada, although the deeper borings, from which the petroleum is chiefly obtained, appear to pass through its strata into the underlying Corniferous formation. Natural springs have been noticed in various parts of the region, as in Mosa, Enniskillen, Zone, Orford, &c. In the township of Enniskillen, overflows from springs of this kind have formed deposits of solid bitumen or "mineral tar," varying in thickness from an inch or two to nearly a couple of feet, and extending over an acre or more of ground. One of these deposits or "gum beds," in the northern part of the township, is covered by several feet of Drift clay; and in places it presents a leafy or shaly texture, and contains impressions of leaves and insects. As proved by the very different results obtained in many instances from closely contiguous borings, the petroleum is evidently confined to comparatively narrow and tortuous channels, within limited belts of country. These belts are characterized, both in the United States and Canada, by the presence of anticlinals, by which a more or less fissured condition of the strata has been produced. The petroleum in these fissures is almost always accompanied by salt or brackish water, and inflammable gas is usually emitted on the first tapping of the fissure. As a rule, the wells become gradually impoverished, and frequently end by yielding water only. The petroleum, as first obtained, is of a dark colour, and more or less viscid consistency. When decolourized and purified it loses about forty per cent.—five barrels of crude oil yielding about three barrels of refined oil.

The Portage, or Portage-Chemung formation, as seen in Canada, is made up of dark bituminous shales, holding in places large calcareous concretions, and also much iron pyrites, with occasional fish-scales and impressions of long-flattened stems of a calamite. Here and there these shales become coated, by weathering, with a yellow crust of oxalate of iron. The formation extends probably over a considerable area around Lake St. Clair and the adjoining country; but it is thickly overlaid by Drift and superficial deposits throughout the greater part of this area, and the only well-recognized exposures occur at Kettle point, or Cape Ipperwash, in the township of Bosanquet, on Lake Huron, and at one or two places in the townships of Warwick and Brooke. As seen at these spots, the thickness of the formation does not exceed twelve or fifteen feet.

Deposits of Glacial, Post-Glacial, and Recent age are spread very generally over the Silurian and Devonian strata of the Erie and Huron district—a wide break in the geological succession occurring in this region, as in other parts of the province. These deposits may be referred, in ascending order, to five more or less distinct series, as follows: (*i.*) Lower Drift clay formation; (*ii.*) Upper, or stratified Drift clay formation—the "Erie clay" of the Geological Survey; (*iii.*) Lower Fresh-water clay and sand formation—the "Saugeen clay" (and probably, also, the "Artemisia gravel") of the Survey; (*iv.*) Upper Fresh-water sand and clay formation; and (*v.*) a series of Recent deposits, proper.

The Lower or true Drift formation consists of a thick deposit of unstratified clay, holding Laurentian and other boulders. It appears to be essentially a Glacier formation, derived in chief part from the grinding action of ice on the surface of the subjacent rocks. As a rule, it is greatly concealed from observation; and much of its original substance has undoubtedly been removed, or otherwise rearranged in the form of succeeding deposits, by the subsequent action of water. The Upper Drift deposits consist principally of dark blue or gray calcareous clays, arranged in distinct layers, and containing, as a rule, numerous stones and boulders, but no shells or other fossils. These "Erie clays" yield white or light-yellow bricks. In places, as near Brantford, etc., their planes of stratification are greatly contorted. Good displays occur along the north shore of Lake Erie generally; also near Clark Point, &c., and adjacent coast of Lake Huron; and at Woodstock, St. Mary's, London, and elsewhere throughout the district.

The Lower Fresh-water deposits, or "Saugeen clays and sands," where in contact with the "Erie" or underlying boulder-holding clays, commonly rest on the denuded surface of the latter. The clays present a very general brown colour, and although more or less calcareous, they yield, as a rule, red bricks. All are distinctly stratified, and, in most cases, boulders are but sparingly present in them. Good exposures, showing the blue or Erie clay below, occur more especially near Port Talbot and Port Stanley on Lake Erie. Others may be seen around Woodstock; and also between Clark Point and Port Frank on Lake Huron, as well as at various spots on the Saugeen, around Walkerton, and throughout the township of Brant generally. Layers of sand and gravel are commonly associated with

these clays; and a deposit of coarse gravel with boulders—the "Artemisia gravel" of the Geological Survey—which extends largely throughout the country between the Grand River and Georgian Bay, is probably of the same general age, as it is seen near Brantford and elsewhere to overlie the blue or Erie clay. In many parts, again, of the Erie and Huron district (as in the more western portion of the Lake Ontario region, already described) the brown clays, or in their absence the underlying deposits, are capped by sands and gravels containing numerous shells of fresh-water mollusca —species of unio, cyclas, amnicola, valvata, planorbis, physa, limnæa, melania, &c.—still inhabiting our lakes and streams; and similar shells are occasionally found in the clay beds. Terraced deposits containing fresh-water shells of this kind occur especially around Niagara Falls. Other examples have been seen in the vicinities of Paris, Brantford, Walkerton, &c. In addition to these Glacial and Post-Glacial accumulations, various deposits of still more recent origin occur within the district. The principal comprise: The sandy flats of the Grand River and other streams; the beds of shell-marl which underlie and margin most of the swampy areas; the ochre deposits of the counties of Middlesex and Norfolk; and the peat beds of Humberstone and Wainfleet on Lake Erie.

(5.) *The Manitoulin District.*—This district may be regarded as an outlying portion of the Ontario and Erie districts combined, the Silurian strata of the latter extending into it, and ranging continuously throughout its area. It comprises the Great Manitoulin Island, eighty miles in length, lying along the north shore of Lake Huron, with the La Cloche and other smaller islands between the Manitoulin and the Lake Huron coast, and Cockburn Island, St. Joseph's Island, Campement d'Ours, &c., farther west. Drummond Island belongs also, geologically, to the district, but lies beyond the Canadian boundary. The more northern portion of the Great Manitoulin contains numerous lakes, and its north shore is indented by comparatively deep bays. These appear to lie in synclinal folds, formed by a series of undulations (with north and south axes) which traverse the island throughout its length.* The strata of the district succeed each other from north to south, the general dip being in the latter

* See "Reports on the Manitoulin Islands," by Prof. Robert Bell, by whom these anticlinals were first pointed out, in Geological Survey Reports for 1866 and 1867.

direction. They comprise a slight development of Huronian quartzites, with representatives of the Chazy, Black River and Trenton, Utica, Hudson River, Clinton, Niagara, and Guelph formations. The Huronian outcrops occur principally in the form of bare, rocky ridges, but are only seen at one or two places, principally at Shequenandod village, near the eastern extremity of the Great Manitoulin, on La Cloche Island, and on the Island of Campement d'Ours, near the entrance to St. Mary's River. Exposures of reddish marls and light-coloured sandstones on the north side of La Cloche Island are commonly referred to the Chazy division; and the thin-bedded sandstones (provisionally known as the Ste. Marie sandstones), which occur in small outlying patches on Campement d'Ours and St. Joseph's Island, are thought to represent the same formation. The southern portions of La Cloche Island, and the smaller islets immediately west, are occupied entirely, or essentially, by dark gray dolomitic limestones of the lower part of the Trenton (or so-called Black River) series—the higher beds merging into the Trenton division proper, and supporting at one or two points small strips or patches of Utica shale. The Bigsby, Thessalon, and other rocky islands farther west, and a large part of Campement d'Ours and St. Joseph's Island, belong to the same series. From the La Cloche group of islands these Trenton strata extend across the intervening channel, and crop out in several places as a fringe along the north coast of the Great Manitoulin. They show principally in the Manitowaning headland, and also between Little Current and West Bay. Southwards, the dark bituminous shales of the Utica formation come up, and range entirely through the island. Good exposures occur at Shequenandod village (where the shales incline against an outcrop of Huronian quartzite), and at Cape Smyth. At the latter spot the formation is capped by a considerable thickness of arenaceous shales and sandstones, very rich in fossils, belonging to the Hudson River series. This latter formation ranges also entirely through the Great Manitoulin, and extends over Barrie Island on the north. It is followed along its southern border by a series of strata holding Clinton fossils. These strata consist mostly of light-coloured dolomites capped by a bed of red marl—the best soil on the island, according to Prof. Bell, resulting from the disintegration of the latter. South of these Clinton beds, a steep escarpment of Niagara limestone runs through the central part of the island, facing the north, and following in its

strike the same east and west direction as the other formations of the district. From the top of the escarpment, the limestones extend in a series of steps to the south shore, where they become covered in places by patches of semi-crystalline dolomites belonging to the Guelph formation. The southern portion of the Great Manitoulin is thus occupied entirely by these Middle Silurian strata, and broad shelves of bare limestone-rock form large portions of its surface. A continuous outcrop occurs along this south shore; but the best exposures are seen in the lower beds along the line of escarpment, more especially about Lake Manitou and Lake Wolsey (and intervening country), and around the south shore of Bayfield Sound. Cockburn Island, immediately west of the Great Manitoulin, is also underlaid throughout its whole extent by Niagara limestone.

The other formations recognized within the district consist of Drift clays and higher sand deposits—the "Algoma Sand" of the Geological Survey. The clays appear to belong essentially to the lower or unstratified Drift. They occur in great thickness upon St. Joseph's Island, and are overlaid very generally on Cockburn Island by the higher Algoma sands. Both divisions are also seen on the Great Manitoulin and elsewhere throughout the district. Detached boulders, mostly of Huronian rock, occur likewise in many places; and glacial striæ and furrows are seen on almost all the exposed rock-surfaces. The striæ have a general south-westerly direction, but vary from a few degrees west of south to about S. 50° W.

Petroleum springs occur both on the Great Manitoulin and on some of the other islands of the Manitoulin group. The petroleum appears to come from the Utica shales; but although the formation has been penetrated and even traversed by several wells or borings, no permanent supply has hitherto been obtained.

(6.) *The District of the Upper Lakes.*—This region may be described in general terms as extending over the entire north-western portion of Ontario, from Lake Temiscamang and French River, on Lake Huron, to the boundary of the Province beyond Lake Superior. It forms for the greater part a densely wooded but rugged and mountainous region, broken up by numerous bodies of water, and underlaid throughout its area generally by hard crystalline rocks of the Laurentian series. The surface of Lake Huron is 578 feet, and that of Lake Superior 600 feet above the sea. From these levels the ground rises

more or less abruptly to an average height of from 1,000 to 1,500 feet, with occasional points of still greater elevation. The recognized rock formations comprise representatives of the Laurentian, Huronian, Upper Copper-Bearing, and Chazy (?) series, with many eruptive Granitic and Trappean rocks, and overlying Glacial and Post-Glacial deposits.

The Laurentian rocks are composed of vast beds of micaceous and hornblendic gneiss, quartzites, and other crystalline strata; but bands of crystalline limestone, so commonly associated with these rocks in eastern districts, are here apparently wanting. These Laurentian strata are mostly inclined at high angles, and are variously folded and contorted by undulations. In places also they are broken through by vast masses of granite. They form a great part of the north and east coasts of Lake Superior; but along the north shore of Lake Huron they are mostly overlaid by Huronian strata, although forming the coast-line from the River Thessalon to a short distance east of the Mississagui. In the back country of both lakes, however, they extend over almost the entire surface of the region.

The Huronian strata are composed mostly of green and other slates, quartzites, quartz and jasper conglomerates, and limestones of semi-crystalline aspect. They are interstratified also with trappean bands, and are penetrated by numerous dykes of trap and greenstone. In many places likewise, they are traversed by quartz veins carrying ores of copper and other metals. They form a broad belt ranging from Lake Temiscamang to Lake Huron, west of French River, and along the lake shore to the River Mississagui. They re-appear again on the coast west of Thessalon River, and occupy a large area between Lake George and the country around Echo Lake. They occur also on the east and north-east coast of Lake Superior, and in a band at the back of Thunder Bay, as well as in several other bands farther west and north, where they appear, according to Prof. Robert Bell, to occupy synclinals, in folds of Laurentian strata. Their more important economic minerals comprise: The copper ores of Lake Huron (worked at the Bruce and Wellington mines); the iron ores of Echo Lake, Michipicoten River, Pic River, &c.; the antimony ore of Echo Lake country; the silver bearing veins (opened at the 3 A mine, &c.) of the Huronian belt of Thunder Bay; and the gold-bearing veins of the Lake Shebandowan country.

The strata known conventionally as the Upper Copper-Bearing Rocks of Lake Superior, overlie the Huronian formation in some

places, and rest directly on Laurentian rocks in others. They belong to three series: a lower series, composed mostly of dark slates, beds of chert, and greenish-gray sandstones with interstratified beds of trap or hardened volcanic mud; a middle or second series, consisting chiefly of red and white marls and calcareous sandstones, also with interstratified belts of trap or volcanic mud; and a third division, consisting of an enormous overflow of trap, resting uncomformably on both the lower series. The first or lowermost division occurs along the coast between Pigeon River and the eastern extremity of Thunder Bay, and it is capped by the third division, or so-called crowning overflow of trap, in many places, as, more especially, at the bold promontory of Thunder Cape, at McKay's Mountain, at Pie Island, and elsewhere. The red and white marl and sandstone series occurs principally between Thunder Cape and Nepigon Bay, and is also capped by masses of trap belonging to the crowning overflow. Grand exposures of these sub-columnar traps are seen at Thunder Cape, Pie Island, St. Ignace, the Nepigon River, and elsewhere on the north-west coast of Lake Superior. The red marls and sandstones appear also to occur at other points on the north-east and eastern shores of the lake. Both the first and second divisions are penetrated by quartz veins carrying various metallic matters, as native silver, silver glance, galena, zinc blende, nickel ore, copper ore, &c.; and many of these minerals contain small amounts of gold. The Silver Islet, Thunder Bay, Trowbridge, Duncan or Shuniah, Jarvis Island, Spar Island, and other mineral locations lie on the lowermost series; whilst the North Shore, Cariboo, Enterprise or Black Bay, Silver Lake, and other locations, belong to the second division. The age of these rocks is still a subject of controversy. By some observers they are regarded as Triassic, a view based chiefly on mineral aspect. Sir William Logan, on the other hand, stoutly maintained their Lower Silurian age, regarding them as probable equivalents of the Potsdam and Calciferous formations of eastern localities, or, at least, as occupying a lower geological horizon than that of the Chazy formation; and the weight of evidence at present is certainly in favour of this view. Certain sandstone beds, commonly known as the Ste. Marie sandstones, are seen at points east of St. Mary's River (as on the Island of Campement d'Ours, &c.) to underlie fossiliferous limestones of the Trenton (or Black River) formation; and these same sandstones, at points on the eastern side of Lake Superior, overlie

strata with bedded traps, &c., apparently belonging to the second Copper-Bearing series. The Sault Ste. Marie sandstones must, at least, be as old as the Chazy series of strata, if not older; and consequently, if the rocks on the east side of Lake Superior belong really to the Copper-Bearing group, the latter cannot be far removed from the base of the Silurian series.

Over the floor of crystalline rocks by which this vast region is essentially underlaid, Drift clays and boulders, and Post-Glacial clays and sands, with other recent accumulations, are spread in many places. Glacial furrows and striæ also are seen in numerous localities. The prevalent direction of the striæ is decidedly towards the south-west, although some run nearly south, others east of south, and others, again, almost east and west. Where commonly seen, two or more sets of striæ occur together, and thus intersect each other. Drift clays are seen in many of the river channels, and boulders are of very general distribution. The latter are accumulated in some places in long ridges or moraines at the opening of valleys, or along the lower slopes of the hills. Whilst many of these boulders are of essentially local origin—and thus consist on the north shore of Lake Huron of jasper-conglomerate, quartzite, and other Huronian rocks, and of Laurentian and Copper-Bearing rocks about Lake Superior—numerous examples of limestone boulders, containing Middle or Upper Silurian and Devonian fossils, occur throughout the region. These latter must have come generally from the northern country which lies beyond the height of land and extends towards Hudson's Bay, although small patches of fossiliferous limestone are said to have been seen near the head waters of the Pic River, and others may perhaps be found as the region becomes more thoroughly explored. The Post-Glacial deposits of the district consist in their lower beds of stratified clays and sands, referred by the Survey to the "Saugeen" division; and in their higher beds, of ridges and widely spread accumulations of fine sand only, referred to the "Algoma" series. The stratified clays (of gray, red, and buff colours) are seen in places on the north shore of Lake Huron and St. Mary's River, and prominently in the high terraces around the Sault, as well on the Pic River, and in the ancient banks of the Kaministiquia and other rivers of Lake Superior. The higher sands are also displayed in the Kaministiquia banks, and more or less throughout the Nepigon country, where they form in places hills and

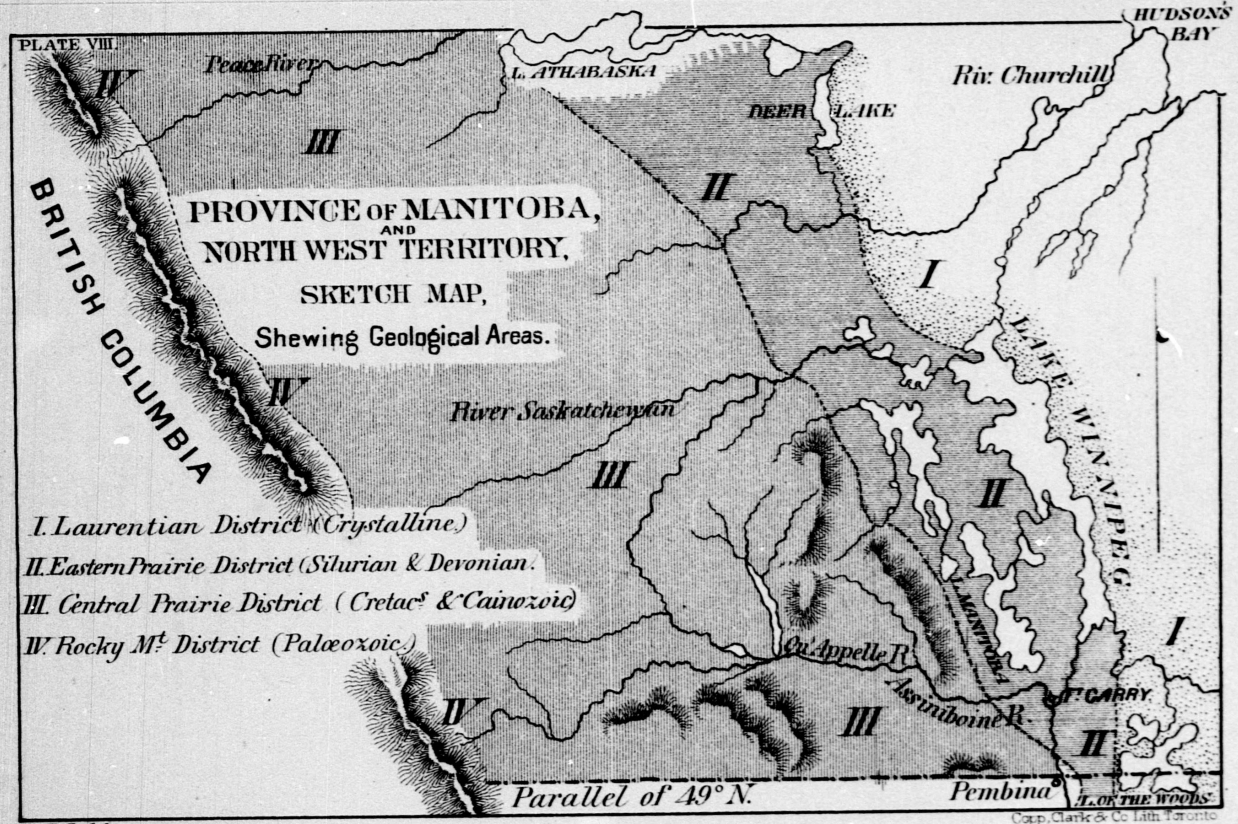


PLATE VIII.
PROVINCE OF MANITOBA, AND NORTH WEST TERRITORY,
SKETCH MAP,
Shewing Geological Areas.
BRITISH COLUMBIA
Peace River
L. ATHABASKA
DEER LAKE
Riv. Churchill
HUDSONS BAY
River Saskatchewan
LAKE WINNIPEG
L. MANITOBA
Qu'Appelle R.
Assiniboine R.
Ft. CARRY
Pembina
L. OF THE WOODS
Parallel of 49° N.
I. Laurentian District (Crystalline)
II. Eastern Prairie District (Silurian & Devonian.
III. Central Prairie District (Cretacs & Cainozoic)
IV. Rocky Mts District (Palæozoic.)
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ridges of considerable elevation. Also on the Pic River, and largely around Michipicoten Harbour, and on the Goulais River; and along nearly all the river valleys, and over many intervening tracts of country, north of Lake Huron.

PROVINCE OF MANITOBA,

AND

REGION OF THE NORTH-WEST TERRITORY.

The geology of this vast area—extending from the western boundary-line of Ontario (not yet permanently established) to the Rocky Mountains—is only known at present in its broader or more general features, but it appears to indicate a natural subdivision of the region into four leading districts. These comprise: (1) The Eastern or Laurentian District; (2) The Eastern Prairie or Lake Manitoba District; (3) The Central Prairie District; and (4) The Rocky Mountain District.

(1.) *The Eastern or Laurentian District.*—This forms an elevated rocky region, more or less densely wooded; a continuation of the Lake Superior country, described, under the District of the Upper Lakes, in the geology of Ontario. It includes all the country lying between the boundary-line of Ontario (not yet definitely settled), and the Winnipeg River and Lake, with probably a wider extension of area towards the north-west. It is occupied essentially by Laurentian strata of micaceous and syenitic gneiss, quartzite, &c., with overlying belts, in various places, of micaceous, chloritic, and hornblendic slates, and slaty conglomerates, of Huronian age. These Crystalline strata form the surface in many parts, but in others, and especially on the south-east shore of Lake Winnipeg, they are covered by thick deposits of Glacial and Post-Glacial clays and sands. The average altitude of the district is about 1,200 feet—the ground rising in places to 1,500 or 1,600 feet above the sea, but descending to 107 feet at Lake Winnipeg.

(2.) *The Eastern Prairie, or Lake Manitoba District.*—This subdivision comprises the country immediately west of Lake Winnipeg, Deer Lake, Lake Arthabasca, &c., and the entire area around Lake Manitoba, Lake Winnipegosis and connected series of lakes, with the valley of Red River and the Lower courses of the Assiniboine,

Swan River, and Saskatchewan. It forms essentially the "First Prairie Steppe" of the north-west, and occupies an elevation of about 750 or 800 feet above the sea, stretching to the base of the second prairie along the line of hilly country defined by the Pembina, Riding, Duck, and Porcupine Mountains, and the Basquia Hills. It is underlaid in its more eastern portion (including Fort Garry, the lower course of Red River, the western shores of Lake Winnipeg, Cedar Lake, &c.) by Lower Silurian strata, belonging essentially, if not wholly, to the Trenton formation, and consisting chiefly of dolomitic limestones in horizontal or nearly horizontal beds. The more western and north-western portion (including Lake Manitoba, Dauphin Lake, the west shore of Lake Winnipegosis, Swan Lake, &c.) is underlaid by Devonian strata, consisting most probably of the higher portion of the series. Numerous brine springs, and, here and there, outflows of petroleum, appear to mark the Devonian area generally; but the surface of the district is almost entirely covered by Glacial and Post-Glacial deposits, mostly in the form of stratified marly clays.

(3.) *The Central Prairie District.*—This is essentially a prairie region, but interspersed with patches of woodland, and forming on the whole a rolling and often hilly country. It comprises the second and third prairie-steppes, rising in the east, above the line of elevation between Pembina Mountain and the Basquia Hills, to an altitude of about 1,600 feet above the sea, and in its more western extension on the third prairie (west of the Grand Coteau, Eagle Hills and Thickwood Hills) to from 2,000 to over 4,000 feet. It encloses many sterile tracts, but over a large portion of its area the soil appears to be of good fertility. Ranging west of the Pembina, Riding, Porcupine, and Basquia Hills, it extends over the vast region traversed by the Qu'Appelle River, the Upper Assiniboine, north and south branches of the Saskatchewan, and the upper course of the Arthabasca, and rises gradually into the eastern slopes of the Rocky Mountains. The eastern section—and probably the greater portion of the entire district—is occupied by Cretaceous strata, consisting mostly of sandstones and shaly clays in generally horizontal beds, overlaid more or less by sands of Glacial or Post-Glacial age; whilst towards the west, but without any strongly marked lines of demarcation, these Cretaceous strata are succeeded by Cainozoic deposits.

The latter consist chiefly of sandy clays, with associated beds of lignite and ironstone. Lignite occurs also in the Cretaceous strata of the district. In many of its beds, as in the Qu'Appelle valley and southwards generally, it presents the usual woody or earthy character, but on the Upper Saskatchewan and elsewhere, much of it is of a comparatively dense compact quality, and closely resembles ordinary bituminous coal.

(4.) *The Rocky Mountain District* includes the foot-hills and eastern ranges of the Rocky Mountains, and extends westward to the boundary-line of British Columbia. This eastern portion of the Rocky Mountain chain enters the North-west Territory in the form of several distinct ranges which curve towards the north-west, and appear gradually to intermingle. Southwards, the mountains present an average elevation of about 8,000 feet above the sea, with occasional points of higher latitude; but in their northern extension—as seen in the transverse valley of the Peace River and elsewhere towards the Arctic Ocean—their altitude becomes greatly diminished. They are composed essentially of dolomites, limestones, and sandstones, apparently of Devonian, or of Devonian and Carboniferous age. Probably, older Palæozoic and more recent formations will eventually be found amongst them. In some few places their uplifted strata still retain their original horizontality, but as a rule they occur in highly-tilted, broken and contorted beds, with deeply escarped faces fronting abruptly on the east, and strong westerly dip towards the central part or axis of the chain. Gneissoid rocks and crystalline schists—which make up the main mass of the Rocky Mountains in New Mexico and Colorado, and which occur almost immediately west of the chain in British Columbia—appear to be altogether wanting in these eastern ranges. Finally, it may be pointed out, as a characteristic feature of the district, that, along the base and gorges of the mountains, terraced accumulations of gravel and limestone-shingle are seen at varying elevations; and in many cases these shingle terraces or beaches extend along the river-valleys far into the prairie region to the east.

PROVINCE OF BRITISH COLUMBIA.

This Province — extending westward from the boundary-line of the North-west Territories in the Rocky Mountains, to the Pacific coast and outlying islands—admits of a convenient and more or less natural subdivision into four areas. These may be named as follows: (1) The Eastern Mountain District; (2) The District of the Central Table-land; (3) The Coast and Western Mountain District; and (4) The Island District.

(1.) *The Eastern Mountain District.*—This includes the western ranges of the Rocky Mountains proper, and the adjacent ranges of the Selkirk, Gold and Cariboo Mountains. Physically, it consists of a number of roughly-parallel chains, running in a general north-west direction, and presenting an average elevation of from 8,000 to 10,000 feet above the sea, with many isolated points of greater altitude. Among the latter, some of the more striking in the main chain include Mount Sabine, Mt. Forbes (13,460 ft.?), Mt. Balfour (14,431 ft.?), Mt. Murchison (16,000 ft.?), Mt. Hooker (15,700 ft.?), and Mt. Brown (15,990 ft.?). Several points in the Selkirk Mountains also exceed 12,000 feet; and glaciers occur in the higher valleys or gorges of both chains. Tilted and contorted strata of limestone and sandstone, apparently for the greater part of Devonian and Carboniferous age, occur on the western as on the eastern slopes of the Rocky Mountains proper, and terraced accumulations of gravel and limestone-shingle are seen at various elevations. The Selkirk, Gold and Cariboo ranges, which are only separated from the western flanks of the central mountains by comparatively narrow valleys, appear, on the other hand, to consist largely of talcose and micaceous schists. It is through these ranges, therefore, rather than along the line of the "Rocky Mountains" as defined on maps, that the core of the great chain would seem to be continued to the north.

(2.) *The District of the Central Table-Land.*—This district comprises the great plateau which extends from the Selkirk and other mountain ranges, on the east, to the Cascade and Coast Mountains on the west. It lies at an average elevation of from 2,000 to 4,000 feet above the sea, and presents for the greater part a more or less mountainous character. Numerous lakes occur upon its surface; and it is traversed by the Columbia, Fraser, and other rivers, flowing mostly in deep-cut channels or cañons. In many places it is thickly

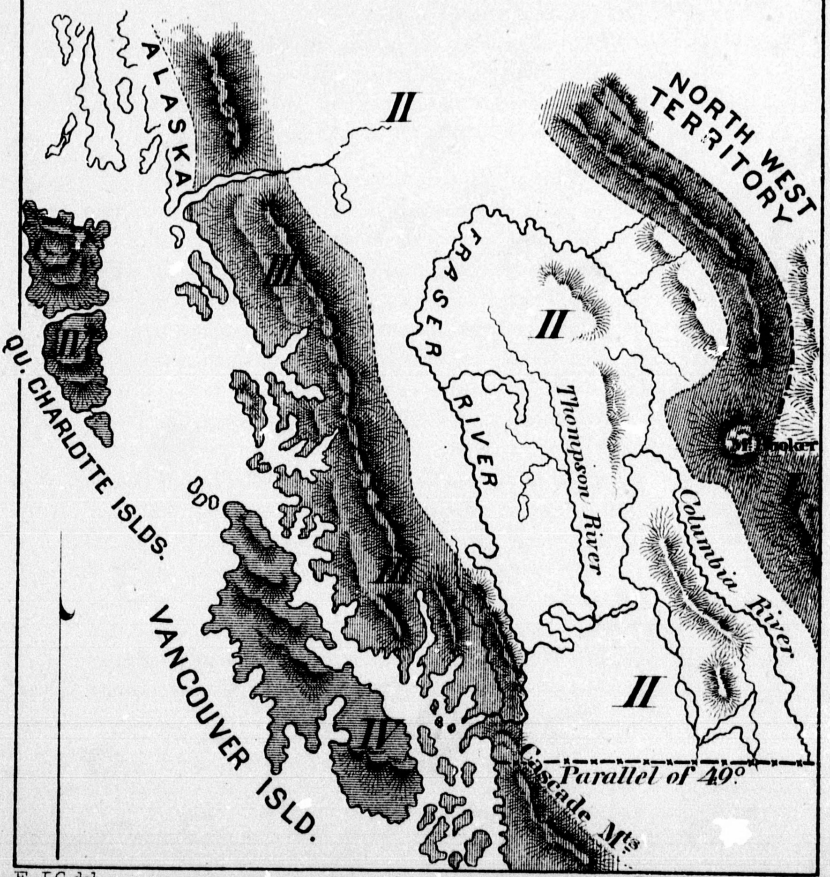
PLATE IX.

PROVINCE OF BRITISH COLUMBIA,

SKETCH MAP,

Shewing Geological Areas.

I. Eastern Mountain District (Palæozoic; Metamorphic.)
II. Central or Table Land District (Met^c; Palæox^c & Cainox^c; Volcanic.)
III. Coast and Western M^t District. (Metamorphic; Volcanic.)
IV. Island District (Chiefly Upper Mesozoic: Coal bearing.)



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wooded; but gravelly and comparatively sterile tracts prevail over considerable areas, and swamps are also numerous. So far as known at present, its lower rocks appear to consist of granitic, talcose, and micaceous formations (more or less tilted and contorted), succeeded by shales, conglomerates and limestones of Middle and Upper Palæozoic age, or by more recent strata of alternating sandstones, shales and lignites, with bedded volcanic products (partly of trappean, and partly of scoriaceous lava-like aspect)—the whole overlaid, very generally, by accumulations of sand and gravel. The latter, as seen more especially in the valleys of the Fraser, Thompson and other rivers, often form sharply-defined terraces or beaches at varying elevations on the flanks of the older rocks. These sands and gravels, especially in the streams which descend from the Cariboo and Gold ranges, and in the valley of the Lower Fraser, are more or less auriferous. The lignite-bearing strata and associated volcanic beds are probably in part Cretaceous, although chiefly of Cainozoic age.

(3.) *The Coast and Western Mountain District.*—This is essentially an alpine region, forming the western margin of the high Table-land, and extending from the latter to the coast-line of the Pacific Ocean. With the exception of some comparatively restricted areas upon the coast, as at the mouth of the Fraser and smaller rivers, it is occupied entirely by the northern ranges, and their spurs, of the Cascade Mountains, which present an average elevation, in this district, of from 5,000 to 7,000 feet above the sea, with perhaps here and there a peak of somewhat higher altitude.* Glaciers occur in many of the higher gorges; and deep fiords, between, in many places, high walls of perpendicular rock, strike far inland from the sea. Very little is known respecting the geology of the district; but the mountain ranges appear to consist largely of granitic or crystalline formations, broken through by volcanic rocks of comparatively recent origin. Outlying patches of intervening Palæozoic strata, and more recent coal-bearing beds, probably occur amongst these, with overlying terraced deposits of sand and gravel, as seen in the Table-land District on the west.

(4.) *TheIsl and District.*—This subdivision comprises Vancouver Island, Queen Charlotte Islands, and the numerous smaller groups

*Mt. Baker, Mt. Hood, and Mt. Regnier or Rainier, although referred to in many works on Physical Geography as belonging to British Columbia, lie south of the Province boundary-line as now adopted—*i.e.*, the parallel of 49°.

lying near these and along the coast generally. All are essentially of a mountainous character; and the larger islands contain isolated peaks, or are traversed by broken ranges—northern outliers of the "Sea Alps" of California, and thus undoubtedly composed in part of volcanic rocks—of comparatively high elevation. In Vancouver Island, amongst other elevated points, the Beaufort Range exceeds 5,000 feet in altitude; and Mt. Arrowsmith is 5,970 feet, Victoria Peak 7,484 feet, Mt. Albert Edward 6,963 feet, and Mt. Alexandra 6,395 feet above the sea. In the Charlotte Islands, the ranges are apparently of corresponding height. In both of these island groups, however, comparatively level tracks, well adapted for agricultural settlement, occupy extensive areas. The geology of the district, so far as at present known from the Reports of Mr. Richardson of the Canadian Survey, Mr. Bauerman, Dr. Brown, and others, may be briefly summarized as follows: The smaller islands lying more immediately along the coast consist principally of crystalline hornblendic strata, associated with beds of semi-crystalline limestone, and holding in some localities—as on Texada Island, more especially—valuable beds of magnetic iron ore. Rocks of a similar kind occur upon the flanks of the mountain ranges in Vancouver and other islands to the west—these easterly and westerly exposures seeming to form the edges of a long trough, or series of troughs, filled with coal-bearing Cretaceous strata. The semi-crystalline limestones contain in places many imperfectly preserved fossils of Carboniferous or Upper Palæozoic types. The coal-bearing strata consist mostly of alternations of sandstones, conglomerates, and shales (the first greatly predominating), with layers of iron-stone nodules and seams of coal, the latter varying from a few inches to about five or six feet in thickness. These coal strata are characterized by the presence of many well-known Mesozoic types — Ammonites, Belemnites, &c. Those of the Queen Charlotte Islands to the north, apparently indicate Lower Cretaceous deposits, or beds of passage between Jurassic and Lower Cretaceous formations, whilst the fossils of the coal strata of the Vancouver group are clearly Upper Cretaceous. The coal of the northern islands is more or less anthracitic in character, but that of Vancouver Island is of ordinary bituminous quality, identical in all essential respects with the coals of the Coal Measures proper. These Cretaceous strata are covered very generally by thick deposits of sand and clay, forming high cliffs in many places; and over a large portion of Vancouver Island, the latter

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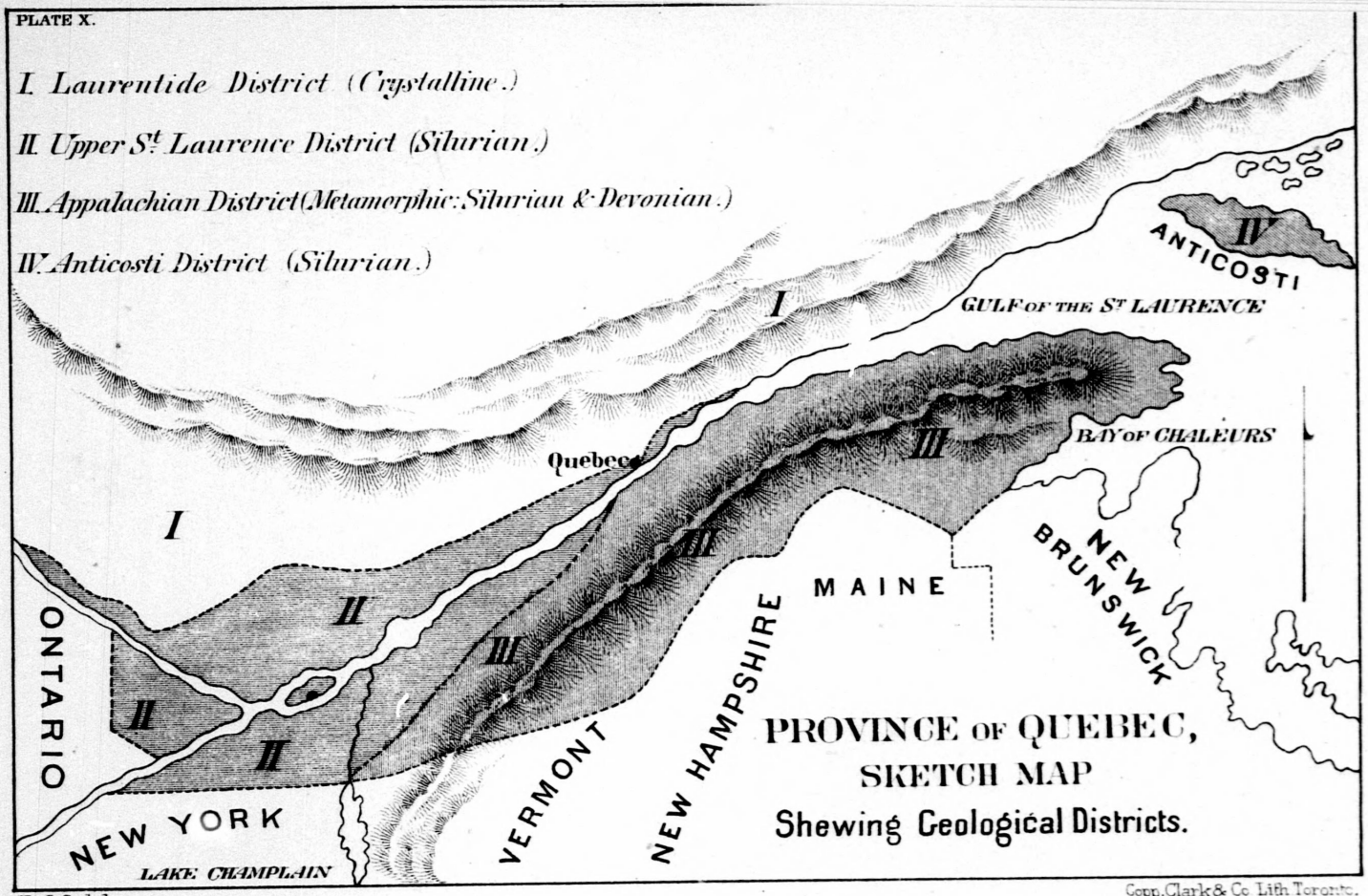
PLATE X.



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deposits are again overlaid by a dark vegetable soil, holding, here and there, layers of marine shells belonging apparently to existing species. Brine springs occur on one of the islands of the Vancouver group; and the sands of Leech River and other streams have yielded considerable amounts of gold.

PROVINCE OF QUEBEC.

This Province may be subdivided geologically into four principal areas, comprising: (1) The Laurentide, or Northern Crystalline District; (2) The Upper St. Lawrence, or Western Palæozoic District; (3) The Appalachian, or Eastern Metamorphic District; and (4) The Anticosti, or Eastern Palæozoic Area.

(1.) *The Laurentide District.*—This is essentially a region of ancient crystalline strata—rocky and mountainous in character: an eastward extension of the Laurentian districts of Ontario, but with certain special features of its own. It comprises the wide expanse of territory lying between the Ottawa River and Labrador, with the exception of a comparatively narrow strip of country (occupied by Lower Palæozoic formations), extending along the St. Lawrence from the junction of the two great rivers to a point a short distance below the city of Quebec. It is traversed by the Laurentide Mountains, proper, which form within it several broken ranges curving roughly parallel with the course of the St. Lawrence. The more southern of these gradually approach the river, and run closely adjacent to it along the lower part of its course. The average height of the Laurentides, generally, is from about 1,200 to 2,000 feet, but at one or two points they reach an altitude of nearly 4,000 feet above the sea. Numerous rivers rise amongst them. Some of the more important comprise: the Rivière du Moine, the Gattineau, the Rivière du Lièvre, the Rivière Rouge, and the Rivière du Nord, flowing into the Ottawa; and the l'Assomption, Chicot, St. Maurice, Batiscan, Ste. Anne (Portneuf), Jacques Cartier, Montmorenci, Ste. Anne (Montmorenci), Murray, Saguenay, Moisie, and other eastern rivers, flowing into the St. Lawrence.

The rocks within this region consist mainly of Lower or typical Laurentian strata, overlaid in some few localities by feldspathic rocks of the Upper Laurentian or Labrador series. The Laurentian strata, proper, are composed essentially of vast beds of micaceous and syenitic gneiss, hornblende rock, and quartzites, with interstratified

bands of crystalline limestone and oxidized iron ores. Valuable deposits of the latter occur, especially, in the townships of Hull, Templeton, and Grenville, on the Ottawa. As a rule, these Lower Laurentian strata are more or less strongly tilted, corrugated, or otherwise disturbed. They are also very generally traversed by granitic or syenitic veins, and are broken through in places (more especially in Wentworth, Chatham, and Grenville, on the Lower Ottawa) by enormous masses of eruptive syenite and greenstone. The crystalline limestones very commonly contain numerous examples of diopside, phlogopite, zircon, sphene, and other crystallized silicates; and they are associated in many places with workable amounts of graphite and fluo-phosphate of lime, as in the townships of Buckingham, Portland, Lochaber, Grenville, &c. The Upper Laurentian or Labrador formation is represented principally by thick beds of anorthosite or feldspar rock, with associated feldspatho-pyroxenic beds and interstratified gneissoid rocks. Titaniferous iron ore is a frequent accompaniment of these higher strata, and in some localities, as at Baie St. Paul, it is present in large quantity. Whilst the Lower Laurentian strata occur throughout the district generally, the upper series has been recognized only in detached areas of comparatively limited extent. One of these is seen in the counties of Argenteuil, Terrebonne, Montcalm, and Joliet, in the western part of the district; and others occur in the vicinity of the Montmorenci Falls; in the country about Baie St. Paul and Murray Bay; in the vicinity of Lake St. John on the Saguenay; and on the River Moisie, in the east. In addition to these crystalline formations, a few outlying patches of Silurian strata, consisting mostly of Trenton limestones and Utica shales, occur here and there within the Laurentide area. The largest of these Silurian outliers is seen around Lake St. John on the Upper Saguenay; and small exposures occur at one or two spots on the shore of the St. Lawrence, below Quebec, as at the Montmorenci Falls, Murray Bay, &c. Glacial boulders, clays, and gravels, with Post-Glacial sands and other superficial deposits—among which the titaniferous iron sands of the Lower St. Lawrence may be especially mentioned—are distributed more or less generally throughout the region. The glacial striæ of the district run most commonly either towards the south-east or south-west; but in some few localities their direction is almost north and south, and in others, not far removed from east and west.

(2.) *The Upper St. Lawrence District.*—This is essentially a Silurian area, occupied—apart from some isolated eruptive-masses—by sandstones, limestones, and other strata, which retain their original sedimentary aspect, and occur, for the greater part, in undisturbed beds. It extends along both sides of the St. Lawrence from the western boundary of the Province to the neighbourhood of Quebec. In the west, it includes the counties of Vaudreuil and Soulanges, lying in the point of the triangular space immediately west of the junction of the Ottawa and St. Lawrence Rivers. From the county of Vaudreuil, its northern boundary crosses the Ottawa, and then, keeping entirely on the north side of the St. Lawrence, runs along the southern edge of the Laurentide district already described, and gradually approaching the river, strikes it a short distance below Quebec. Its southern limit runs from the south-west corner of Huntingdon (south of the St. Lawrence), along the boundary-line between the Province and the State of New York, to a little beyond the River Richelieu at the northern extremity of Lake Champlain; and east of this, the district is bounded by the disturbed and metamorphic area of the Eastern Townships—its actual limit in this direction being a remarkable line of dislocation, with accompanying fault, running (as first traced out by Sir William Logan) from near the north-west end of Lake Champlain to the vicinity of Point Lévis, and from thence around the City of Quebec, along the north side of the Island of Orleans, and down the river to near the mouth of the Magdalen, where it enters and runs along the Gaspé shore.

The rock-formations of the district belong to three distinct series. The stratified rocks, proper, consist of representatives of the Potsdam, Calciferous, Chazy, Black River and Trenton, Utica, and Hudson River (Lower Silurian) formations—with some small exposures, south of the St. Lawrence, of strata referred to the Middle Silurian, Medina group, and a few outlying patches of Upper Silurian strata (belonging to the Lower Helderberg formation) in the vicinity of Montreal. These formations are broken through in places by large eruptive-masses of trachytic and trappean rock, forming a series of picturesque mountains, which rise abruptly from the generally level surface of the district in the more southern and western portions of its area; and in addition to these Silurian and eruptive rocks, Glacial and Post-Glacial accumulations, with deposits of comparatively modern origin, occur throughout the district generally.

The Potsdam beds consist of coarse conglomerates and fine-grained siliceous sandstones—the latter in many localities sufficiently pure for glass-manufacture and for the hearths of furnaces. The formation is largely displayed in Hemmingford Mountain, and over large portions of Huntingdon, Chateauguay, and Beauharnois, from whence it crosses the St. Lawrence, and spreads over a large part of Soulanges and Vaudreuil; and from thence, passing across the western end of the Island of Montreal and Isle Bizard, it wraps around a large outlying mass of Laurentian gneiss (forming Mount Calvaire on the north shore), and continues uninterruptedly along the edge of the Laurentide district as far east as the River Chicot, where the continuity of the strata is broken by a fault, and limestones of the Trenton formation are let down against the Potsdam beds. East of this point, the formation only appears at one or two places—notably on the St. Maurice, where it exhibits a slight thickness of nearly horizontal beds of conglomerate and sandstone, resting upon gneiss. Throughout its range, as far east as the Chicot, it is accompanied by sandy and dolomitic limestones of the Calciferous formation, and these cover large areas south of the St. Lawrence, and in the country around the junction of the St. Lawrence and Ottawa. East of this formation, on the south side of the St. Lawrence, limestones of the Chazy and Trenton series, and dark bituminous shales of the Utica formation, with succeeding sandstones and arenaceous shales of the Hudson River formation largely prevail—the latter, especially, east of Richelieu River. These formations cross the St. Lawrence, and range in regular sequence along the north shore between the Calciferous outcrop and the river bank. The intervening Island of Montreal, Isle Jésus, Isle Bizard, &c., consist essentially of Chazy, Trenton, and Utica strata—the Hudson River beds coming up farther east. The Chazy limestones of Caughnawaga and St. Doménique on the south shore, those of Ste. Genéviève on the Island of Montreal, of Isle Bizard, and of St. Lin on the north shore, yield marbles (red-spotted or uniformly red) of good quality. East of the River Chicot, which enters the St. Lawrence on the north shore, near the upper or western extremity of the expansion known as Lake St. Peter, the comparatively narrow strip of country between the Laurentian gneissoid rocks and the river margin is occupied almost entirely by Trenton, Utica, and Hudson River strata—one or two small exposures of the Potsdam formation on the St. Maurice and at St. Ambroise alone representing

the lower beds as seen west of the Chicot fault. In this eastern portion of the district, the strata are tilted in many places at considerable angles, as near Pointe aux Trembles, Montmorenci Falls, &c., and their continuity at these spots is more or less disturbed by minor faults.

As stated above, the Silurian strata of the more southern and western portions of the Upper St. Lawrence district are broken through in places by trachytic and trappean masses, forming a series of isolated mountains which rise above the generally level surface of the country to elevations of from 600 to 800 feet. Most of these occur apparently upon a single line of fissure traversing the district in a general south-easterly direction. They comprise: (1) the Mountain of Rigaud in Vaudreuil, composed partly of a purely feldspathic, and partly of a dioritic or hornblendic trachyte, porphyritic in places; (2) the Montreal Mountain, composed essentially of angitic trap or dolerite, but traversed by dykes of compact and granitic trachyte; (3) Montarville or Boucherville Mountain, also essentially trappean in composition; (4) Belœil, a dioritic and micaceous trachyte; (5) Monnoir or Mount Johnson (south of Belœil), of the same mineral character; (6) Rougemont, in Rouville County, a trappean mass like that of Montreal in general composition; and (7), the Yamaska Mountain, essentially a micaceous trachyte. The Mountains of Brome and Shefford belong to the same eruptive series, but lie within the metamorphic district to the east. In addition to these principal masses, many dykes of similar character traverse the surrounding strata; and some of these in the neighbourhood of Montreal and Lachine are intercalated with the soft shales of the Utica series, which have become more or less worn away, leaving the associated trap bands in the form of projecting ledges. Most of the rapids in this part of the St. Lawrence have been thus produced.

The superficial deposits of the district comprise Glacial boulders and related clays and gravels, with Post-Glacial and recent accumulations. Drift or Glacial deposits, proper, are of general distribution; and in some places, as on the Rigaud Mountain, the boulders form roughly parallel ridges of several feet in height. The Glacial striæ of the country have two prevailing directions—south-west and south-east respectively. The Post-Glacial deposits belong chiefly to two series, as first determined by Dr. Dawson of Montreal: a lower deep-sea formation, known as the "Leda Clay;" and a succeeding deposit,

apparently a shallow-sea or shore-line accumulation, known as "Saxicava Sand." These occur widely within the district, and at various elevations. On the Montreal Mountain, beds of Saxicava sand, for example, form a series of terraces, one of which is at an altitude of nearly 500 feet above the present sea-level. Beauport, below Quebec, is another locality at which these deposits are well exposed; but they occur also, and over large areas, around Murray Bay, as well as on the Lower St. Maurice, and elsewhere. The more recent formations of the district comprise, principally, the bog iron ores and ochres of the St. Maurice and other localities on the north shore of the St. Lawrence; the great peat-beds of Lanoraye, Lavaltrie, St. Sulpice, &c., on the same side of the river; and those of Sherrington, Longueuil, and St. Doménique, with others, on the south shore. Most of these peat beds overlie deposits of shell marl.

(3.) *The Appalachian District.*—The term "Appalachian region" was first bestowed on this part of Canada by Dr. Sterry Hunt. The district forms, indeed, a prolongation into Eastern Canada of the Appalachian region of the United States: the Appalachian chain, with its tilted, contorted, and in great part metamorphosed, system of rocks, being continued into the Orford, Sutton, and other mountains of the Eastern Townships, and from these into the Notre Dame and Schickshock ranges of the St. Lawrence and Gaspé. The district is essentially a Palæozoic area, but disturbed and altered over most of its extent by metamorphic agencies. It includes the section of country known as the Eastern Townships, and also the peninsula of Gaspé and intermediate country. It thus comprises all that portion of the Province which lies east of the line of dislocation and fault, referred to under the preceding district. This line of fault extends from the north-east extremity of Lake Champlain in a general north-easterly direction, to a short distance west of Point Lévis, from whence, crossing the St. Lawrence, it curves round the back of Quebec, runs along the Island of Orleans, down the bed of the river to near the mouth of the latter, and finally traverses the north coast of the extremity of Gaspé. The strata along the outer edge of this line of fracture—in the Upper St. Lawrence district, described above—belong essentially to the Hudson River formation. They show (except on the Gaspé coast) no actual signs of disturbance; but on the east side of the line, an uplift has brought older strata (of the

Calciferous or Quebec series) in seemingly conformable stratification against their flanks; and hence it has been conjectured, in explanation, that the Hudson River beds have been broken and partially reversed along the fault by this upward movement, the older strata overlapping them, and so following deceptively without any visible break in the sequence. The district is thus bounded (practically) by the River St. Lawrence on the north, and by the States of New York, Vermont, New Hampshire, and Maine, and the Province of New Brunswick, on the south. As regards physical features, it is more or less throughout of a mountainous character, but also, as a rule, of good fertility—differing altogether in this respect from the mountainous Laurentian region of the north shore. The average elevation of the Gaspé peninsula is about 1,500 feet, and that of the other portion of the district probably about 1,000 feet above the sea; but several peaks in the Schichshock ranges of Gaspé approach 4,000 feet in height, and the summits of some of the mountains in the Eastern Townships are apparently over 3,000 feet. Many lakes, but none of large size, occur within the latter portion of the district. Among these, Lake St. Francis lies at an elevation of 890 feet, and Lake Memphramagog at an elevation of 760 feet above the sea. In Gaspé, Lake Temiscouata and Lake Matapedia lie, respectively, at altitudes of 470 and 480 feet. The district abounds in rivers. Some of the principal comprise the Yamaska and St. Francis (as regards their upper courses), the Chaudière, with its tributaries, the Famine, Des Plantes, &c., and the Etchemin, in the more western portion of the district; and the Kamouraska, Rivière du Loup, Trois Pistoles, Rimouski, Métis, Matanne, Chatte, Ste. Anne, York, Cascapediac, Matapediac, and other rivers of the Gaspé peninsula, most of which flow in deeply excavated channels.

The rock formations of the district belong to three general groups: (i.), a series of Palæozoic strata, more or less altered in most localities; (ii.), a series of eruptive, trachytic, and granitic rocks; and (iii.), a series of Post Cainozoic or superficial deposits.

The altered condition of many of the Palæozoic formations, and their disturbed condition generally, renders the determination of their exact age somewhat doubtful; but they appear to consist of representatives of Lower and Upper Silurian, Devonian, and Lower Carboniferous, formations.

The Potsdam formation has been recognized at points on the St. Lawrence, between the Chaudière and the Trois Pistoles, in Temis-

couata; and a strip of the Hudson River formation, represented by a series of contorted sandstones, dolomites, and bituminous shales, occurs along the coast of Gaspé, between the River Marsouin and Anse à la Tierce. The more important strata of the district, however, comprise representatives of the Quebec group (see below), with the overlying Gaspé limestones and sandstones (Upper Silurian and Devonian formations), and the Lower Carboniferous Bonaventure formation of South Gaspé. The Quebec group of strata occupies, apparently, a position between the Calciferous and Chazy formations of other localities, or otherwise represents the two series combined. It is subdivided into three formations, comprising, in ascending order: (i.), The Lévis formation, made up principally of black graptolitic shales or slates, containing numerous graptolites and other fossils; (ii.), the Lauzun formation, consisting in part of red and green shales, sandstones, and dolomites, but composed mostly of metamorphic strata, among which talcose and other magnesian rocks (chloritic schists, serpentines, &c.) largely predominate—the lower and upper portions of the series containing many bands of copper ore and other metalliferous deposits; and (iii.), the Sillery formation, consisting chiefly of red and green shales, sandstones, and dolomites, but including, in places, altered rocks in the form of crystalline schists and epidotic and gneissoid strata. The Lévis formation occurs prominently around the City of Quebec and Point Lévis, chiefly in the form of hard black shales dipping at high angles; but it is also seen around Richmond, on the St. Francis, and in the neighbouring townships, as well as around Phillipsburg, on the boundary line, and, again, east of the Chaudière. It is of much palæontological interest from the great number of graptolites obtained from its strata. The altered and metalliferous Lauzun division occurs more or less throughout the Eastern Townships, or between the north-east shore of Lake Champlain and the Chaudière River, generally. It is especially rich in copper ores; but contains, also, chromic iron ore, magnetic iron ore, specular iron schists, gold in quartz bands and veins, galena, serpentines and serpentine-marbles, roofing slates, and other economic substances. Its strata, as a rule, are much folded and disturbed, as well as altered chemically. The Sillery formation follows in most places the outcrop of the Lauzun beds, and the altered portions of its strata cannot always be sharply separated from the latter. In its unaltered state, it occurs, in the form of red and green shales, micaceous sand-

stones, and dolomitic beds, at Sillery Cove and Cape Rouge, near Quebec; and on the south shore, between the Chaudière and the vicinity of Point Lévis, and still more extensively in the country east of the Chaudière.

The "Gaspé-Limestone formation" is regarded as mainly equivalent in position to the Lower Helderberg series of western localities. Although composed chiefly of gray limestone strata, it is partly made up of a lower (perhaps Middle Silurian) series of black shales and slates; and some green and red shales are interstratified with its calcareous beds. The lower part of the formation occurs principally in the Eastern Townships of Orford, Melbourne, Westbury, &c., where it contains workable beds of slate, and is seen in places to overlie the Sillery formation unconformably; whilst the higher or more calcareous portion is chiefly developed in Gaspé. On the extreme eastern coast, as at Barry Cape, the Percé Rock, and elsewhere, the limestones present bold cliffs and pinnacles of rock, worn and hollowed by the action of the sea.

The "Gaspé-Sandstone formation," as shown by its fossils, is of Devonian age, representing most probably the Oriskany, Hamilton (or Lambton), and Chemung formations of western districts It occurs in Dudswell, Burford, and other sections of the Eastern Townships, in the form of light or dark-coloured limestones or dolomites (rendered crystalline in places by metamorphism), which appear to merge more or less into the underlying "Gaspé-Limestone" beds. In Gaspé proper, where the formation occurs in its more typical aspect, it consists essentially of interstratified sandstones, shales, and conglomerates, holding in places many fossilized plant-remains. A thin seam of impure coal occurs also in these beds at Little Gaspé Cove; and petroleum springs ooze through the strata at Douglastown and elsewhere.

The "Bonaventure formation" represents the lower portion or base of the coal measures, but is entirely destitute of coal. Its strata are chiefly composed of conglomerates, with associated sandstones and red and greenish shales, some of which hold carbonized plant-remains; and in many places they are penetrated by trap dykes. They rest unconformably on strata of the Gaspé-Sandstone series. The formation is seen principally on the eastern coast of Gaspé and on the opposite Island of Bonaventure, and still more prominently along the coast of the Bay of Chaleurs, where its average thickness was estimated by Sir William Logan at no less than 3,000 feet.

The more important of the eruptive rocks occurring within the district, comprise:—(i.), The trachytic mountains of Brome and Shefford, agreeing in character with most of the eruptive mountains of the Upper St. Lawrence district, and belonging to the same linear series; (ii.), the granites of the Great and Little Megantic Mountains, and other granitic masses around Lake St. Francis, with those of Winslow, Hereford, Stanstead, Weedon, and other portions of the Eastern Townships' area; and (iii.), various trappean exposures of Eastern Gaspé and the Bay of Chaleurs. Most of these latter occur as interpenetrating and overlying dykes; but at some spots, trappean (or trachytic?) masses form mountains of high elevation, as seen in the "Conical Mountain" of the Cascapedia, and in others of similar character in the country between the Matapedia and the Restigouche.

The third series of formations referred to as occurring within the Appalachian district, consist of Post-Cainozoic deposits. These comprise:—(i.), Beds of auriferous gravel and magnetics and; (ii.), boulder-clays, or drift deposits, proper; (iii.), beds of Leda clay and Saxicava sand; and (iv.), sundry superficial deposits of comparatively recent origin. The drift clays in many parts of the Eastern Townships and adjacent areas, are underlaid by (and also partially mixed with) layers of gravel and black magnetic sand, containing, very generally, fine grains, and occasionally small nuggets, of free gold. These auriferous deposits have been recognized in the beds of most of the streams and rivers which flow through this section of the Province, and especially in the St. Francis, Chaudière, Famine, Rivière des Plantes, Etchemin, Gilbert, Metgermet, and Rivière du Loup. The Leda clay and Saxicava sand deposits are largely displayed on the Trois Pistoles, Cacouna, Rivière du Loup, Ste. Anne, Matanne, Métis, and other rivers. On the Métis (in Gaspé) a bed of Saxicava sand occurs at an elevation of 245 feet above the present sea level. The more superficial deposits of the district include the bog iron ores of Stanbridge, Farnham, Simpson, Ascot, Stanstead, Ireland, St. Lambert, St. Vallier, Vallery, Cacouna, and other sites; the ochres of Durham; the shell-marls of Stanstead, New Carlisle, &c.; and the peat beds of the Rivière Ouelle, Rivière du Loup, Métis, Rimouski, and Madawaska.

(4.) *The Anticosti District.*—This division includes the large Island of Anticosti, in the St. Lawrence Gulf; the group of the Mingan

Islands on the opposite northern shore; and a narrow strip of the latter lying around the mouth of the Mingan River, and extending eastward for several miles. It should also include, strictly, the strip of land along the Gaspé Coast, lying north of the line of dislocation described under the preceding division. It is essentially a region of unaltered and comparatively undisturbed Silurian strata. The Island of Anticosti extends in a general north-west and south-east direction, with a length of about 150 miles, and a breadth, in its broadest part, of about 35 miles, gradually tapering at the extremities. The northern coast presents bold ranges of cliffs, from 200 to 400 feet in height, cut through in places by deep water-courses. The interior of the island is thickly wooded, but is destitute of lakes and important streams. It appears to consist of a series of plateaux or broad terraces, gradually descending to the south shore. The latter, although showing in places high cliffs of drift clay, is mostly of a low and swampy character, and this part of the island is especially characterized by the presence of extensive beds of peat.

The Mingan Coast consists of arenaceous limestones and dolomites of the Calciferous formation, and similar strata on the islands are succeeded by Chazy beds composed of reddish and pale-gray limestones, with interstratified arenaceous shales. On the principal island (Large Island) of the Mingan group, light-coloured limestones, holding characteristic Lower Trenton or Black-River fossils, overlie the Chazy beds—the whole dipping, at a slight angle, southwards or towards the Gulf. The next exposure (in the regular sequence of Lower Silurian formations) occurs along the opposite north coast of Anticosti, and consists of grayish and other coloured limestones, with interstratified shales and conglomerates, having an inland or southerly dip of very slight amount. These beds belong to the upper part of the Hudson River formation, and it may thus be legitimately inferred that the intervening area of the Gulf is occupied uninterruptedly by other Hudson River beds, with Utica and Trenton strata cropping out successively from beneath them. In some of these Hudson River strata, examples of the curious stem-like corals (*Beatricea undata*), resembling the petrified trunks of large trees, occur in considerable abundance. The succeeding area of the Island to the south, is occupied by argillaceous and other limestones, essentially of Middle Silurian age, the equivalents apparently of the Medina, Clinton, and Niagara formations of the West; but char-

acteristic Niagara fossils are asociated in some of these strata with Hudson River and other Lower Silurian types.

The other rock-formations of the district consist of Post-Cainozoic deposits. Raised beaches, in the form of a series of terraces, extending to a height of about 100 feet above the sea, occur on some of the Mingan Islands; and other evidences of elevation are seen in the pillared rocks left here and there upon the surface, at heights of fifty or sixty feet above the present sea-level. Drift clays, holding limestone pebbles, overlie the calcareous strata of some parts of Anticosti, especially on the south-west coast, where they form cliffs of considerable height. But the more remarkable of the Post-Cainozoic formations of Anticosti are the great peat-beds, which cover large areas on the southern part of the Island. One of these extends in a narrow band along the south-east coast, between Heath Point and South Point, over a length of nearly eighty miles.

PROVINCE OF NEW BRUNSWICK.

The geology of New Brunswick, notwithstanding the numerous reports already published upon it, still remains, in a great measure, to be worked out. Viewed, however, in its broader or more general features, the Province may be looked upon as including two essentially distinct geological regions. These comprise: (1), the Western and Southern district, occupied for the greater part by granitic, and more or less altered rocks—the latter mostly of Pre-Silurian and Silurian age—with a few limited exposures of higher strata; and (2), the Eastern or Carboniferous district, occupied exclusively, or practically so, by subdivisions of the Carboniferous formation. If a line be drawn from near Bathurst, on Nipisiguit Bay (an inlet of the Bay of Chaleurs), to Lake Oromocto, in the south-east corner of York County, and another from this point, in an easterly or north-easterly direction (roughly parallel with the Bay of Fundy), to Chepody Bay, in Albert County, the two districts will be marked out with sufficient accuracy for general purposes. All the country west and south of these lines will belong to the first district; and the great triangular area extending east and north of the lines to the Gulf shore, will form the second or Carboniferous district.

(1.) *The Western and Southern District.*—The geological structure of this region is of a very complicated character. Most of its strata

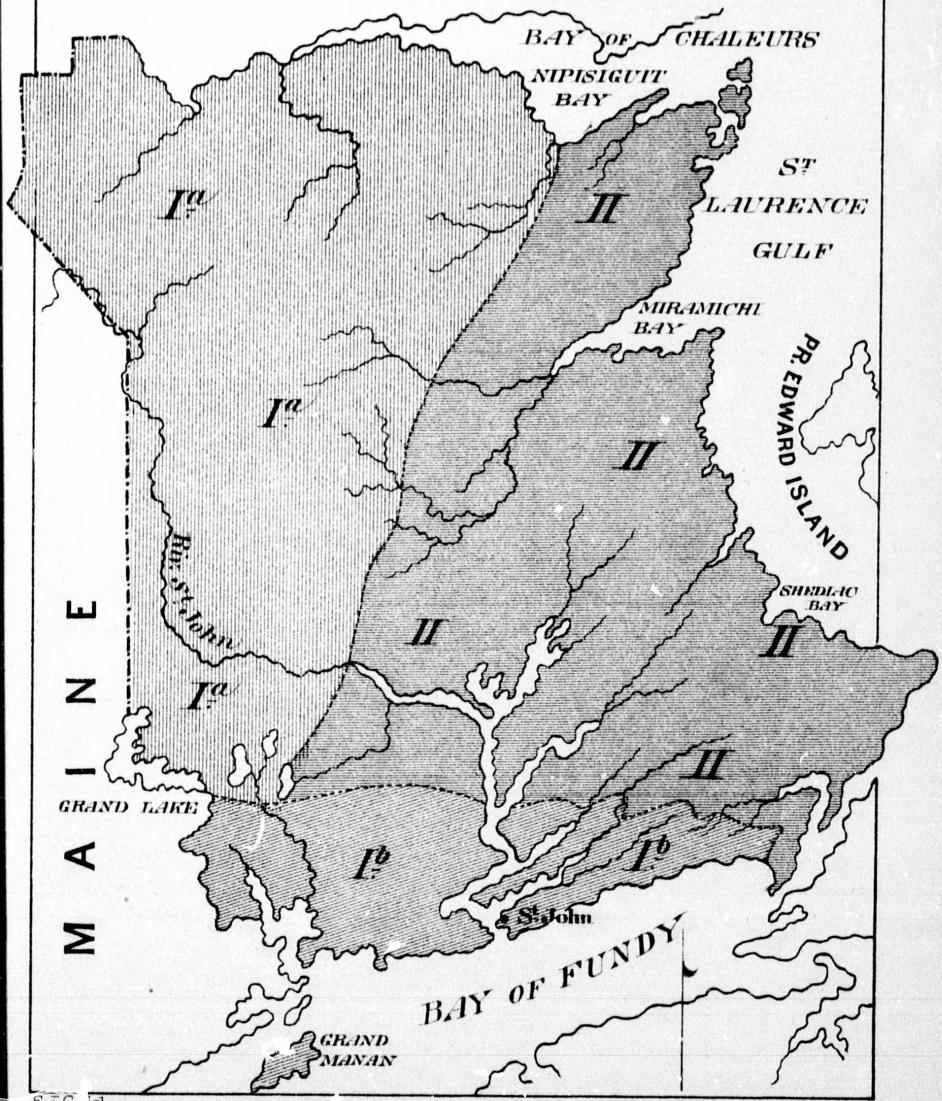
PLATE XI.

PROVINCE OF NEW BRUNSWICK,

SKETCH MAP,

Shewing Geological Areas.

I^a & I^b Western and Southern District.
II Eastern Carboniferous District.



E. J. C. del.

Copp, Clark & Co. Lith. Toronto.

are in an altered or metamorphic condition, and are more or less broken up, contorted, and intermixed; whilst faultings and overturn dips are of frequent occurrence amongst them, thus adding, in many cases, to the general obscurity of their age. In the present state of our knowledge, the district is most conveniently described under two subdivisions, as below:

(*i.*) *The Western Division.*—This may be assumed to include the country lying west of the line described above as running from Nipisiguit Bay to Lake Oromocto. It thus includes the Counties of Ristigouche, Victoria, and Carleton, with the chief part of York, and the north-west portion of Northumberland. Its surface consists very generally of extended plains, cut by numerous river-valleys, and heavily wooded throughout. The average elevation above the sea is, probably, under 500 feet, but isolated mountains in its more northern limits attain to elevations of from 1,500 to over 2,000 feet. The principal rivers comprise the head-waters and upper course of the St. John, with its numerous tributaries, including the Tobique, the Beccaguimic, &c.; and the upper portions of the Miramichi, Nipisiguit, and Ristigouche. The rock-formations within it consist principally of a series of micaceous and other slates, with quartzose and argillo-calcareous strata, dipping at high angles and greatly contorted in places; whilst over a broad tract of country, extending from Grand Lake on the Province boundary-line, in a general north-easterly direction to the vicinity of the Bay of Chaleurs, they are associated with long belts of granitic rock. The slates, quartzites, and other altered strata, are regarded mainly as Upper Silurian formations, from a few characteristic fossils discovered in some of their beds, but older formations (as seen in the Southern Division of the District) may perhaps occur among them. The granites are probably in chief part, if not wholly, of Devonian age. Copperpyrites, and beds of slaty hematite, occur in these altered strata in the neighbourhood of Woodstock; and veins of antimony ore in the parish of Prince William, between Woodstock and Fredericton. The only other formations—apart from superficial deposits—recognized within this western section, consist of sandstones, shales, and conglomerates, with subordinate beds of limestone and gypsum, of Lower Carboniferous age. These occur as outlying portions of the great carboniferous district of the east. The most important of these outliers, none of

which, however, contain any coal, occupies a comparatively large area on the Tobique River; and a smaller one lies on the St. John, between Fredericton and Woodstock. (See "Survey Reports," by C. Robb: 1869-70.)

(*ii.*) *The Southern Division.*—This geological area, although forming properly a portion of the Western Division described above, presents certain points of difference in the apparently more complete series of rock-formations contained within it, and in the still greater signs of disturbance to which the older of these formations have been subjected. It comprises the region lying immediately along the north shore of the Bay of Fundy, and extends over the entire areas of Charlotte and St. John Counties, over part of Queen's County, and over large portions of the counties of King and Albert. The rock-formations recognized within its limits are as follows:

First, a series of gneissoid strata, with succeeding dioritic and chloritic slates, quartzites, and related metamorphic beds, associated very generally with high belts of granitic and syenitic rock, and for the greater part, in a much disturbed condition. These crystalline and semi-crystalline strata are Pre-Silurian formations, and are regarded as of Laurentian and Huronian age; but the associated granites and syenites are probably Devonian. Elevated areas of this character occupy large portions of Charlotte and St. John Counties, and others occur in Queen's, King's, and Albert County—as seen in the Nerepis Hills, the Porcupine and Bald Mountain Ridges, the Quaco Hills, and elsewhere. Many of these granites and syenites are porphyritic; and some of them, especially the red varieties, furnish ornamental building-stones of much beauty.

A second series, composed of dark slates associated with beds of sandstone, forming a collection of strata known as the St. John's Group or Formation. These strata overlie crystalline beds of the supposed Huronian series; and they contain examples of Paradoxides, Conocephalites, and other trilobites of so-called "Primordial" type, with brachiopods, &c., characteristic of the same geological horizon. They are thus regarded as forming the extreme base of the Silurian series—including under this term the Cambrian strata of many geologists. As a rule, they are greatly folded and contorted, and they appear to be destitute of economic minerals. Outcrops occur, more especially, within and around the City of St. John, and in the valleys of the St. John, Kennebecasis, and Nerepis Rivers.

A third series, consisting mostly of gray shales and limestones, and siliceous conglomerates, with associated feldspathic and dioritic beds, containing in places some obscure fossils of Middle and Upper Silurian type. These higher Silurian strata occur chiefly on Foye's Island and the adjacent coast, on the shores of Oak Bay, &c., and along the granitic slopes of the Nerepis Hills in King's and Queen's Counties.

A fourth and higher series, composed of Devonian and Lower Carboniferous strata, represented essentially by shales, sandstones, and conglomerates, and characterized for the greater part by the presence of numerous fossil plants. The Devonian beds have been divided into five groups, known, in ascending order, as the Bloomsbury, Dadoxylon, Cordaite, Mispec, and Perry groups—the latter regarded as Upper Devonian. The lower and middle groups are principally developed around Carleton and other points on the west side of St. John's Harbour; at Mount Prospect and elsewere in the valley of Little River; and also in Lancaster Parish and around Leprean Basin, where a thin seam of slaty anthracite has been observed in one of their beds. The Upper Devonian or Perry strata also appear at Point Leprean, but are chiefly exposed around the City of St. Andrews, where they extend over a comparatively large area. The beds recognized as Lower Carboniferous are entirely destitute of coal, and in this southern part of the province they occur only in the form of detached outliers, of comparatively small extent—as on the west side of Grand Bay on the River St. John, the south side of Kennebecasis Bay, and around Quaco, on the Bay of Fundy. (See "Survey Reports," by Prof. L. W. Bailey and G. F. Mathew: 1870-73.

A fifth series, composed of a few strips and patches of Triassic strata, essentially in the form of soft, red sandstones, but associated in places with a few layers of conglomerate. These strata occur sparingly near Quaco Village and elsewhere on the Bay of Fundy, and also on the north shore of the Island of Grand Manan, where the characteristic red sandstone of the series is overlaid by a light-gray siliceous bed holding copper ore, with an immense overflow of columnar trap covering the whole.

Finally, accumulations of boulder clay and gravel, with sands and other recent surface-deposits, are spread very generally over this southern portion of the district, which appears, moreover, to have been largely denuded and otherwise affected by glacial agencies.

The more important of the recent formations are the peat bogs of the Mispec Barrens and Musquash Bay, in St. John's County, and those of Mace's Bay and other localities in Charlotte County, further west.

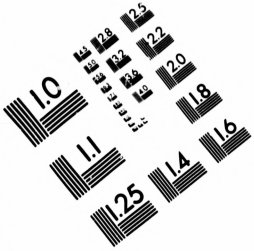
(2.) *The Eastern or Carboniferous District.*—This geological region occupies the central and eastern portions of New Brunswick, forming a large triangular area, the sides of which converge, respectively, from Nipisiguit Bay, on the Bay of Chaleurs, and Salisbury Cove, on Chinecto Bay, to a point in the vicinity of Oromoctoo Lake, near the boundary-line of York and Charlotte Counties. It presents, as a rule, a flat or gently undulating surface, drained principally by the Miramichi and branches, in its more northern and central portions; and by the St. John, with the Nashwauk, Salmon, Washademoxe, and other tributaries of the St. John, in the south. Its average height above the sea is probably about 400 feet. Its strata consist essentially of sandstones, calcareous and other conglomerates, and argillaceous shales; and they belong to the lower, middle, and upper subdivisions of the Carboniferous series. Seams of coal are confined entirely to the middle division—as elsewhere in the Carboniferous formations of the Maritime Provinces—but those hitherto discovered in New Brunswick are of comparatively slight thickness, the most important seam scarcely exceeding a couple of feet, whilst the greater number present a thickness of a few inches only.

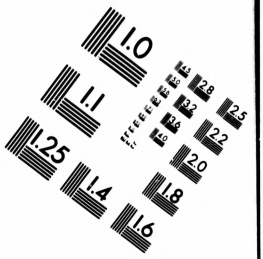
The Lower Carboniferous division is made up principally of sandstones, shales, and conglomerates, characterized by a very generally prevailing red colour. Apart from outliers, it is confined, practically, to the inner edge of the metamorphic area which borders the present district on the east and south; and its strata in many places are folded among the metamorphic formations, and are also more or less broken up by faults, or are otherwise disturbed, as below Long Island, on the River St. John, and elsewhere. Coal, except in unimportant traces, is apparently altogether absent. In some localities, however, and notably in the parish of Hillsborough, in Albert County, the remarkable bituminous substance known as "Albertite" occurs in these Lower Carboniferous strata, in the form of undoubted veins. This substance is a kind of solid bitumen—black, brittle, and highly lustrous. At the Hillsborough mines, it traverses—and for the greater part at a high angle of dip—calcareo-bituminous shales containing

remains of fossil fishes (belonging to Palæoniscus, Holoptychius, and other genera), with overlying gray and red conglomerates, intercalated with beds of limestone and gypsum. At other localities, as at Markhamville, in Upham Parish, King's County, and near Shepody Mountain, in Albert County, the Lower Carboniferous strata contain important deposits of pyrolusite or black manganese ore. Finally, at Clarke's and McLeod's Mountains, north of Frederickton, and at Bald Mountain, near Cranberry Lake, and some other spots, the strata of this lower division are broken through by eruptive masses of trappean or trachytic rock.

The Middle Carboniferous strata consist essentially of sandstones, sandy shales, and conglomerates, of a prevailing gray colour. The series may be subdivided into two groups: a lower group, made up of rocks of a more or less coarse texture, destitute of coal—the equivalent of the millstone grit subdivision of Nova Scotia; and a higher group of conglomerates and sandstones of finer texture, intercalated with coal shales, layers or partings of clay, and thin seams of bituminous coal, representing the productive portion of the coal measures proper. The strata of both groups occur, as a rule, in nearly horizontal beds, or dip only at very moderate angles, rarely exceeding four or five degrees. Most of the coal seams hitherto discovered are under five or six inches in thickness, but one seam, known as the "surface seam," averages eighteen or twenty inches, and, in places, exceeds a couple of feet. It has been worked somewhat extensively as a source of local supply. These Middle Carboniferous beds appear to extend over the entire portion of Eastern New Brunswick, between the Gulf on the east, and the border of Lower Carboniferous and Metamorphic rocks on the south and west; but in some places the lower rocks have been exposed, by denudation, over limited areas; and at other spots, the beds in question have been covered by red and purplish shales, &c., of the Upper Carboniferous series.

The strata of the Upper, like those of the Lower, Division, are essentially composed of shales, sandstones, &c., for the greater part of a red or reddish purple colour, and destitute of coal. They overlie the Middle Series conformably, and appear to be associated more or less generally with the latter throughout the greater portion of the district.





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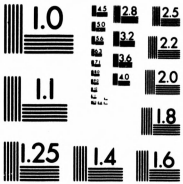
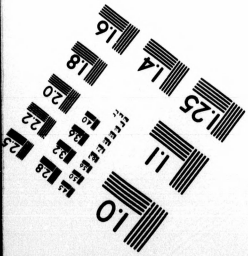
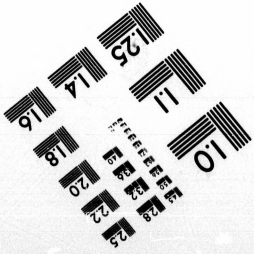
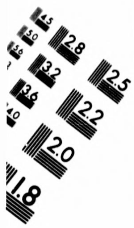








PROVINCE OF NOVA SCOTIA.

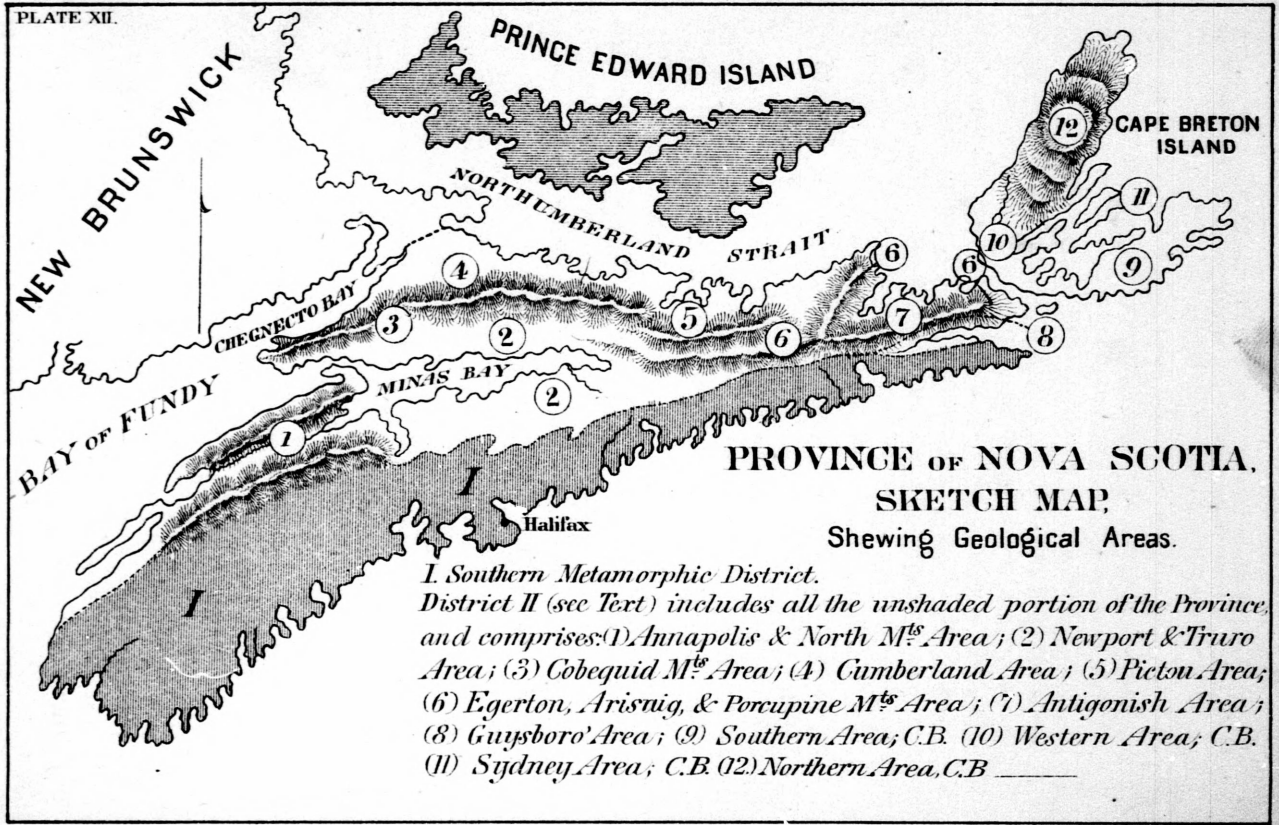
This Province, as regards its more salient geological features, is divisible into two broad regions, comprising: (1), The Southern Metamorphic District, occupied essentially by crystalline and granitic formations; and (2), the Northern Carboniferous District, in which a number of Palæozoic, and for the greater part Carboniferous, areas, are separated more or less by belts and mountain ranges of syenitic and other related crystalline rocks.

(1.) *The Southern Metamorphic District.*—This forms a long but comparatively narrow area, extending over the country along the entire southern coast of Nova Scotia proper, from a point between Yarmouth and Cape Sable, in the west, to Cape Canso and the south shore of Chedabucto Bay, in the east. Gradually contracting in width between these points, it includes small portions of Digby and Annapolis Counties, the whole of Shelbourne, and large portions of Yarmouth, Queen's, Lunenburg, Halifax, Hants, and Guysboro'. Its coast-line is deeply indented, and its interior, for the greater part, of a wild and rocky character. As regards its geology, it is essentially a metamorphic region, occupied by crystalline strata, with considerable areas of unstratified granitic rocks, the latter, apparently, of Post-Silurian age.

The crystalline strata appear to consist in part of Laurentian formations, and in part of altered higher beds, ranging into the Silurian series. They are composed mostly of gneiss, fine-grained in some localities and porphyritic in others, with associated mica-slates and quartzites, succeeded in many places by black or bluish-black argillites with well-marked slaty cleavage. These strata, as a rule, occur in highly-tilted or otherwise disturbed beds. Thin layers (or bedded veins?) of quartz, for the greater part auriferous, are present, more especially, in the middle and upper portions of this metamorphic series. The gold is mostly distributed through special zones or so-called "streaks," or "pipes," in these quartz deposits, and it occurs chiefly in the free state. In some places, however, it is also present in arsenical and common pyrites.* These quartz layers, as a rule, are under a foot in width. They are very commonly situated on anti-

* Streaks or pipe-bands of this character are not uncommon in ordinary mineral veins. As regards Western Canada, the writer has pointed out their occurrence in certain lead veins in the township of Galway, in Ontario.

PLATE XII.



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clinals, with high angle of dip; and in many cases they are sharply corrugated—the enclosing rock presenting, necessarily, a correspondingly convoluted structure. The more important localities, or "districts," in which these gold deposits have been recognized, are as follows:—(i.), The *Lunenberg* district, including the *Ovens* area, &c.; (ii.), the *Waverley*, *Oldham*, and *Renfrew* district, north of Halifax; (iii.), the *Uniacke* district; (iv.), the *Tangier* district; and (v.), the *Sherbrooke* and *Stormont* district, including *Wine Harbour*, *Country Harbour*, &c.

The granite areas lying within this southern metamorphic region have not yet been thoroughly explored, so that eventually many apparently isolated masses will probably be found to constitute connected bands. Those at present recognized occupy the following sites: The country around Barrington and Shelburne, north and north-east of Cape Sable; the more southern portions of Digby, Annapolis, and King's counties; the Aspatagoen promontory between Mahone Bay and Margaret Bay; the country around Halifax, especially north and west of the city; the lower portion of the Musquodoboit valley, and adjacent country to the east; the south shore of Chedabucto Bay and the country westward to the vicinity of St. Mary's River.

(2.) *The Northern Carboniferous District.**—This region extends along the Bay of Fundy, and throughout all the northern, central, and eastern portions of Nova Scotia, including the Island of Cape Breton.

In its general features it presents a number of detached Silurian (and Devonian?) areas, separated for the greater part by ridges and mountainous masses of syenites, and surrounded by areas of Carboniferous strata. The Silurian and Devonian rocks are mostly tilted at high angles, and are altered more or less by metamorphic action. The surrounding Carboniferous strata belong partly to the Lower division, but chiefly to the Middle or Productive portion of the series, and in many localities they contain important beds of bituminous coal, some of the seams being of unusual thickness. In addition to these strata, some comparatively narrow strips of Triassic sandstone, associated with vast trappean overflows, range along the Bay of Fundy and the shores (in part) of Cobequid Bay. Boulder

* The names given to these districts must not be taken in too limited a sense. The present region is named as above, because it is especially characterized, when viewed generally, by the presence of Carboniferous strata.

clays and Post-Glacial deposits are distributed also throughout the region generally.

Although regarded in the present outline as forming a single geological district, characterized as above, this northern portion of the Province may be provisionally subdivided, for descriptive purposes, into twelve subordinate areas. These follow each other, roughly, from west to east in the following order:—1. The Annapolis and North Mountains area, mostly Triassic and Trappean; 2. The Newport and Truro area, essentially Lower Carboniferous and Triassic; 3. The Cobequid Mountains area, essentially syenitic and slaty; 4. The Cumberland area, Middle Carboniferous (coal-bearing); 5. The Pictou area, Middle Carboniferous (coal-bearing); 6. The Egerton, Arisaig, and Porcupine Mountains area, essentially syenitic and slaty; 7. The Antigonish area, essentially Lower Carboniferous; 8. The Guysboro' area, Lower Carboniferous; 9. The Southern area of Cape Breton, essentially syenitic and slaty; 10. The Western Cape Breton area, mostly Lower Carboniferous, with some overlying coal-bearing beds; 11. The Sydney Cape Breton area, Middle Carboniferous (coal-bearing); 12. The Northern area of Cape Breton, syenitic and slaty.

1. *The Annapolis and North-Mountains Area.*—This division extends along the south shore of the Bay of Fundy. It includes the North Mountains and the valleys of the Cornwallis and Annapolis Rivers, and is limited inland by the granitic slopes of the South Mountains. The strata which rest against the latter, consist essentially of altered and partially-altered slates of Upper Silurian or Devonian age. They dip away from the granite mass, and they are traversed generally by transverse cleavage-lines. Towards the north, as in Kentville and New Canaan, they are but little altered, and numerous crinoid stems and other apparently Upper Silurian fossils occur in their beds at these sites. A thick bed of granular iron ore on the River Nictau, farther south, also contains fossils. A few miles south of this stream, the continuity of the strata is interrupted by a granite spur, but beyond this, the slates reappear, although in a more altered condition, and extend broadly to the sea-coast, south of St. Mary's Bay. North of this granite spur, or along the valleys of the Annapolis and Cornwallis, the slates are bordered by a narrow strip of red sandstone country, apparently Triassic. The sandstone is mostly in the form of thin and slightly-inclined layers. These

rest in places on highly-inclined strata of the Carboniferous series, but the latter are of quite subordinate occurrence in this area. Immediately west of the Triassic country, a broad belt of columnar and amygdaloidal trap ranges continuously, in the form of a bold line of cliffs, along the shore of the Bay of Fundy from Bryer's Island to Cape Blomidon, with outlying patches in Partridge Island, &c., and at Cape d'Or on the opposite coast. A layer of tufaceous material marked by green cupreous stains, arising from the decomposition of imbedded bunches of copper-glance, occurs very generally between the sandstone and the overlying trap. Zeolites and other characteristic trap minerals are abundant in the latter at many spots.

2. *The Newport and Truro Area.*—This subdivision occupies the country around Minas Basin and Cobequid Bay, extending northwards to the Cobequid mountain range, southwards to the northern edge of the Atlantic metamorphic region, and eastward to the slopes of the syenitic ranges in the south-east of Colchester County. It thus includes the country around Windsor, Newport, Walton, Maitland, Truro, and Parrsborough, with the valleys of the Kennetcook, Shubenacadie, Stewiacke, and Musquodoboit rivers, more especially. Its strata belong, for the greater part, to the Lower Carboniferous series, and consist of red and other-coloured sandstones, dark shales holding numerous coal-plants and fish remains, marls, and limestones. The latter strata contain an abundance of Carboniferous brachiopods and other fossils; and in many places, as in the vicinity of Windsor, in the cliffs of the St. Croix River, at Newport and Walton, along the Shubenacadie, &c., they are associated with beds (and occasional veins) of anhydrite and gypsum. A few comparatively limited patches of Middle Carboniferous strata overlie these lower beds here and there along the edge of the Cobequid Range, and in places in the valleys of Kennetcook and Stewiacke, but they appear to contain merely thin seams of coal, of value only as a source of local supply. Both the north and south shores also of Cobequid Bay are bordered by soft red sandstones and conglomerates of assumed Triassic age. These rest unconformably on the prevailing Lower Carboniferous formations of the country; and in places, as at Gerrish's Mountain and elsewhere, they are overlaid by masses of amygdaloidal trap.

3. *The Cobequid Mountains Area.*—This section of the Province forms a wild but thickly-wooded mountainous district, of an average

elevation of from 1,000 to 1,200 feet above the sea. It ranges, roughly, from Cape Chignecto in the west, to the Carboniferous district of Pictou in the east. Southwards it is bounded by the Newport and Truro area, and northwards by the Cumberland coal region. The Cobequid range is composed essentially of syenites and related crystalline rocks, probably of Pre-Silurian age, with slates, shales, sandstones, and quartzites, dipping at high angles on its southern flanks. These latter formations are regarded as altered Silurian strata. In the township of Londonderry (Colchester county), more especially, they are traversed by veins of brown and red iron ore and ankerite.* One of these is remarkable for its continuity over a length of several miles. It is filled principally with ankerite, but carries large quantities of fibrous and botryoidal brown iron ore in some places, and micaceous red ore in others. The ankerite averages in metallic iron 11¾%, the brown ore 56%, and the red ore nearly 69%, as deduced from a series of analyses by the writer. These ores, moreover, contain very little rock matter, and they are practically free from titanium; whilst sulphur and phosphorus are present in them in traces only.

4. *The Cumberland Area.*—This is one of the leading Carboniferous districts of the Province. It occupies in the County of Cumberland a large extent of country between the Cobequid Mountain Range on the south, and the Straits of Northumberland on the north. Westward it runs into the Carboniferous area of New Brunswick; and in the east it merges into the Pictou area. Its strata consist of the Lower and Middle (or Productive) Carboniferous divisions. The latter hold numerous seams of coal, but most of these are of slight thickness. Workable seams occur, however, within the area, more especially in the Springhill coal basin, near the slopes of the Cobequid Range. The strata here dip northwards, or away from the mountain flanks; but in the central and northern, or north-western, portion of the area, they dip towards the south, thus forming a more or less regular trough or basin. On a portion of the northern edge of this trough (the strata dipping nearly S.S.W.), the celebrated "South Joggins section" occurs. This is exposed along the eastern shore of Cumberland Basin, a continuation of Chegnecto Bay. It exhibits a continuous series of Lower and Middle Carboniferous beds, dipping

* See Dawson's "Acadian Geology." Also a detailed notice, with working plan, by Mr. Selwyn, Director of the Geol. Survey, in the Report for 1872.

S. 25° W., at an average angle of 19°, throughout a thickness of 14,500 feet, and containing seventy-six seams of coal, nearly all of which rest upon stigmaria under-clays. These coal seams for the greater part, however, average, individually, only a few inches in thickness; but two are of workable dimensions. One of these is the "Joggin's Main Seam," consisting, really, of two seams separated by a thin layer of shale, but worked as a single seam. It averages nearly five feet in thickness. In the associated sandstones and shales, upright and prostrate trunks of sigillariæ and lepidodendra—with other coal plants, shells of fresh water mollusca, and numerous fish scales—occur throughout the section. In these rocks, also, the remains of an extinct amphibian—the Dendrerpeton Acadianum of Owen and Wyman—belonging, apparently, to the perrenibranchiate section of the Urodela—were discovered by Dr. Dawson, in 1852; and reptilian tracks have been discovered subsequently. Some of the lower beds of this locality yield grindstones of high reputation. On the southern margin of this area, where the general dip of the strata is towards the north, seams of greater thickness have been recognized. These lie east of the River Macan, in the Springhill coal country. Several seams of workable thickness have been discovered by trial pits. One exceeds 13 feet, and another 11 feet in thickness, the others ranging from 2 to 6 feet. The coal is a bituminous or gas coal, of excellent quality.

5. *The Pictou Area.*—This is the most important coal area of Nova Scotia proper. It lies directly east of the Cumberland Carboniferous district and the Cobequid mountain range, and thus comprises the country around Pictou Harbour, generally. It extends, however, southwards and eastwards to the older Palæozoic and Syenitic mountainous country, which ranges from the eastern borders of the Truro area through Egerton and Maxwelltown, and continues to the north coast in the Antigonish and Arisaig Hills. On these southern and eastern borders the area is occupied generally by various conglomerates, dark green and other-coloured slates and shales (many of which become opaque white by weathering), and some dark quartzites—all Pre-Carboniferous, but otherwise of doubtful age; and these are followed towards the north or north-west by gray and red sandstones and conglomerates, with a few limestone and gypsum beds, belonging to the Lower Carboniferous series. These

lower formations are more or less tilted and disturbed, and they exhibit nearly opposite dips in different localities. The central and northern portions of the area are occupied by succeeding strata of the Middle or Productive series, with overlying beds of the Upper series in places along the coast. The general dip of these strata is northwards—*i.e.*, a little west or east of north—or towards Northumberland Straits; but they are affected, over the more southern portion of their limits more especially, by a series of faults, by which their relative positions are somewhat disturbed. The base of the Middle Division is a coarse red conglomerate, which outcrops immediately north of one of these lines of fault, and runs in a general easterly direction through New Glasgow, between the inlets or harbours of Pictou and Merrigomish. This dips generally towards the north, in which direction it is followed by the more typical coal strata (although these present little more than indications of workable coal seams), with strata of the Upper Division outcropping beyond them and so passing under the straits. South of the New Glasgow conglomerate and fault—the outcrop of the conglomerate being due to the latter—other beds of the Middle or Productive Division occur; and it is in these that the great workable coal seams of the Pictou area are situated. They are traversed by several faults running roughly east and west, or parallel with the northern or New Glasgow fault; and they are also partially disturbed by minor faultings, running more or less transversely to the latter. The coal seams lie principally in two main synclinals between the north and the extreme south fault—a breadth or distance of from three to four miles intervening between these. Two of the seams are of remarkable thickness. These are exposed principally on and near the East River in the district of the Albion and Acadia mines, a few miles south-east of Pictou Harbour. One seam, known as the "Main Coal Seam," has an average thickness of about 36 feet; and a second seam, the "Deep" or "Cage-Pit" seam, lying 150 feet vertically beneath the main seam, is about 23 feet in thickness. These seams do not consist throughout of coal of uniform quality but include subordinate layers of coarse coal and slaty coal, and also some thin seams of ironstone; the whole, however, being taken out together, and thus worked as a single bed. At the Albion mines the dip of the main seam is N.E., at an angle of 18°–23°, and the thickness varies from 36 ft. 10 in. to 28 ft. 3 in. Several seams have been discovered below the Deep or Cage-Pit

seam, varying in thickness from 3 feet to about 12 feet; and a 3½ feet seam occurs also above the Main seam. Other seams have likewise been recognized by outcrops at Fraser's Mountain, and on Middle River, &c., within the present area. One of the lower seams, lying at a vertical depth of 580 feet below the Deep seam, consists of a layer or "bench" of ordinary bituminous coal, about 3 feet in thickness, resting on a layer of inflammable substance, somewhat resembling in character the Albertite of New Brunswick, and the Torbanite of Scotland. This substance has been named "Stellarite," by Professor How, from its property of emitting numerous sparks during combustion. It varies in the thickness of its bed, from five or six inches to about a couple of feet. Immediately beneath it there is another layer of a bituminous, or so-called "oil," shale, differing principally from the stellarite layer by its more shaly structure, and by the presence of a comparatively large amount of ash. The stellarite yields on an average about 120 gallons of crude oil per ton, and the oil shale about 60 gallons. In a band of impure ironstone, forming part of the Albion main seam, the skull and several teeth of a large Labyrinthodont—the *Baphetes planiceps* of Owen, were discovered some years ago by Dr. Dawson. (See "Survey Reports," by Sir W. Logan and E. Hartley: 1869.)

6. *The Egerton, Arisaig, and Porcupine-Mountains Area.*—This area might be regarded as an eastern extension of the Cobequid Mountains, although separated from the latter by a narrow strip of Carboniferous country connecting the Truro and Pictou areas. Like the Cobequid-Mountain area, it consists of high rocky land, made up of central ranges of syenitic rocks with altered Silurian (and Devonian?) strata, in the form of highly-tilted slates and quartzites, upon their flanks. It extends in a general north-easterly direction from near the head-waters of the Shubenacadie to within a few miles of Antigonish Harbour, where it subdivides into two branches, one of which terminates in the Arisaig Hills and in Cape St. George, and the other in the Porcupine Mountains on the Gut of Canseau. Some of the slates of this area, as those of Arisaig and other localities, contain Middle Silurian (?) fossils. The Antigonish Hills and Cape St. George in the north-east, and Cape Porcupine on the Gut of Canseau are composed, at least in their central portions, of vast masses of syenite and greenstone (probably of Pre-Silurian age) flanked by dark slates in highly-tilted and more or less contorted beds.

7. *The Antigonish Area.*—This extends over the eastern portion of Antigonish (formerly Sydney) County. It lies chiefly around Antigonish Harbour and the south shore of St. George's Bay, and thus includes the valleys of West River, South River, Pomket River, Black River, the Tracadie River, &c., and intervening breadths of country—the syenitic and altered rocks of Arisaig and Cape Porcupine bounding it, respectively, on the west and south. It is occupied essentially by strata of the Lower Carboniferous series, consisting of sandstones, limestones, &c., with thick and widely-extended beds of pink and white gypsum. A slight development of the Middle Carboniferous series occurs in the more northern portion of the area, and extends under St. George's Bay. Workable seams of coal are said to be present in its strata, but further explorations are required to confirm this.

8. *The Guysboro' Area.*—This area lies around the north-west shore of Chedabuctoo Bay, and extends westward, in a gradually narrowing belt from the south entrance of the Gut of Canseau, entirely across the county of Guysboro' and along the valley of the west branch of the St. Mary's River. It is bounded on the south by the eastern extension of the Atlantic crystalline area, and northwards by the southern slopes of the Cape Porcupine and Egerton syenitic and metamorphic region. Its strata appear to belong entirely to the Lower Carboniferous division, and they are destitute of coal. They consist, in the more eastern portion of the area, very largely of dark and other limestones, traversed here and there by thin veins or strings of specular iron ore, and accompanied by various sandstones and conglomerates, the latter occupying the chief portion of the area westward. In many places, especially around the town of Guysboro', these Lower Carboniferous strata dip at high angles, and present a more or less altered aspect.

9. *The Southern Area of Cape Breton.*—This area ranges from Isle Madame across St. Peter's Bay, and along the entire south coast of Cape Breton. It may be defined in general terms as occupying all the more southern portion of the Island, or those portions of the counties of Richmond and Cape Breton which lie to the south and south-east of the Great Bras d'Or and the Mire River. Its geology to some extent has still to be worked out, but the area is occupied essentially by masses of porphyritic syenite and related rocks, associated with

slates and other apparently altered strata, for the greater part of Palæozoic age, but including, probably, a few subordinate representatives of Pre-Silurian epochs.

10. *The Western Area of Cape Breton.*—This division lies immediately east of the Strait or Gut of Canseau. It extends from St. Peter's Bay over the western half of Richmond county, and northwards over the Bras d'Or Lake or Great Bras d'Or, and over the more western portion of the Little Bras d'Or. From these points it stretches to St. George's Bay and along the Gulf to beyond the Margarie River. It thus includes the greater portion of Richmond county, with the more western portion of the county of Cape Breton, and the southern portions of Inverness and Victoria. The rocks within this section of country belong chiefly to the Lower Carboniferous series, but the area includes also some slight exposures of the Middle or Productive series, and several tracts of considerable size occupied by syenites and related rocks. The Lower Carboniferous strata consist of various beds of conglomerate, sandstone, limestone, and marl—the two latter associated in many places (as at Plaister Cove, Port Hood, and Mabou, on the Gut of Canseau; at Caribou Cove on the south coast; and at Baddeck and other points on the Little Bras d'Or) with beds and occasional veins of gypsum and anhydrite. These lower strata are succeeded here and there by small patches of the Middle Carboniferous series, containing seams of coal. These occur at Caribou Cove and on Little River (where the beds are much tilted and disturbed), and also on the Inhabitants River, in the south; and near Port Hood and Mabou in the north-west. The coal bed at Caribou Cove, as described by Dr. Dawson, is 11 feet 8 inches in thickness, but of inferior quality; and it shows an overturn dip with the original underclay now forming its roof. At Port Hood several seams have been recognized, but these, apparently, are of no great thickness. The strata at this latter locality contain numerous stigmaria-roots in undisturbed position, together with other characteristic coal plants. In addition to these Carboniferous strata, this western portion of Cape Breton, as indicated above, includes some detached syenitic areas of considerable extent. The largest appears to range from the River St. Denys to within a short distance of St. George's Bay. Others of similar character—outliers of the great syenitic area of the northern peninsula of Cape Breton—lie in

the immediate vicinity of Ainslie Lake, a large body of fresh water, with the River Margarie for its outlet, in Inverness.

11. *The Eastern, or Sydney Area of Cape Breton.*—This area, as a coal-bearing district, rivals in importance the Pictou area of Nova Scotia proper. It occupies the country around Sydney Harbour, and extends northward across the Little Bras d'Or and Boulardrie Island, and eastward and southward to Mire Bay and the Mire River. Its strata belong essentially to the Middle or Productive Carboniferous series, and consist of the usual sandstones, conglomerates, and shales, with seams of bituminous coal and fire-clay, and occasional bands of ironstone nodules. They dip, generally, towards the coast, and their coal beds are worked in some instances to a considerable distance beneath the sea. The area thus evidently forms a portion of the western margin of a great sub-marine coal basin, the eastern or north-eastern edge of which outcrops in places on the opposite shore of Newfoundland. A fine section of these strata is exposed on the north-west shore of Sydney Harbour and around Cranberry Head. The beds at this locality dip towards the N. E. (or more strictly, N. 60° E.), at an angle of 7°; and they contain a great abundance of sigillariæ with attached roots, and other examples of characteristic coal-plants. Although numerous seams of coal occur within the area, the actual seams of workable thickness do not appear to exceed six or seven in number. These have been brought up, however, at various points by a succession of undulations; and outcrops of the same seam on different properties have thus been regarded in many instances as distinct seams, and special names have been bestowed upon them.* These workable seams vary in thickness from about 4 feet to 10 feet—the average thickness being about 5½ to 6 feet. The average dip is from 5 to 6 degrees, or about 1 in 10 or 12, but the beds flatten greatly, as a rule, in descending. In some places, however, the dip is much higher. The Victoria (Ross) seam, for example, dips at an

* The writer made a rapid examination of the Sydney Harbour coal country in 1873, and published commercial reports on the Collins' coal property immediately east of the Little Bras d'Or, and on the Campbell property near Clace Bay. He found no indications of faults at these localities; and he is informed by Mr. Hugh Fletcher (one of his old students, now on the staff of the Geological Survey) that late investigations have failed to detect their presence within the coal district proper, the repetition of the seams at different spots being entirely due to a series of folds, as stated in the text above. Mr. Fletcher, partly alone, and partly in conjunction with Mr. Charles Robb, has mapped and examined the entire coal area of this part of Cape Breton. (See the "Survey Report" for 1874, and that for 1875 now under preparation.)

angle of 38° or 39°; and the McAulay seam, near Cow Bay, dips on one side of a sharp synclinal at an angle of nearly 45°, whilst on the opposite side the slope is only about 7° or 8°. The principal mines are situated more or less immediately along the coast, in a curved line extending from Boulardrie Island, across the Little Bras d'Or and Sydney Harbour, by Lingan and Bridgeport, to beyond Glace Bay and Cow Bay, in the south-east. The coal throughout this area is a bituminous caking coal, containing, as a rule, a very low amount of ash.

12. *The Northern Area of Cape Breton.*—This division includes the more northern portions of the counties of Inverness and Victoria, forming the great northern peninsula of Cape Breton. Very little is known of its geology; but the greater portion, if not the entire surface, of its area appears to be occupied by high ranges of syenitic rocks of Pre-Silurian age, flanked by micaceous and other slates, resembling the altered Palæozoic formations which occur in the southern part of the island, with here and there a few exposures of Lower Carboniferous strata. These latter are seen along the west coast, between Margarie and Cheticamp; and on the eastern coast at Aspy Bay, St. Anne's Bay, and one or two intervening points.

PROVINCE OF PRINCE EDWARD ISLAND.

This fertile island presents a generally level or but slightly undulating surface, with an average altitude of from 100 to 200 feet above the sea. Mountain elevations are altogether unknown within its limits. The coast-line is indented by numerous bays and creeks—some of which penetrate far inland. Its geology is comparatively simple, indicating a single district only. The surface strata consist almost wholly of soft red sandstones, and other Triassic representatives in nearly horizontal or but slightly inclined beds, with here and there an outcrop of underlying Upper Carboniferous (or Permian?) strata, and some overlying drift and modern deposits.

A very complete Report on the geology of this Province, by Dr. Dawson, (with the co-operation of Dr. Harrington,) was issued by the Geological Survey of Canada in 1870. From this Report—aided by personal observation, the writer having visited the island on two occasions—the brief details which follow are chiefly drawn.

The oldest recognized strata on the island are either Upper Carboniferous representatives, or beds of transition representing part of

the Permian formation. They occur on the south coast at the Gallows or Gallas promontory, east of Hillsborough Bay, as well as on Governor Island, in the centre of the latter inlet; and they range also in a narrow strip, along the greater portion of the north-west coast, from near West Point to the vicinity of North Point. At these localities the strata consist chiefly of brown, red, and gray sandstones, with some reddish shales, and a few concretionary limestones and conglomerates. The beds at Gallas Point form a slight anticlinal, ranging roughly north and south, and extending apparently through Governor Island. These strata, both at Gallas Point and on the north-west shore, contain silicified trunks of a coniferous tree, (*Dadoxylon materiarium*, Dawson,) with several species of calamites, ferns, and other plants belonging essentially to the Upper Division of the Carboniferous series.

These Carboniferous strata, however, are of little significance as regards the geology of the Province generally. The main area of the island, as stated above, is occupied by Triassic representatives. These consist essentially, at the lower part of the series, of concretionary, and more or less magnesian and sandy limestones, with beds of comparatively hard red sandstone and occasional conglomerates; and, at the upper part, of soft red sandstones and clayey marls. The red sandstones form the characteristic strata of the island, but calcareous conglomerates are seen in many of the coast sections on the western shore. Some of the lower beds contain obscure plant-remains and impressions; and portions of the under jaw, with attached teeth, of a Dinosaurian (?) reptile (the *Bathygnathus borealis* of Leidy) were discovered many years ago in the red sandstone of New London, on the northern coast, a short distance east of Cape Tryon. On Hog Island, a small islet lying off the western entrance of Richmond Bay, on this coast, a dyke of dark gray trap or dolerite—the only example of an eruptive rock known within the Province—runs for a short distance along the shore.

The only other rock formations occurring within the Province, consist of Glacial and Post-Glacial deposits, and some modern accumulations. Scattered boulders and deposits of boulder-clay occur more or less generally throughout the island, and are accompanied in places by stratified sands and gravels containing occasional shells of *Tellina Grœnlandica*, so characteristic of Post-Glacial deposits in Quebec and the New England States. The boulders of the south-eastern portion

of the island appear to have come chiefly from the syenitic and crystalline ranges of Nova Scotia, whilst those of the north shore have followed the more usual law of distribution, and have come apparently from northern sources, and principally from the gneissoid rocks of Labrador and Newfoundland.

The more recent formations of the Province comprise a series of sandy dunes, or hills and ridges of blown sand, lying mostly along the north-west coast; various beds of peat, as those of Cascumpeque Bay, Lennox Island, Squirrel Creek, &c.; and accumulations of "mussel mud." This latter deposit contains much organic matter, with carbonate and a little phosphate of lime, and is largely used as a mineral manure. It forms beds of variable thickness, exceeding in places ten or twelve feet, in many of the creeks and bays of the island.

INDEX.

[*Abbreviations*:—B. C., British Columbia; C., Cape; C. B., Cape Breton; Co., County; Dist., District; Fn., formation; I., island; L., lake; Man., Manitoba, including N. W. Territory; Mt., mountain; N. B., New Brunswick; N. S., Nova Scotia; Ont., Ontario; Pt., point or promontory; Q., Province of Quebec; R. or Riv., river; T., township.]

ADDENDA.

The names of Mr. J. W. Salter and Professor Rupert Jones, as authors of descriptions of fossils in Decades I. and III. of the Canadian Survey Series, should be inserted in the lists, given under the Geological Literature of Canada, on pages ix-xi.

3, 65.

The following paragraph should also be added to page xxii of the INTRODUCTION, at the close of the Huronian Series:—

HIGHER SERIES OF LAKE SUPERIOR.

This series—commonly known as the Upper Copper-bearing Series of Lake Superior—is placed here provisionally, as its exact period of formation is still unsettled. It has been regarded as Triassic by some observers; but its true position (as explained at page 55) is most probably at or near the base of the Cambrio-Silurian Series, or below the Chazy horizon. It is seen to overlie the Huronian strata (or in the absence of these, the underlying Laurentian rocks) in places on the north shore of Lake Superior. Its rock representatives belong to two, or, more properly, to three distinct formations. These comprise, in ascending order: (*i*), a series of black slates, with subordinate beds of chert, greenish-gray sandstones, &c., and interstratified bands of trap or hardened volcanic mud; (*ii*), a series of red and white calcareous sandstones and marls, with some jasper conglomerates, &c., and interstratified trappean layers; and (*iii*), a great overflow of sub-columnar trap (in places, amygdaloidal) resting unconformably on both the lower series. The dark slates and other strata of the first division occur chiefly between Pigeon River and Thunder Cape. They are traversed by numerous veins holding native silver, galena, copper pyrites, and other metallic ores. The rocks of the second division outcrop chiefly to the east of Thunder Cape, and are seen, more especially, in the Black Bay and Nepigon areas. They are also traversed by metalliferous veins containing silver, lead, copper, and other ores. See, more fully, under the *District of the Upper Lakes*, in the Geology of Ontario, pp. 53-57.

ERRATA.

P. xvi, bottom line—for "incontestibly" read "incontestably."
P. xxi, prefix the sign "‡" to the last note.
P. xxiv, under Utica Formation—for "*Lingula obtusa*" read "*Lingula curta.*"
P. 55, line 7—for "uncomformably" read "unconformably."
P. 57, line 7 from bottom—for "107" read "710."
P. 59, line 15—for "latitude" read "altitude."

EXPLANATION

OF

PLATES.

ERRATUM.

P. 57, line 7 from bottom—for "107" read "710."

PLATE I.

1. Lingula acuminata (Conrad)=L. antiqua (Hall). A brachiopod. Potsdam Formation.

2. } Protichnites and Climactichnites. Supposed tracks of crustaceans,
3. } but perhaps fucoidal impressions. Potsdam Formation.

4. Lingula Mantelli (Billings). A brachiopod. Calciferous Formation.

5. Ophileta compacta (Salter). A gasteropod allied to Euomphalus. Calciferous Formation.

6. Orthoceras Lamarcki (Billings). A tetrabranchiate or "chambered" cephalopod. Calciferous Formation.

7. Graptolithus Logani (Hall).
8. G. flexilis (Hall).
9. Phyllograptus typus (Hall).

} Levis (Quebec) Formation. Extinct types of doubtful classification. Probably, horny Cœlenterates allied to Sertularia; but perhaps Bryozoons. The figures copied from Hall.

10. Lingula Quebecensis (Billings). A brachiopod. Levis Formation.

11. Lingula Lyelli (Billings). Chazy Formation.

12. Rhynconella plena (Hall. A brachiopod. Chazy Formation.

13. Camerella varians (Billings). A brachiopod. Chazy Formation.

14. Orthis borealis (Billings). A brachiopod. Chazy Formation.

15. Bolboporites Americanus (Billings). A Cœlenterate (coral). Chazy Formation.

16. Illœnus globosus (Billings). A trilobite; an extinct crustacean. The example is in a "rolled-up" condition. Chazy Formation.

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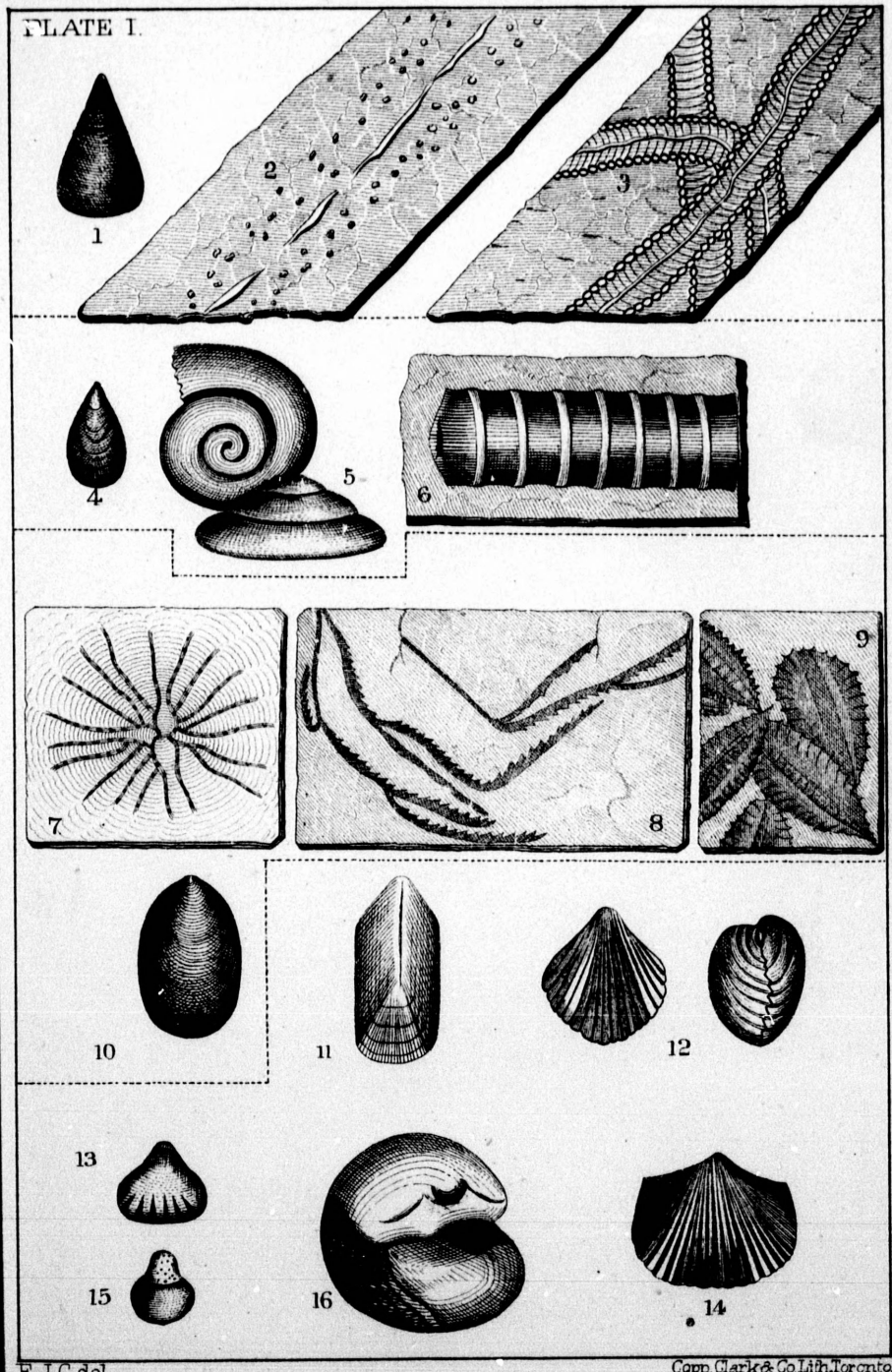


PLATE II.

17. Stromatopora rugosa (Hall). A Protozoan of doubtful position. Black River and Trenton Formations.

18. Tetradium fibratum (Safford). A Cœlenterate (coral). Black River and Trenton Formations.

19. Columnaria alveolata (Goldfuss). } Cœlenterates (corals). Black River
20. Favistella stellata (Hall). } and Trenton Formations.

21. Stenopora fibrosa (Goldfuss). } Cœlenterates (corals). Chazy Formation to Middle Silurian series, inclusive.
22. Stenopora petropolitana (Pander). }

23. Petraia corniculum (Hall). A Cœlenterate (coral). Trenton Formation.

24. Lingula quadrata (Eichwald). A brachiopod. Trenton and Hudson River Formations.

25. Orthis testudinaria (Dalman). A brachiopod. Trenton Formation to Middle Silurian series.

26. O. pectinella (Conrad). A brachiopod. Black River and Trenton Formations.

27. O. tricenaria (Conrad). A brachiopod. Chiefly in Trenton Formation; but ranging through the Lower Silurian series, from the Chazy Formation upwards.

28. O. lynx (Eichwald), = Delthyris lynx of old American Reports. Chiefly a Trenton fossil, but ranging into the Middle Silurian series.

29. Rhynconella increbescens (Hall). A brachiopod. Trenton and Utica Formations.

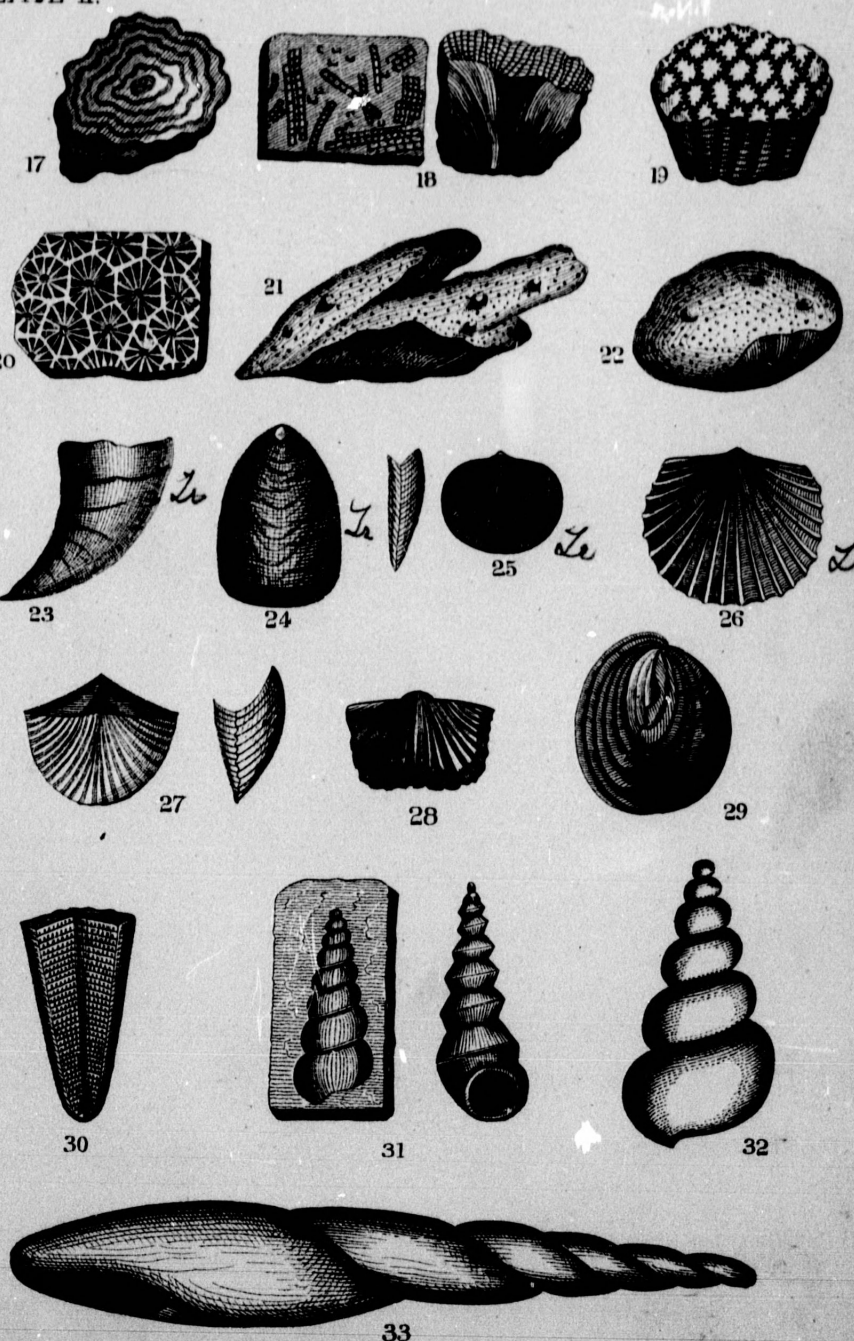
30. Conularia Trentonensis (Hall). A pteropod (?) Trenton Formation.

31. Murchisonia gracilis (Hall): shell and internal cast. A gasteropod. Trenton and Hudson River Formations.

32. M. bellicincta (Hall): internal cast. Trenton Formation.

33. Subulites elongatus (Conrad). A gasteropod. Black River and Trenton Formations.

PLATE II.



E. J. C. del.

Copp, Clark & Co. Lith. Toronto.

PLATE III.

34. Maclurea Logani (Salter), with its operculum. A supposed heteropod. Black River and Trenton Formations.

35. Bellerophon bilobatus (Sowerby). A heteropod. Trenton Formation to Middle Silurian series.

36. Orthoceras bilineatum (Hall). A tetrabranchiate cephalopod. Chazy (?) Trenton, and Hudson River Formations.

37. Orthoceras proteiforme (=Endoceras proteiforme, Hall). Black River and Trenton Formations. In the figure, a portion of the shell is broken away, shewing a projecting cone of calcareous matter. The latter was secreted in the lower part of the large siphuncle, probably as a counterpoise to the buoyancy of the shell at that extremity.

38. Asaphus platycephalus (Stokes)=Isotelus gigas of older American Reports. A trilobite; an extinct form of crustacea. Chazy to Hudson River Formations, but especially abundant in Trenton strata.

39. Ceraurus pleurexanthemus (Green)=Cheirurus of European authors. A trilobite: an extinct form of crustacea.

40. Trinucleus concentricus (Eaton). A trilobite. Trenton, Utica and Hudson River Formations.

41. Graptolithus pristis (Hisinger).
42. Graptolithus bicornis (Hall).

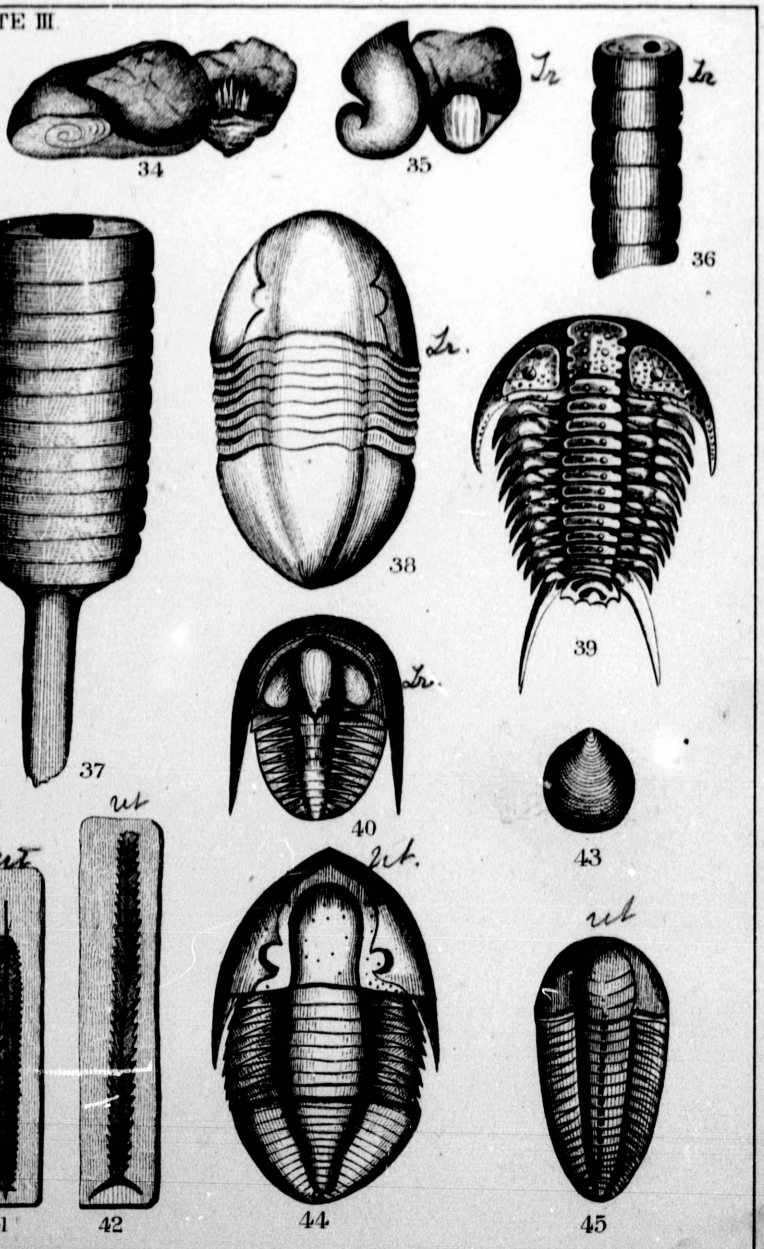
Utica and Hudson River Formations. Extinct types of uncertain classification, but probably Cœlenterates allied to Sertularia.

43. Lingula curta (Hall). A brachiopod. Utica and Hudson River Formations.

44. Asaphus Canadensis (Chapman). A trilobite. Utica Formation.

45. Triarthrus Beckii (Eaton). A trilobite. Utica Formation.

PLATE III.



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Copp, Clark & Co. Lith. Toronto.

PLATE IV.

46. Leptæna sericea (Sowerby). A brachiopod. Trenton Formation to Middle Silurian series, but chiefly characteristic of Hudson River strata.

47. Strophomena alternata (Conrad). Chiefly in Hudson River Formation, but ranging from the Chazy Formation into the Middle Silurian series.

48. Ambonychia radiata (Hall). A Lamellibranch. Trenton Formation to Middle Silurian series ; but especially abundant in Hudson River strata.

49. Orthonota parallela (Hall). A Lamellibranch. Hudson River Formation. The lithographer has departed from the author's drawing, in this figure, in not keeping the outline of the shell sufficiently straight.

50. Modiolopsis modiolaris (Conrad). A Lamellibranch. Hudson River Formation.

51. Cyrtolites ornatus (Conrad). A heteropod. Hudson River Formation. The genus is closely allied to (if not identical with) Bellerophon.

52. Orthoceras crebriseptum (Hall). A tetrabranchiate cephalopod. Hudson River Formation.

53. Calymene Blumenbachii (Brongniart). A trilobite. Trenton to Middle Silurian series.

54. Arthrophycus Harlani (Hall). A sea-weed. Medina and Clinton Formations.

55. Rusophycus bilobatus (Hall). A sea-weed. Medina and Clinton Formations.

58. Favosites Gothlandica (Goldfuss :=F. Niagarensis of early American publications). Hudson River to Devonian series. Chiefly characteristic of the Niagara Formation.

59. Halysites catenulatus (Linnæus :=Catenipora escharoides of early American writers). A Cœlenterate : a tabulated coral. Chiefly characteristic of Upper Clinton and Niagara strata.

PLATE IV.

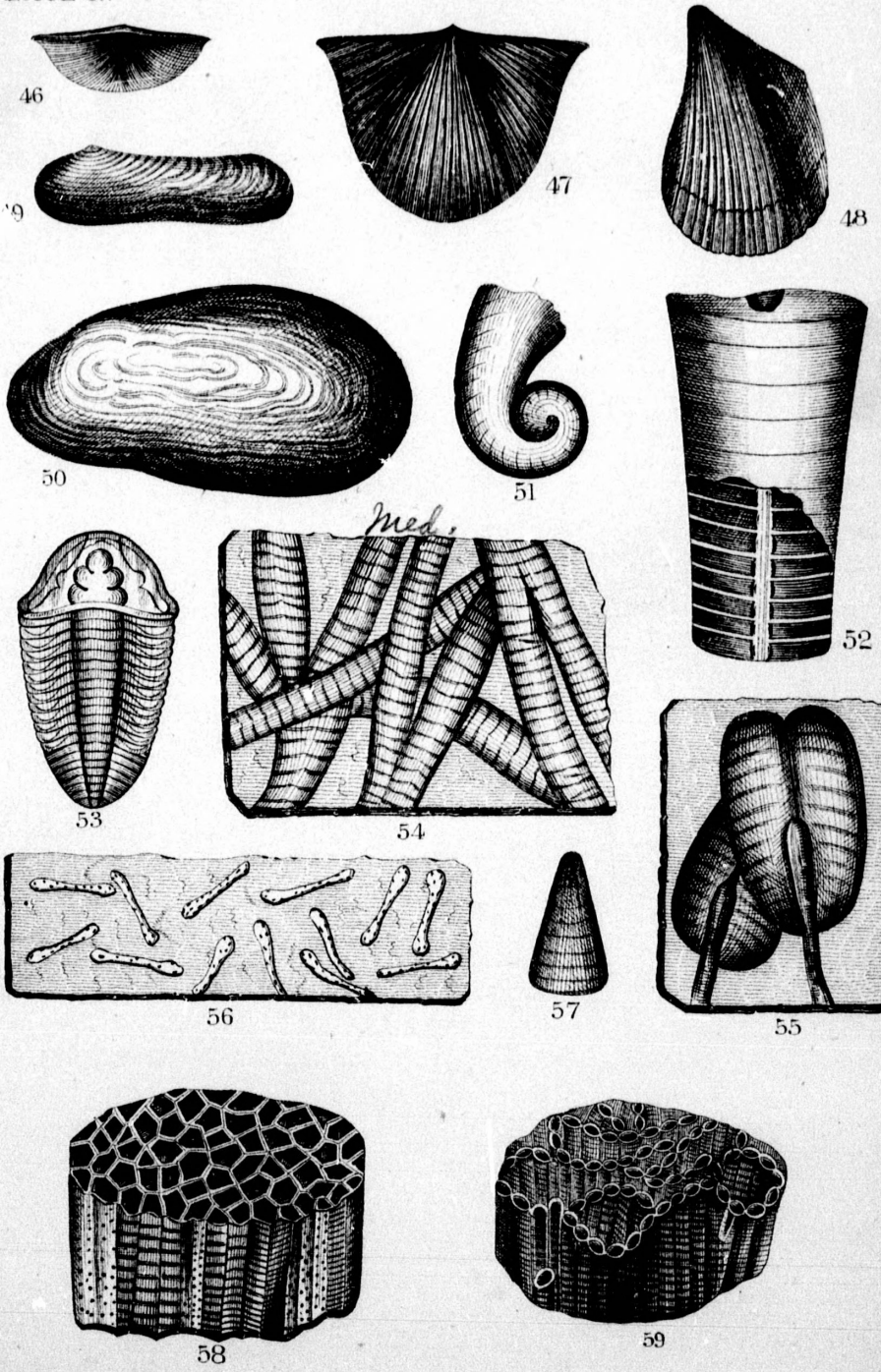
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PLATE V.

60. Fenestella elegans (Hall). A bryozoon. Niagara Formation.

61. Pentamerus oblongus (Sowerby). A brachiopod. Clinton and
62. Niagara Formations; but regarded in Canada as indicating, essentially, the latter. Fig. 62 is an internal cast).

63. Orthis elegantula (Dalman). A brachiopod. Niagara Formation.

64. Spirifer Niagarensis (Conrad). } Brachiopods.
65. Spirifer radiatus (Sowerby). } Niagara Formation.

66. Homalonotus delphinocephalus (Green). } Trilobites.
67. Dalmannites limulurus (Green). } Niagara Formation.

68. Megalomus Canadensis: internal cast (Hall). A Lamellibranch. Guelph Formation.

69. Eurypterus remipes (Dekay). A crustacean allied to the Limulus. Lower Helderberg Formation. The figure is a restoration: about one-third natural size.

70. Aulopora cornuta (Billings). A coral (Cœlenterata). Corniferous Formation. Copied from Billings' figure.

71. Alveolites cryptodens (Billings). A coral (Cœlenterata). Corniferous Formation. Copied from Billings' figure.

72. Michelinea convexa (d'Orbigny). } Corals (Cœlenterata).
73. Syringopora Maclurei (Billings). } Corniferous and Hamilton Formations.
74. Syringopora Hisingeri (Billings). }

PLATE V.

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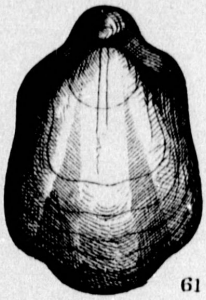

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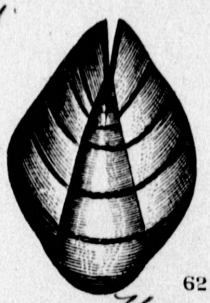

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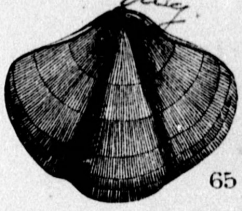

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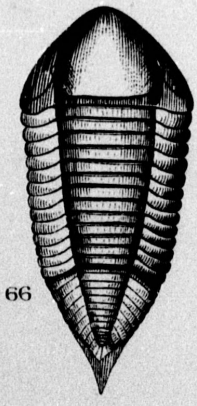

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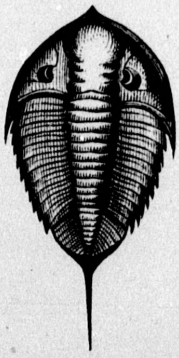

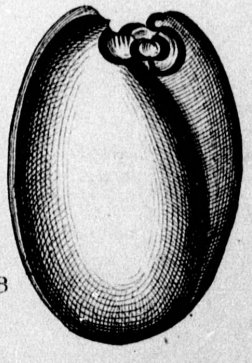

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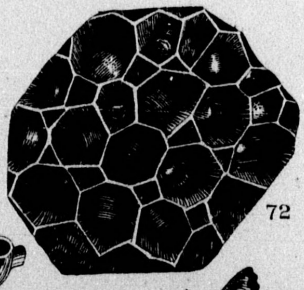

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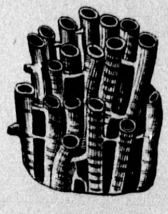

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PLATE VI.

75. Zaphrentis prolifica (Billings). A coral (Cœlenterata). Corniferous and Hamilton Formations.

76. Strophomena rhomboidalis (Wahlenberg). A brachiopod. Corniferous and Hamilton Formations.

77. Atrypa reticularis (Linnæus). A brachiopod. Especially abundant in Corniferous and Hamilton (or Lambton) Formations, but ranging from the Middle Silurian series upwards.

78. Spirifer gregarius (Hall). A brachiopod. Corniferous Formation.

79. Spirifer mucronatus (Conrad). A brachiopod. Corniferous and Hamilton Formations; especially abundant in the latter.

80. Spirigera concentrica (Von Buch). A brachiopod. Corniferous and Hamilton (Lambton) Formations.

81. Stricklandia elongata (Billings). A brachiopod. Corniferous and Hamilton (Lambton) Formations.

82. Lucina proavia (Hall). A Lamellibranch. Corniferous and Hamilton (Lambton) Formations.

83. Conocardium trigonale (Conrad). A Lamellibranch. Oriskany, Corniferous and Hamilton (Lambton) Formations.

84. } Phacops bufo (Green). A trilobite. Corniferous and Hamilton
85. } (Lambton) Formations.

86. Heliophyllum Halli. A coral. Corniferous and Hamilton Formations.

87. Orthis Vanuxemi (Billings). Corniferous and Hamilton (Lambton) Formations.

88. Fucoides cauda-galli. A sea-weed. Portage-Chemung Formation.

89. Calamites inornatus (Dawson). A swamp plant, allied to existing Equisetaceæ. Portage-Chemung Formation.

PLATE VI.

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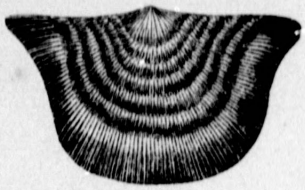

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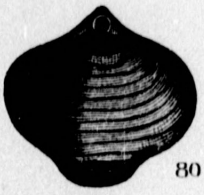

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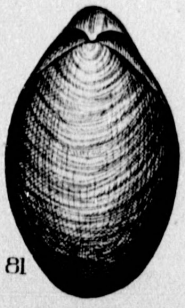

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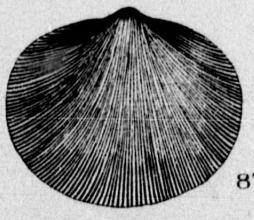

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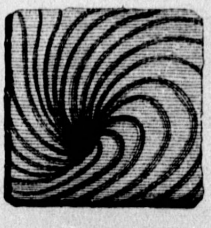

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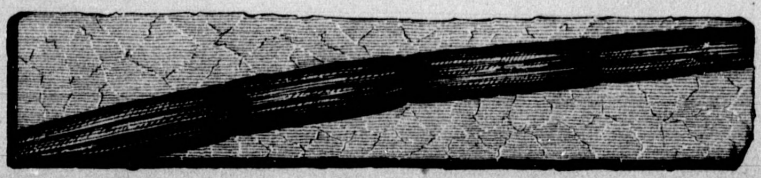

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E.J.C. del.

Copp Clark & Co Lith. Toronto.