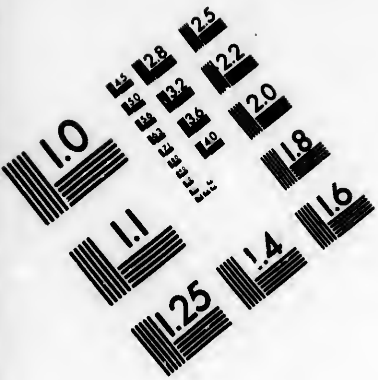

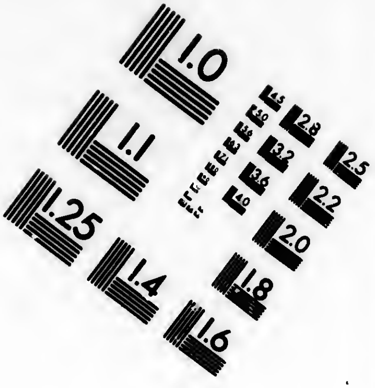

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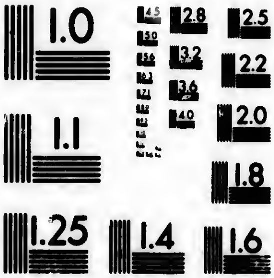

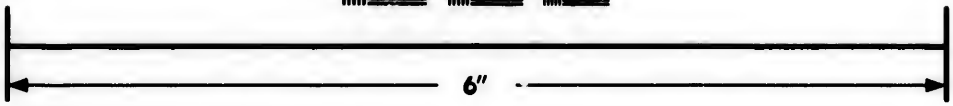

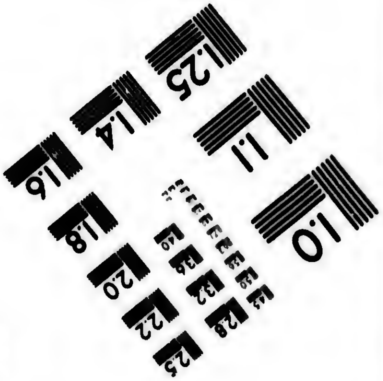

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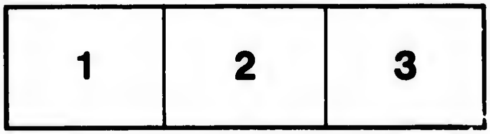
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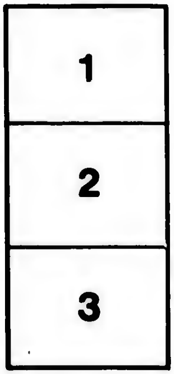
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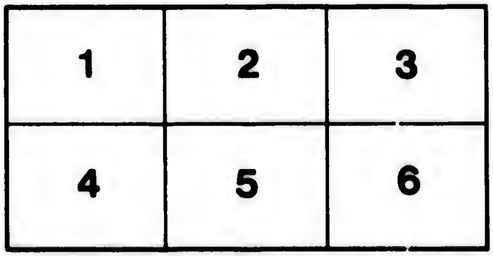
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CHAPMAN'S
MINERALS AND GEOLOGY
OF CANADA.

A POPULAR AND PRACTICAL

EXPOSITION

OF THE

MINERALS AND GEOLOGY

OF

CANADA.

BY E. J. CHAPMAN, Ph.D.
PROFESSOR IN UNIVERSITY COLLEGE, TORONTO,
(LATE PROFESSOR IN UNIVERSITY COLLEGE, LONDON, ENGLAND.)

WITH OVER TWO HUNDRED WOODCUTS,
AND
A COPIOUS INDEX.

TORONTO:
W. C. CHEWETT AND CO.
1864.

CHAPMAN, E J

TORONTO:
PRINTED BY LOVELL & GIBSON,
YONGE STREET.

TO

SIR W. E. LOGAN, F.R.S., &c., &c., &c.,

Director of the Geological Survey of Canada,

THIS WORK

(BASED LARGELY ON THE EXPLORATIONS OF THE SURVEY)

IS INSCRIBED,

IN ALL HOMAGE AND RESPECT,

BY HIS SINCERE FRIEND,

THE AUTHOR.

PREFACE.

The subject matter of this volume was originally published in the form of a series of papers, in the pages of the *Canadian Journal of Science nnd Art*. In its present shape, the work is intended to fulfil two purposes: first, to supply the general reader with a popular, and, at the same time, a practical, or really useful, handbook of our minerals, fossils, and geology; and secondly, to serve as an explanatory introduction to the enlarged Report on the Geology of Canada, and other publications, issued by the Geological Survey.

The term "popular," in its application to works of this kind, is so frequently abused, that I may perhaps be allowed to explain, at the outset, the sense in which it is employed in the present volume. This will be done most readily, by an explanation of the scope and general character of the work. With this view, it may be observed that the subject of the present Essay is arranged under five divisions or parts. The two first, of these, relate to the minerals of Canada; the other three, to our fossils and rock groups. Now, if it were designed to draw up a description of Canadian minerals for the perusal of the mineralogist, these substances might be arranged in a chemical or chemico-physical order, and an analysis of their crystallographic peculiarities, chemical relations, and other allied points of inquiry, at once entered upon; but as this work is intended to meet the wants of the general reader, another method—a popular or explanatory treatment—is rendered necessary. The object here, moreover, is not only to describe the characters, uses, localities, &c., of these minerals, in general terms; but to enable the reader, whilst acquiring this information, to recognise these bodies, or, in other words, to make out their names, whenever subsequently met with; and thus to convey to him, as far as it goes, a really practical knowledge of the subject. The more common characters or properties, consequently, by which minerals are distinguished from one another, are first passed under review. These, discussed in PART I, are considered, however, only in their simpler or more practical bearings, so as to occasion no difficulty in their application. In PART II, our Canadian minerals are arranged in groups and sections, founded on these easily-observed characters, in such a manner as to lead at once to the recognition of any species: see pages 20—22[*]. During the publication of this portion of the work in the *Canadian Journal*, many amateurs and others, previously unacquainted with Mineralogy, availed themselves of this plan, and always succeeded, by its use, in discovering the name of any specimen presented to them. In the descriptions of the minerals, thus arranged, all the more important characters, uses, Canadian localities, &c., are fully given; and at the close of the division (page 62), these substances are re-arranged in groups according to their chemical composition. In order, moreover, to facilitate still further, the recognition of the more common minerals of Canadian occurrence, a synoptical view of the distinctive characters of the latter, is also given at the conclusion of this PART, (page 64).

The third part of the work is devoted to a brief but sufficiently-detailed analysis of the classification, structural characters, composition, modes of formation, and other allied points, relating to rocks in general. In this division, the various technical terms employed in geological descriptions, are fully illustrated and explained—reference being made, as frequently as possible, to Canadian examples. An introductory section of this kind—together with the general sketch of the typical characters and natural relations of organic remains, in the succeeding division of our subject—is absolutely necessary to ensure a proper understanding of the geology of Canada, as developed in PART V. Persons unacquainted with these details, can have no clear conception, for example, of what is implied by the term "metamorphic" in its application to rocks, or by that of "Silurian strata," "trap dyke," "anticlinal axis," "unconformable stratification," and so forth. As a general rule, the term *Silurian* is associated in their estimation with some particular kind of rock, as limestone, sandstone, or the like; and experience shews that there are many readers of geological books, who have but a very confused idea

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[*] The Reader is recommended to mark the number of the page to which the Sections refer, immediately after each of these, on pages 21 and 22. Thus: after "Aspect metallic: Hardness sufficient to scratch glass: A:—write, *page* 22. After "Aspect metallic: Hardness insufficient to scratch glass: B:—write, *page* 27—and so on with regard to the other sections and sub-sections.

of some of the commonest principles of geological reasoning. It is next to useless, in like manner, to inform a person, unacquainted with the more general details of Zoological classification, that a particular set of strata contains many examples of *Orthis testudinaria*, or of *Calymene Blumenbachii*, oroth er fossil species: or even to state that the strata in question are characterized by the presence of particular *brachiopods* and *trilobites*—since he can have no idea of the true nature and existing relations of these forms. For this reason, I have tried to put myself, throughout, in the position of the uninitiated reader; and I have given in PART IV, a general view of the leading classes and groups of the Animal Kingdom, with the fossil relations of these, as regards Canadian strata, fully explained. I have also taken care, whenever it seemed necessary, to prefix to each group a few explanatory observations on the structural characters of the shell or other parts found in a fossilized condition, as will be seen more especially under the corals, brachiopods, cephalopods, trilobites, &c. The reader will thus be rendered familiar with most of the technical terms employed in the descriptions of fossils in other works; and the examination of these bodies, when their peculiar characters and conditions of occurrence, and their relations to existing types, are thus known, will present an interest altogether new. A fragment of fossil-marked shale, picked up on the lake shore, on the road, or in the quarry, becomes to us something more than a mere piece of stone, if we can read aright the strange record of life and death, of ancient shore and sea, and Nature's ceaseless changes, thus impressed upon its surface in some far distant epoch of the Past, between whose day, and ours, immeasurable ages must have come and gone. But apart from this, a practical interest is also attached to the study of these organic remains: inasmuch as certain fossils are characteristic of certain strata, and serve to define the geological position of these in the rock series generally. Hence the necessity of the study in even geological investigations of a purely technical character.

Finally, in PART V., after these introductory sections, the various geological formations of Canada, including their economic materials, fossils, instructive exposures, &c., are brought under review. In this part of my work, more especially, I am bound to record my obligations to the Reports and other publications of Sir William Logan and the assistant officers of the Geological Survey. I have been careful, throughout, to acknowledge my special obligations to these geologists, as well as to Dr. Dawson, the able Principal of McGill College, Montreal, and others; but it is only just that I should prominently express also, in this place, my indebtedness to the researches and publications of the Survey, generally. In justice to myself, however, it should be stated, that the materials of this part of the work, though largely, and, in places, essentially, derived from the sources in question, have been put together, as regards generalizations, &c., in at least an original spirit. They are interwoven, also, with various notices drawn from my own field-books, and are accompanied by no inconsiderable amount of explanatory observation.

The engravings given in the work are of somewhat rude execution; but there is at least this merit connected with them: a small number only—under ten or twelve, at the most—have been copied from other publications. The rest are either original diagrams, or figures that I have drawn directly from the objects which they represent. For the use of the greater part of these woodcuts, I am indebted to the Canadian Institute of Toronto.

In order to render the volume especially useful as a book of reference, an exceedingly copious index has been added to it. A glance, at this, will shew the large amount of matter condensed within the book.

In conclusion, I may observe that the earlier portions of this Essay were printed in 1861; and that the entire work was completed, as now given to the Public, at the commencement of 1863. Various circumstances however, over which I have had no control, have prevented its final publication until the present time.

E. J. C.

University College, Toronto,
February 1, 1864.

CONTENTS.

A
POPULAR EXPOSITION
OF THE
MINERALS AND GEOLOGY
OF
CANADA.

Introductory Notice.

In attempting to convey to the general reader a practical or really useful knowledge of the Minerals and Geology of Canada, it is advisable to consider the subject under the following heads:

1. How minerals are distinguished from one another.
2. The minerals and metallic ores met with in Canada.
3. How rocks are classified and distinguished.
4. Organic Remains: their use and teachings.
5. Subdivisions and distribution of Canadian rocks.

The term "Geology" comprises, strictly, a knowledge of the physical history of the Earth, as revealed to us by the study of the rock-masses which lie around and beneath us; and by a comparison of the results of ancient phenomena, with the forces and agencies still at work in modifying the surface of the globe. As geology is thus essentially based on the study of rocks and their contents, and as rocks are made up of a certain number of simple minerals, it is necessary, or at least advisable, to obtain a knowledge of these latter (so as to be able to recognize them when met with), before proceeding to the discussion of the rocks into which they enter. With these minerals, also, it is convenient to consider a few others of economic application and common occurrence, including the more important metallic ores. In this consideration, the characters or properties by which minerals are distinguished from one another will first be explained, introductory to a Tabular Distribution of Canadian minerals. The latter will be so arranged as to enable the reader to make out the name of any one of the included species, with great facility.

I. How Minerals are distinguished from one another.

Minerals are distinguished from one another by certain characters or properties which they possess: such as form, degree of hardness, fusibility, &c. Hence, it is to these characters that our attention must be first directed.

Mineral characters are of two kinds: *physical* or *external* characters, and *chemical* characters. The former are exhibited by the mineral under ordinary conditions; the latter, only when the mineral is exposed to the action of heat or mineral acids, by which, in general, a certain degree of chemical decomposition is effected. Hence the term "chemical" as applied to these latter characters.

The physical properties of minerals are somewhat numerous; but many, although of the highest interest in indicating the existence of natural laws, and in their relations to physical science generally, are not readily available as a means of mineral discrimination. These, consequently, will be omitted from consideration in the following pages; and the other characters will be discussed only in so far as they admit of direct application to the end in view—namely, the practical discrimination of minerals one from another.*

---

* In the explanation of these various characters, it is occasionally necessary to refer, as examples, to a few substances of foreign occurrence. The reader will therefore understand, that the present Part of this Essay makes no special mention of the minerals of Canada, but is simply an Introduction to Part II, in which these minerals will be found arranged together.

The following are the characters in question:

1. Aspect or Lustre.
2. Colour.
3. Streak.
4. Form.
5. Structure.
6. Hardness.
7. Specific Gravity.
8. Relative Malleability.
9. Magnetism.
10. Taste, &c.

1. *Aspect or Lustre.*—We have here to consider, first: the *kind;* and, secondly, the *degree* or *intensity* of the lustre, as possessed by the mineral under examination. The kind of lustre may be either *metallic*, as that of a piece of copper, silver, &c.; or *sub-metallic*, as that of most kinds of anthracite coal; or *non-metallic*, as that of stones in general. Of the non-metallic lustre there are several varieties, as, more especially: the *vitreous* or glassy lustre—example: rock-crystal; the *resinous* lustre—ex.: native sulphur; the *pearly* lustre—ex.: talc; the *silky* lustre (usually accompanying a fibrous structure)—ex.; fibrous gypsum; the *stony* aspect; the *earthy* aspect, &c. These terms sufficiently explain themselves. Occasionally, two kinds of non-metallic lustre are simultaneously present, as in obsidian, which exhibits a "resino-vitreous" aspect; and the lustre in some zeolites is pearly within, and vitreous externally. In mica, and some few other minerals, there is frequently a *pseudo-metallic* lustre. This may be distinguished from the metallic lustre properly so-called, by being accompanied by a degree of translucency, or by the powder of the mineral being white or light-colored: minerals of a true metallic aspect being always opaque, and their powder being always black or dark-colored. So far as regards the metallic and the non-metallic lustres, there are very few minerals which exhibit (in their different varieties) more than one kind. Thus, galena, the common ore of lead, copper pyrites, &c., always present a metallic lustre; whilst, on the other hand, quartz, feldspar, calc-spar, gypsum, &c., are never found otherwise than with a non-metallic aspect. Hence, by means of this easily-recognized character, we may divide all minerals into two broad groups; and thus, if we pick up a specimen

and wish to ascertain its name, we need only look for it amongst the minerals of that group with which it agrees in lustre. The first step towards the determination of the substance will in this way be effected.

The *degree* of lustre may be either splendent, shining, glistening, glimmering, or dull; but the character is one of comparatively little importance.

2. *Colour.*—When combined with a metallic aspect, colour becomes a valuable character in the determination of minerals, because it then remains constant as regards a given substance. Thus galena, the common ore of lead, is always lead-grey; copper pyrites, always brass-yellow; native gold, always gold-yellow; and so forth. When accompanied, however, by a vitreous or other non-metallic lustre, colour is, practically, a character of no value; as in that case, the mineral may present, in its different varieties, every variety of colour. Thus, we have colourless quartz, amethystine or violet quartz, red quartz, yellow quartz, &c., just as in the vegetable kingdom, we have red, white, and yellow roses; and dahlias, &c., of almost every shade. When combined with a metallic aspect, the colour is said to be metallic; and of metallic colours we may enumerate the following:

White...	Silver-white	ex. Native silver.
	Tin-white	ex. Pure tin; cobalt ore.
Grey ...	Lead-grey.........	ex. Galena.
	Steel-grey.........	ex. Specular iron ore.
Black	Iron-black (usually with sub-metallic lustre)	ex. Magnetic iron ore.
Yellow ..	Gold-yellow	ex. Native gold.
	Brass-yellow......	ex. Copper-pyrites.
	Bronze-yellow (a brownish-yellow)	ex. Magnetic pyrites.
Red	Copper-red	ex. native copper.

These metallic colours are often more or less obscured by a black, brownish, purple, or iridescent ***surface-tarnish.*** Hence, in noting the colour of a mineral, a newly-fractured surface should be observed. The non-metallic colours comprise, white, grey, black, blue, green, red, yellow, and brown, with their various shades and intermixtures; as orange-yellow, straw-yellow, reddish-brown, greenish-black, &c. In minerals of a non-metallic aspect, the colour is sometimes uniform; and at other times, two or more colours are present together, in spots, bands, &c., as in the varieties of quartz, called agate, bloodstone, jasper, and so forth. In Labradorite, or Labrador feldspar, a beautiful play or change of colour is observed in certain directions. The finer varieties of Opal also exhibit a beautiful and well-known iridescence.

3. *Streak.*—Under this technical term is comprised the *colour of the powder* produced by drawing or "streaking" the mineral under observation, across a file or piece of unglazed porcelain. The character is a valuable one on account of its uniformity; as, no matter how varied the colour of a mineral may be in different specimens, the streak will remain of one and the same colour throughout. Thus, blue, green, yellow, red, violet, and other specimens of fluor spar, quartz, &c., exhibit equally a white or "uncoloured" streak. The streak is sometimes "unchanged," or of the same tint as the external colour of the mineral; but far more frequently it presents a different colour. Thus, Cinnabar, the ore of mercury, has a red colour and red streak; realgar, a sulphide of arsenic, has a red colour and orange-yellow streak; copper pyrites, a brass-yellow colour, and greenish-black streak; and so forth. In certain malleable and sectile minerals, whilst the colour remains unchanged in the streak, the lustre is increased. The streak is then said to be "shining." Finally, it should be remarked, that in trying the streak of very hard minerals, we must crush a small fragment to powder, in place of using the file; because otherwise, a greyish-black streak, arising from the abrasion of the file, might very possibly be obtained, and so conduce to error. It may be observed, however, that all minerals of a non-metallic aspect, and sufficient hardness to resist the file, have a white streak.

4. *Form.*—The forms presented by minerals, may be either *regular* or *irregular*. Regular forms are called *crystals*, whether the minerals which present them be transparent or opaque. The term "crystal" was first applied to transparent vitreous specimens of quartz or rock-crystal; but, as it was subsequently found that opaque specimens of quartz presented exactly the same forms, and that opaque as well as transparent forms of other minerals existed, the term gradually lost its original signification, and came to be applied to all regular forms of minerals, whether transparent, translucent, or opaque. Minerals of a metallic lustre are always opaque; and many of these, as iron pyrites and galena, occur frequently in very regular and symmetrical

crystals. Crystals originate in almost all cases in which matter passes from a gaseous, or liquid, into a solid state; but if the process take place too quickly, or the matter solidify without free space for expansion, crystalline masses, in place of regular crystals, will result. If a small fragment of arsenical pyrites, or native arsenic, be heated at one end of an open glass tube (five or six inches long and one-fourth of an inch in diameter), the arsenic, in volatilizing, will combine with oxygen, and form arsenious acid, which will be deposited at the other end of the tube, in the form of minute octahedrons (Fig. 3, below). In like manner, if a few particles of common salt be dissolved in a small quantity of water, and a drop of the solution be evaporated gently (or suffered to evaporate spontaneously) on a piece of glass, numerous little cubes and hopper-shaped cubical aggregations will result. Boiling water, again, saturated with common alum, will deposit octahedral crystals on cooling: the cooled water not being able to retain in solution the full amount of alum dissolved by the hot water. In like manner, sugar, sulphur, and other bodies crystallise by slow cooling from the molten state.

The study of crystal-forms constitutes the science of Crystallography. To enter into the details of this science would extend our present discussion beyond its proposed limits, and carry us altogether beyond the object in view—the simple determination of the names of commonly-occurring minerals—and hence we shall confine ourselves to the general statement, that crystals admit of being arranged in six groups, or "systems;" the forms of each individual group passing into one another by simple transitions, but having no relations to the forms of the other groups.* The names of these respective groups,

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* The reader desirous to take up the study of Crystallography in a more extended manner, may attend the author's special courses of lectures which include that subject. In these, the use of crystallographic instruments is shewn, and the lectures are illustrated by numerous wood and porcelain models, drawings, and natural crystals. The following is extracted from the syllabus of the advanced course on Mineralogy:

CRYSTALLOGRAPHY, PART I.—Crystals, how defined. Formation of Crystals. Elements of Crystals: planes, edges, angles; diagonals, axes. Forms and combinations. Replacing planes. General nomenclature of Forms and simple Crystals. Law of constant Angles. Measurement of Angles. Laws of Symmetry: Holohedral, Hemihedral, and Tetartohedral Forms. Classification of Crystals. Dimorphism. Isomorphism. Compound Crystals. Distortions. Pseudomorphs.

PART II.—The six systems of Crystallization. The Monometric system. The Dimetric system. The Hexagonal system. The Trimetric system. The Monoclinic system. The Triclinic system. Method of ascertaining the system of a given Crystal.

PART III.—Optical and other physical relations of Crystallography.

with figures of a few of their more common forms and combinations, are given in the annexed tabular view.

The Monometric or Regular System.—This group includes the cube (Fig. 1), the rhombic dodecahedron (Fig. 2), the regular octahedron (Fig. 3), trapezohedrons or leucitoids (Fig. 4), pentagonal dodecahedrons (Fig. 5), &c. Fig. 6 is a combination of the cube and octahedron; Fig 7, a combination of the cube and pentagonal dodecahedron. Native gold, silver, copper, iron pyrites, galena, magnetic iron ore, garnet, fluor spar, rock salt, and numerous other minerals, crystallize in this system.

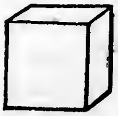
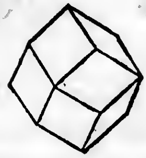


FIG. 1.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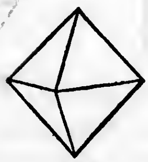
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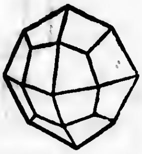
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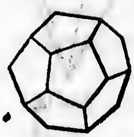
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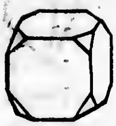
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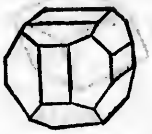
FIG. 7.

The Dimetric or Square-Prismatic system.—This includes, principally, square-based prisms and pyramids (or octahedrons), and their combinations. Figures 8 and nine are examples of Dimetric crystals.

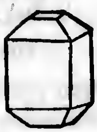
FIG. 8.

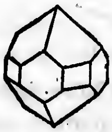
FIG. 9.

Amongst minerals, Copper Pyrites, Tin-stone, Zircon, and Idocrase, may be cited as belonging to the group.

The Hexagonal system.—Regular six-sided prisms (Fig. 10) and pyramids (Fig. 11), combinations of these (Fig. 12), rhombohedrons

(Figs. 13 and 14), and scalenohedrons (Fig. 15), are included under this system. Graphite, Red Silver ores, Cinnabar, Specular Iron Ore, Corundum, Quartz, Beryl, Apatite or phosphate of lime, Calcareous Spar, Dolomite, and Carbonate of Iron, are some of the principal minerals which belong to it.

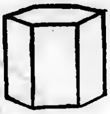
Fig. 10.

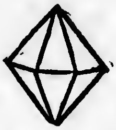
Fig. 11.

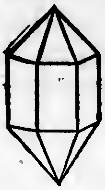
Fig. 12.

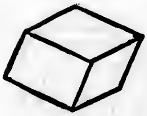
Fig. 13.

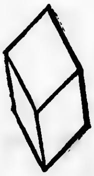
Fig. 14.

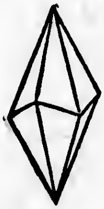
Fig. 15.

The Trimetric or Rhombic system.—This system includes right-rhombic prisms, rectangular prisms, rhombic octahedrons, &c., and their combinations. Fig. 16 is a rhombic prism ; figs. 17 and 18 are combinations belonging to this system. White iron-pyrites, mispickel or arsenical pyrites, native sulphur, topaz, staurolite, arragonite, heavy spar, celestine, and Epsom salt, are some of the principal minerals which belong to this group.

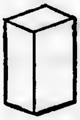
Fig. 16.

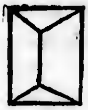
Fig. 17.

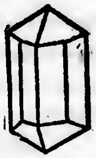
Fig. 18.

The Monoclinic or Oblique Rhombic system.—Rhombic prisms and pyramids, and rectangular prisms and pyramids, with *oblique or sloping base*, belong to this system. Figs. 19 and 20 are monoclinic combinations. The principal minerals comprise: Augite, Hornblende, Epidote, Orthoclase, or potash feldspar, Stilbite, and Gypsum.

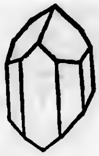

FIG. 19.

FIG. 20.

The Triclinic, or Doubly Oblique system.—The forms of this system are oblique (or they incline) in two directions. The crystals in general are more or less flat and unsymmetrical in appearance. No two planes meet at right angles; and there are never more than two similar planes present in any crystal belonging to the group. Axinite, Albite or soda feldspar, Labradorite or lime feldspar, and sulphate of copper, are the principal triclinic minerals.

Such is a brief exposition of the six crystal systems. For present purposes it will only be necessary for the student to impress upon his memory the following forms, so as to be able to recognize them when met with. The cube (Fig. 1), the regular octahedron (3), the rhombic dodecahedron (2), the pentagonal dodecahedron (5), the cubo-octahedron (6), the regular six-sided prism (10), a combination of a six-sided prism and pyramid (12) a rhombohedron (13 and 14), a scalenohedron (15), a rhombic prism (16).

The *irregular* forms presented by minerals are of very subordinate importance; so that a few of the more common need only be mentioned. Most of the terms used in reference to these, explain themselves.

Irregular mineral forms:—Globular or *nodular*, ex. quartz, iron pyrites; reniform or kidney-shaped, ex. quartz, &c.; botryoidal or mammillated: a form made up of a series of rounded elevations and depressions, or otherwise exhibiting a surface of this character, ex. red and brown iron ore, calcedony, &c.; stalactitic, ex. calc spar, &c.; coralliform, resembling certain branching corals, ex. arragonite; dendritic or arborescent, a branching form, often made up of small aggregated crystals, ex. native silver, native copper, &c.; filiform or wire-like, ex. native silver; acicular, in needle-like crystallizations, ex. many varieties of augite, hornblende, epidote, &c. When a mineral has a perfectly indefinite shape it is said to be "massive" or "amorphous."

Structure:—In the majority of minerals, a certain kind of structure, or, in other words, the shape as well as the mode of aggregation of the smaller masses of which they are composed, is always observable. Structure in minerals may be either *lamellar, laminar* or *foliated, prismatic, fibrous, granular*, or *compact*. When the mineral, as in most varieties of calc-spar, heavy-spar, feldspar, and gypsum, for example, is made up of broad tabular masses producing a more or less stratified appearance, the structure is said to be lamellar. When the tabular masses (whether straight, wavy, or curved,) become extremely thin or leafy, as in mica more especially, the structure is said to be laminar, or foliated, or sometimes micaceous. The scaly structure is a variety of this, in which the laminæ are of small size. When the component masses are much longer than broad or deep, as in many specimens of tourmaline, beryl, calc-spar, &c., the structure is said to be prismatic or columnar. When the prismatic concretions become very narrow, the fibrous structure originates. Fibrous minerals may have either: a straight or parallel-fibrous structure, as in many specimens of gypsum, calc-spar, &c.; a confusedly-fibrous structure, as in many specimens of augite and hornblende; or a radiated-fibrous structure, as in the radiated varieties of iron pyrites, in natrolite, wavellite, &c.,—the fibres radiating from one or more central points. Minerals made up of small grains or granular masses are said to have a granular structure; ex. granular or saccharoidal limestone, granular gypsum, &c. Finally, when the component particles are not apparent, the mineral is said to have a compact structure, as in the native malleable metals, obsidian, and most varieties of quartz. Hard and vitreous minerals of a compact structure (ex. obsidian), generally show when broken, a *conchoidal fracture*, or a series of circular markings resembling the lines of growth on the external surface of a bivalve shell.

Almost all minerals, especially those of a lamellar structure, separate more readily in certain directions than in others. This peculiarity is called *cleavage*. The fragments resulting from "cleavage" have often a perfectly regular or definite form. Thus the purer specimens of calc-spar, no matter what their external form, break very readily into rhombohedrons, which measure 105°5' over their obtuse edges. Galena, the common ore of lead, yields rectangular or cubical cleavage forms; whilst the cubes of fluor-spar break off most readily at the corners or angles, and yield regular octahedrons, fig. 3.

Hardness.—The hardness of a mineral is its relative power of resisting abrasion, not that of resisting blows: many of the hardest minerals being exceedingly brittle. Practically, the character is of great importance. By its aid gypsum may be distinguished in a moment from calc-spar or limestone, calc-spar from feldspar, and copper pyrites from iron pyrites, not to mention other examples.* The degree of hardness in minerals is conventionally assumed to vary from 1 to 10 (1 being the lowest) as in the following scale drawn up by a German mineralogist, *Möhs*, and now generally adopted:

Scale of Hardness—Möhs' Scale.

1. Foliated TALC.
2. ROCK SALT, a transparent cleavable variety.
3. CALCAREOUS SPAR, a transparent variety.
4. FLUOR SPAR.
5. APATITE.
6. FELDSPAR.
7. ROCK CRYSTAL.
8. TOPAZ.
9. CORUNDUM.
10. THE DIAMOND.

In order to ascertain the hardness of a mineral by means of this scale, we attempt to scratch the substance under examination, by the different specimens belonging to the scale; beginning with the hardest, in order not to expose the specimens to unnecessary wear. Or, we take a fine file, and compare the hardness of the mineral with that of the individual members of the scale, by drawing the file briskly across them. The comparative hardness is estimated by the resistance offered to the file; by the noise produced by the file in passing across the specimens; and by the amount of powder so

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* Gypsum may be scratched by the finger nail. Calc-spar and copper pyrites may be scratched easily by a knife; whilst feldspar and iron pyrites are hard enough to scratch window-glass. Not long ago, as mentioned by Sir William Logan, a farmer in the Ottawa district was put to much expense and annoyance by mistaking feldspar for crystalline limestone, and attempting to burn it into lime.

obtained. The degree of hardness of the mineral is then said to be equal to that of the member of the scale with which it agrees the nearest. Thus, if the mineral agrees in hardness with Fluor-spar we say, in its description, H (or hardness) =4. If, on the other hand, it be somewhat softer than fluor-spar, but harder than calcareous spar, we say, H=3.5. Finally, if, as frequently happens, the hardness of a mineral vary slightly in different specimens, the limits of the hardness are always stated. Thus, if in some specimens, a mineral agree in hardness with calc-spar, and in others with fluor-spar, we say, H = 3 to 4; or, more commonly, H = 3 — 4. If the hardness be very rigorously tested, it will frequently be found to differ slightly on different faces of a crystallized specimen, or on the broad faces and the edges of the laminæ of foliated specimens,—but this, so far as regards the simple determination of minerals, is practically of little moment.

As the minerals of which the scale of Möhs consists, may not be in all places obtainable, or always at hand when required, the author of this work contrived some years ago another scale, agreeing closely enough for practical purposes with that of Mohs, and exacting for its application only such objects as are always to be met with. The following is the scale in question; its use explains itself:

Chapman's Convenient Scale of Hardness, to correspond with that of Möhs.

1. Yields easily to the nail.
2. Does not yield to the nail. Does not scratch a copper coin.
3. Scratches a copper coin, but is also scratched by one, being of about the same degree of hardness.
4. Not scratched by a copper coin. Does not scratch glass (ordinary window-glass).
5. Scratches glass very feebly. Yields easily to the knife.
6. Scratches glass easily. Yields with difficulty to the knife.
7. Does not yield to the knife. Yields with difficulty to the edge of a file.

8, 9, 10. Harder than flint or rock-crystal.

Convenient terms of comparison for degrees of hardness above No. 7 cannot be easily obtained; but that is of little consequence, as there are but few minerals of common occurrence which exhibit a higher degree; and these are readily distinguished by other characters. Where, in the above scale, two terms of comparison are employed, both must of course be attended to in the determination of the hardness.

Specific Gravity.—This is also a character of great value in the determination of minerals. The specific gravity of a body is its weight compared with the weight of an equal bulk of pure water. In order to ascertain the specific gravity of a mineral we weigh the specimen first in air and then in water. The loss of weight in the latter case exactly equals the weight of the displaced water, or, in other words, of a volume of water equal to the volume of the mineral. Now, the specific gravity of pure water, at a temperature of about 62°, being assumed to equal 1, or unity, it follows that the specific gravity of a mineral is obtained by dividing its weight in air by its loss of weight in water. Thus, if $a =$ the weight in air, and $w =$ the weight in water, G, or $sp.\ gr. = \frac{a}{a-w}$.

Example.—A piece of calcareous spar weighs 66 grs. in air, and 42 grs. when immersed in rain or distilled water. Hence its sp. gr. $= \frac{66}{66-42} = \frac{66}{24} = 2.75$.*

The weight of the mineral may be ascertained most conveniently and with sufficient exactness for general purposes, by a pair of small scales such as are commonly called "apothecaries' scales." These may be purchased for a couple of dollars, or even less. A small hole must be made in the centre of one of the pans for the passage of a horse-hair or silken fibre, about four inches in length, and furnished at its free end with a "slip-knot" or running noose, to hold the specimen whilst it is being weighed in water. The strings of the perforated pan may also be somewhat shortened, but the balance must in this case be brought into equilibrium by a few strokes of a file on the under side of the other pan, or by attaching thinner strings to it. If grain weights be used with this balance, the following will be required: 50 grs, 30, 20, 10, 5, 3, 2, 1, 0.5, 0.3, 0.2, 0.1.

The specific gravity bottle often recommended in mineralogical works, is too heavy to be carried by the scales described above. Bottles of the smallest capacity, weigh, when filled with water, at least 500 grains; and these scales will not carry more than 200, or 250 grains at the most. They are not very sensitive, indeed, when

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* This is the maximum specific gravity of calcareous spar.

loaded with more than 50 or 60 grains in each pan, although often of great delicacy when carrying lesser weights. The use of the sp. gr. bottle requires a chemical balance, costing, at the very lowest, some twenty-five or thirty dollars, besides being of difficult portability; and hence its employment for general purposes is scarcely available.

Relative Malleability.—Some few minerals, as native gold, native silver, sulphide of silver, native copper, &c., are *malleable* or *ductile*, flattening out when struck, instead of breaking. A few other minerals, as talc, serpentine, &c., are *sectile*, or admit of being cut by a knife; whilst the majority of minerals are *brittle*, or incapable of being cut or beaten out without breaking. In testing the relative malleability of a mineral, a small fragment should be placed on a little anvil, or block of steel polished on one of its faces,* and struck once or twice by a light hammer. To prevent the fragment from flying off when struck, it may be covered by a strip of thin paper, held down by the forefinger and thumb of the left hand. Thus treated, malleable bodies flatten into discs or spangles, whilst brittle ones break into powder.

Magnetism.—Few minerals attract the magnet in their natural condition, although many do so after exposure to the blowpipe. (See below.) In trying if a mineral be magnetic, we chip off a small fragment, and apply to it a little horse-shoe magnet, such as may be purchased anywhere for a quarter of a dollar; or otherwise we apply the specimen to a properly suspended magnetic needle. In this manner the black granular masses which occur frequently in our gneissoid or Laurentian rocks, and in the boulders derived from them, may easily be recognised as magnetic iron ore.† Many specimens of magnetic iron ore (and also of magnetic pyrites) exhibit "polarity," or attract from a given point, one end of the needle, and repel the other.

Taste.—This is a very characteristic although limited property, being exhibited only by a few soluble minerals. In these, the taste may be saline, as in rock salt; or bitter, as in Epsom salt; or metallic, as in sulphate of iron, and so forth.

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* The little anvils called "Watch-makers' anvils," are very suitable for this purpose. They may be purchased (where Watch-makers' tools are sold) for half-a-dollar, or even less.

† The other dark-coloured cleavable masses in these rocks consist of mica or more rarely of hornblende.

CHEMICAL CHARACTERS.*—These, so far as regards the determination of mineral species, comprise the results produced by the action of acids; and the relative fusibility, &c., of minerals, as ascertained by the employment of the blow-pipe.

Action of Acids.—The acid-test is resorted to, chiefly for the purpose of distinguishing the *carbonates* from other mineral substances. The majority of carbonates, as carbonate of lime, carbonate of oxide of copper, &c., when touched with a drop of diluted hydrochloric acid (the "spirit of salt" of the shops), produce a more or less vigorous effervescence. This reaction is still more marked, if a small fragment of the mineral be dropped into a test-tube containing a little of the acid. The effervescence arises from the escape of carbonic acid. Some carbonates, as carbonate of iron, dissolve very slowly, and scarcely produce any effervescence, unless employed in a pulverised state, or unless the acid be gently heated. Sulphate of lime and various other minerals dissolve in hydrochloric acid, but without causing effervescence. Quartz, feldspar, &c., on the other hand, are quite insoluble. Certain silicates, and more especially those named "zeolites" dissolve partially in hot hydrochloric acid, leaving the undissolved silica in the form of a gelatinous mass. Gold and platinum are not attacked by strong nitric acid, whilst this dissolves copper, silver, &c., very readily. Cupreous acid-solutions have always a green or blue colour. Red copper ore dissolves with effervescence in nitric acid producing a coloured solution; by which characters it may be readily distinguished from the red silver ores.

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* The Chemical Characters of minerals are discussed in the present work in the briefest terms. To have entered fully into these characters, would have carried us altogether beyond the object in view: the simple determination of the names of Canadian minerals. The advanced lectures given daily during the Michaelmas Term in University College, Toronto, by the author, are open to all students desirous of obtaining more ample information on the subject. The annexed extract is taken from the author's syllabus to this course of lectures:

"THE CHEMICAL RELATIONS OF MINERALOGY.

"*The Chemical Constitution of Minerals.*—1, Chemical Nomenclature as applied to Mineralogy; 2, The Laws of Combination; 3, The Atomic Theory: 4, Chemical Notation; 5, Construction of Chemical Formulæ; 6, Isomorphism, or Law of Substitution; 7, Atomic Volumes.

"*The Chemical Examination of Minerals.*—1, Action of Acids, &c. 2, Employment of the Blow-pipe, comprising: *a*, Instruments and Appliances; *b*. Reagents; *c*, Operations; *d*, Reactions; and *e*, Plan of Analysis in the examination of an unknown substance."

Students attending these lectures, are strongly advised to go through, also, a course of Practical Chemistry, in the Laboratory of University College, under the direction of Professor Croft.

The acids used in these experiments may be conveniently kept in small glass bottles furnished with a long glass stopper, reaching to the bottom of the bottle, and with a glass cap to prevent the escape of corrosive fumes. For geological purposes (testing calcareous rocks, &c.,) strong hydrochloric acid diluted with half its bulk of pure water, is principally used. The "specimen basket" may be provided near its upper edge with a little nest, or wicker-work pocket, for the reception of the acid bottle.

Action of the Blow-pipe.—The blow-pipe in its simplest form is merely a narrow tube of brass or other metal, bent round at one extremity, and terminating at that end in a point with a very fine orifice (*a:* fig. 21). If we place the pointed end of this instrument just within the flame (and a little above the wick) of a lamp or common candle, and then blow gently down the tube, the flame will be deflected into a horizontal position, and its heating powers will be wonderfully increased. Many minerals when held in the form of a thin splinter at the point of the blow-pipe flame, melt with the greatest ease; and some are either wholly or partially volatilized. Other minerals, on the contrary, remain unaltered; and thus, by the aid of the blow-pipe, we are often enabled to distinguish from one another, in a moment, various minerals which in external characters may be closely alike.*

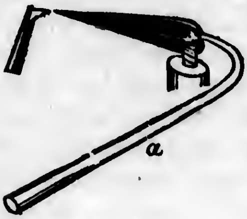

FIG. 21.

The blow-pipe has, strictly, a three-fold application. It may be employed, as just pointed out, to distinguish minerals from one another; some of these being fusible, whilst others are infusible; some attracting the magnet after exposure to the blow-pipe, whilst others do not exhibit that reaction; some imparting a colour to the flame, others volatilizing, and so forth. Secondly, the blow-pipe may be employed to ascertain the general composition of a mineral, or the presence or absence of some particular substance in it, as copper, lead, iron, cobalt, manganese, sulphur, arsenic, and the like. Thirdly, the blow-pipe may be used to determine in certain special

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* More convenient forms of blow-pipe will be found described in special works on the use of that instrument, but the common form described above is quite sufficient for the simple experiments required in the determination of our ordinary minerals.

cases the actual amount of a metallic or other ingredient previously ascertained to be present in the substance under examination.[*]

In the employment of the blow-pipe (in conjunction with external characters) in the simple determination of our Canadian minerals, we are never compelled to resort to more than two experiments: the *fusion-trial*, and the *water-test*. The student will find it of advantage, however, to study in addition the reactions of the more common metals and metallic oxides as given in special works on the Blowpipe. To describe these reactions in the present essay, would extend the subject much beyond its allotted limits.

The Trial of Fusibility.—In order to ascertain the relative fusibility of a substance, we chip off a small particle the (smaller the better) and expose the point of this to the extremity of the blow-pipe flame —holding the test-fragment in a small pair of tongs or forceps with platinum tips;[†] or supporting it, if it be of a metallic aspect or of a certain weight and exhibit at the same time a coloured streak, on a piece of well-burnt pine charcoal. The particle thus exposed to the flame ought not to be larger than a small carraway seed. If it be fusible, its point, in the course of ten or fifteen seconds, will become rounded into a bead or globule. The proper method of blowing can be acquired by half-an-hour's practice. The cheeks are to be filled with air, and this is to be urged *gently* and continuously down the tube by the compression of the cheek muscles, the operator breathing at the same time (if he require to do so) through his nose. By a little practice this becomes exceedingly easy; and the blowing need never be kept up (at least in experiments of this kind) for more than a quarter of a minute at a time. A *thin splinter* will exhibit signs of fusion in ten or twelve seconds, or not at all. The use of the instrument, therefore, is easily acquired, and is in no way injurious to the health.

Thus treated:

(*a*) The test-fragment may "decrepitate" or fly to pieces. Example, most specimens of galena. In this case, a larger fragment

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[*] See, for example, a paper by the author "on the Assaying of Coals by the Blow-pipe," in the *Canadian Journal*, Vol. III. page 208; and Philosophical Magazine for July, 1858. Also Plattner's "Probirkunst mit dem Lothröhre."

[†] These forceps may be obtained from any dealer in chemical apparatus. For simple experiments they may be replaced by a strip of thin sheet iron bent into the form of a pair of nippers or tongs. Some twine or silk must be twisted round the middle part to prevent the fingers from being burned.

must be heated in a test-tube over a small spirit lamp, and after decrepitation has taken place, one of the resulting fragments may be exposed to the blow-pipe flame as already explained.

(*b*) The test-fragment may change colour (with or without fusing) and become attractable by a magnet. Example, carbonate of iron. This becomes first red, then black, and attracts the magnet, but does not fuse. Iron pyrites on the other hand becomes black and magnetic, but fuses also.

(*c*) The test-fragment may. colour the flame. Thus, most copper compounds impart a rich green colour to the flame; compounds containing baryta, and many phosphates and borates, with the mineral molybdenite, colour the flame pale green; sulphur, selenium, lead, and chloride of copper colour the flame blue of different degrees of intensity; compounds containing strontia and lithia impart a crimson colour to the flame; some lime compounds impart to it a paler red colour; soda compounds, a deep yellow colour; and potash compounds, a violet tint.

(*d*) The test-fragment may become caustic. Example, carbonate of lime. The carbonic acid is burned off, and caustic lime remains. This restores the blue colour of reddened litmus paper. It also imparts if moistened, a burning sensation to the back of the hand or other sensitive part.

(*e*) The test-fragment may take fire and burn. Example, native sulphur; common bituminous coal, &c.

(*f*) The test-fragment may "volatilize," or dissipate in fumes, either wholly or partially, and with or without an accompanying odor. Thus, grey antimony ore volatilizes with dense white fumes; arsenical pyrites volatilizes in part, with a strong odor of garlic; common iron pyrites yields an odour of brimstone, and so forth.

(*g*) The test-fragment may fuse, either wholly, or only at the point and edges; and the fusion may take place quietly, or with bubbling, and with or without a previous "intumescence" or expansion of the fragment. Most of the so-called zeolites, for example, (minerals abundant in Trap rocks), swell or curl up on exposure to the blowpipe, and then fuse quietly. Lepidolite fuses with great bubbling, and colours the flame red. Feldspar only melts on the edges, at least, in ordinary cases.

(*h*) The test-fragment may remain unchanged. Example, Quartz, and various other infusible minerals.

The Water-test.—Many solid minerals contain a considerable amount of water, or the elements of water, in some unknown physical condition. Gypsum, for example, contains 20.93 per cent. of water. In order to ascertain if a substance yield water, we chip off a fragment (of about the size of a small pea) and heat this in a common test-tube (or better, in a small "bulb-tube" or glass tube closed and expanded at one end, as shown in the accompanying figure) over the flame of a little spirit lamp. If water be present, it will rise and condense in the form of a thin film or in small drops, on the cold neck or upper part of the tube. When the moisture begins to appear, the tube must be held in a more or less horizontal position, otherwise a fracture may be occasioned by the water flowing down and coming in contact with the hot glass. A small spirit lamp may be made by fitting a piece of glass tubing an inch long (to serve as a wick holder) into the cork of any short, stout bottle. A proper lamp, however, with a glass cap to prevent the evaporation of the spirit when the lamp is not in use, can be purchased for a quarter of a dollar.

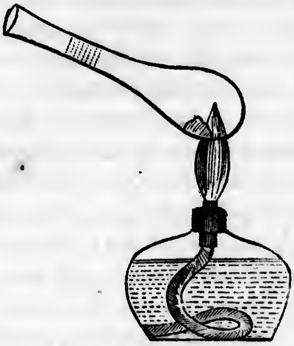

FIG. 22.

PART II.

THE MINERALS OF CANADA.

INTRODUCTORY NOTICE.

In the preceding chapter we have given a brief review of the more common characters or properties employed in the determination of minerals. The present subdivision of our work exhibits the practical application of these characters, in the distribution of our Canadian minerals into a small number of easily recognized groups, so arranged as to lead at once to the names of the included substances.

By referring to the heads of this arrangement or classification,* as given below, it will be seen that there are four principal groups: *A*, *B*, *C*, and *D*: the first two containing those minerals which exhibit a metallic aspect; and the other two containing our glassy, stony, pearly, or earthy-looking minerals. The metallic-looking substances placed in group *A* are sufficiently hard to scratch window-glass; whilst those placed in group *B*, are too soft to effect this. In like manner, the minerals of non-metallic aspect placed in group *C*, scratch glass; whilst those placed in group *D*, are less hard than glass, and are consequently unable to scratch that substance. The term "glass," as employed in this sense, means ordinary window-glass. By these simple characters it is easy to determine in a minute, to which group a substance under examination belongs. This determined, we proceed to a consideration of the sub-groups, **1**, **2**, **3**, &c., of the group in question. In the sub-group or section to which the substance will thus be found to belong, there will probably be some three or four, or perhaps half-a-dozen, other minerals; but these, it will be seen, are readily distinguishable, one from another, by colour, colour of streak, structure, or other easily determined character. In this manner we arrive, without difficulty, at the name of our mineral.

To illustrate this by example, let it be supposed that we have a piece of a red, dull, and somewhat earthy-looking substance, the name of which we wish to ascertain. By its non-metallic aspect, we see at once that it belongs either to group *C* or to group *D*. We try if it will scratch glass. It is not sufficiently hard to do this: hence it belongs to group *D*. Turning now to the respective sub-groups or sections under *D*, we find that our mineral has no taste, and hence does not belong to *D* 1. Neither does it take fire (although it blackens) when a thin splinter of it is held for a moment in the flame of a candle, or in the flame of an ignited match: and hence it does not belong to *D* 2. It has, however, a *coloured streak*† (red), and so belongs to the next section, *D* 3. Now in this section there are only two minerals with red streak: or only one, indeed, of undoubted Canadian occurrence—*Earthy Red Iron Ore*, commonly

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* The general reader should understand that this classification is a purely artificial one, intended solely to lead to the recognition of minerals by means of their more obvious or easily determined characters—somewhat on the principle of the Linnæan classification of plants.

† For an explanation of these characters, technical terms, &c., see Part I.

called *Red Ochre;* and as our mineral becomes magnetic after exposure to the flame of a match or candle, it can be nothing else than a specimen of that substance. This example will be sufficient to shew the method of procedure to be followed in order to ascertain the name, &c., of an unknown mineral, by reference to the annexed TABULAR DISTRIBUTION. In this connexion, it has been thought advisable to include a few substances of more or less common occurrence in the United States, although not yet found in Canada; and also to refer occasionally, in smaller type, to some other minerals of economic value or popular interest, so as to make the subject more complete, and render our Tables available for the examination of the small collections sometimes imported into this country for the purposes of study. Some of the substances thus noticed, may also be discovered eventually in Canada. Finally, it should be observed that the descriptions of these various minerals, given in our TABULAR DISTRIBUTION, are necessarily exceedingly brief, referring only to matters of easy comprehension or general importance. When, however, the name of a mineral is once discovered, the reader, if he desire to pursue the subject further, can refer for fuller details to any of our ordinary works on Mineralogy.

A TABULAR DISTRIBUTION OF CANADIAN MINERALS, INCLUDING, ALSO, A FEW OTHER MINERAL SUBSTANCES OF COMMON OCCURRENCE.

GENERAL INDEX.

The reader is to determine, by this Index, the group and sub-group to which his unknown mineral belongs; and he is then to refer to the descriptions given under that sub-group in the pages immediately following the Index.

Aspect Metallic	Hard enough to scratch glass	*A.*
	Not hard enough to scratch glass ..	*B.*
Aspect Non-metallic..	Hard enough to scratch glass	*C.*
	Not hard enough to scratch glass ..	*D.*

A. Aspect metallic. Hard enough to scratch glass:

Colour, Light Brass-yellow	*A* 1.
Colour, Pale copper-red	*A* 2.
Colour, Tin-white, or Silver-white	*A* 3.
Colour, Steel-grey, Black, or Brown	*A* 4.

B. Aspect metallic. Not hard enough to scratch glass:
Malleable or Ductile. . . . . *B* 1.
Yielding to the nail . . . . *B* 2.
Not yielding to the nail . . . . *B* 3.

C. Aspect non-metallic, (glassy, stony, &c.) Hard enough to scratch glass:
Infusible. Very hard: not yielding to the knife. . . . . . *C* 1.
Infusible, or nearly so. Yielding to the knife . . . . . . *C* 2.
Fusible. Not yielding water in the bulb-tube. . . . . *C* 3.
Fusible. Yielding water in the bulb-tube (*fig.* 22). . . *C* 4.

D. Aspect non-metallic, (stony, glassy, &c.) Not hard enough to scratch glass:
Soluble, and thus affecting the taste . . . . *D* 1.
Taking fire when held (in thin splinters) in the flame of a candle . . . . *D* 2.
Not exhibiting the above reactions. Streak, coloured *D* 3.
Streak, white. Not yielding water in the bulb-tube . . *D* 4.
Streak, white. Yielding water in the bulb-tube (*fig.* 22.) *D* 5.

A. Aspect Metallic Hardness sufficient to scratch glass.

A 1.—*Colour, Light Brass-yellow.*

Iron Pyrites.—A substance of a pale brass-yellow colour, with greyish-black streak, occurring in amorphous, globular, and other masses, and in Monometric crystals (cubes, generally with alternately-striated faces, pentagonal dodecahedrons, &c., *figs.* 23, 24, 25.)

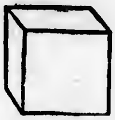
Fig. 23.

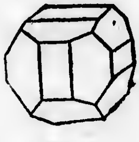
Fig. 24.

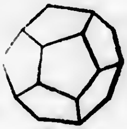
Fig. 25.

H. 6.0–6.5; sp. gr. 4.8–5.1. Fusible, with sulphur fumes, into a magnetic globule. One hundred parts contain: sulphur, 53·5; iron, 46·7; but the iron is sometimes in part replaced by a little cobalt or nickel, and occasionally minute portions of gold and silver are accidentally present. Iron pyrites occurs in all kinds of rocks, and is exceedingly common; but is useless as an ore of iron. It yields copperas, or iron-vitriol, by decomposition; and it is often converted on the surface, or wholly, into hydrated brown oxide of iron. It sometimes forms the substance of organic remains, as in many of the Trilobites, &c., of our Utica Slate. Amongst the principal Canadian localities,* we may note, more especially, the counties of Pontiac (Clarendon Township), Terrebonne, Berthier (Lanoraie Seign.), and Sherbrooke (Garthby Township), in Canada East; the vicinity of Balsam Lake, where it occurs with magnetic pyrites; and many places on the north shore of Lake Huron, Lake Superior, &c. A nickeliferous variety occurs in D'Aillebout, Berthier Co.; and an auriferous variety in Vandreuil, Beauce Co., C. E. We have obtained some brilliant though small, crystals from the white feldspathic trap of the Montreal Mountain; and also from the Niagara limestone, and other fossiliferous rocks; but iron pyrites occurs chiefly in our Laurentian and Huronian Formations, and in the Metamorphic district of the Eastern Townships. The general reader will find these geological terms fully explained in some of the succeeding parts of this series.

Radiated Pyrites, or *Marcasite*, also belongs to this Section, but it does not appear to have been noticed in Canada. It has the same composition as common Pyrites, but crystallizes in the Trimetric or Rhombic System. Many globular specimens, with radiated structure, sometimes referred to Marcasite, belong truly, it should be observed, to common Pyrites.

A. 2.—*Colour, Pale Copper Red* (*usually with grey or black external tarnish.*)

Arsenical Nickel—Pale copper-red, tarnishing dark-grey. Streak, brownish-black. Chiefly in small amorphous masses. H. 5·0–5·5 (it scratches glass feebly.) Sp. gr. 7.3-7.7 (a salient character.) Fusible, with strong odour of garlic. One hundred parts contain: Arsenic, 56; Nickel, 44. This substance, often called *Copper-Nickel* from its copper-red colour, is the common ore of nickel; but in Canada it is very rare. It has been found in small quantities in Michipicoten Island, Lake Superior. A substance composed of sulphur, arsenic, and nickel, occurs likewise, but in very small quanti-

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* For the localities mentioned in these descriptions, we are very largely indebted to the publications of the Canadian Geological Survey, and especially to the *Esquisse Géologique du Canada*, by Sir W. E. Logan and T. Sterry Hunt. We shall be greatly obliged to our readers for any information respecting localities of Canadian minerals; and more especially, if a small fragment of the substance referred to in the information, be furnished at the same time. A piece no larger than our ordinary pea will be of sufficient size. Although we are constantly receiving specimens of different kinds for examination, the exact localities of these are generally kept secret by the senders, in the belief that something has been discovered of more than usual value.

ties, at the Wallace Mines, Lake Huron. It is somewhat less hard than Arsenical Nickel. The Townships of Bolton and Ham, in the metamorphic district of the Eastern Townships, are also cited as localities of nickel ore. The ore is said to occur there very sparingly in Serpentine, associated with Chromic Iron Ore.

A. 3. *Colour, Tin or Silver-white (sometimes with grey or yellowish external tarnish.)*

Arsenical Pyrites (Mispickel.)—Tin or silver-white, inclining to light steel grey. Streak, greyish-black. In amorphous and granular masses, and in modified rhombic prisms (Trimetric System.) H. 5.5–6.0; Sp. gr. 6.0–6.4. Fusible, with garlic odour, into a magnetic globule. One hundred parts contain: sulphur, 20; arsenic, 46; iron, 34. This mineral is of very common occurrence in many countries. It is quite useless as an ore of iron, but is employed in Germany and elsewhere in the production of arsenious acid, the white arsenic of commerce. Arsenious acid is obtained also, and more abundantly, from arsenical nickel and certain cobalt ores. In Canada, arsenical pyrites occurs in small quantities with common iron pyrites, &c., in our azoic and metamorphic rocks more especially, at various localities: as at the Lake Huron Mines; in Clarendon Township (Pontiac Co.); in the Chaudière Valley, &c. It sometimes contains a little cobalt, in which case, after exposure before the blow-pipe to drive off the greater part of the arsenic and sulphur, it fuses with with borax into a rich blue glass.

The common cobalt ores (Smaltine and Cobaltine) belong also to this Section, but they have not yet been discovered in Canada.

A 4. *Colour, Steel-grey, Iron-black, or Brown. (No fumes before the Blow-pipe.)*

[Principal Minerals.—Streak, dull-red: *Specular Iron Ore.* Strongly magnetic; streak, black: *Magnetic Iron Ore.* Yielding water in the bulb-tube; streak, yellowish-brown: *Brown Iron Ore.*]

Specular Iron, or *Red Iron Ore.*—Dark steel-grey, often inclining to blueish red. Streak, dull-red, the same as the colour of the earthy varieties described in Section *D* 3. In rhombohedral crystals and crystalline groups, and in lamellar, micaceous, and fibrous-botryoidal masses, the latter often called Red Hæmatite. H. 5.5–6.5; sp. gr. 4.3–5.3. In thin splinters, fusible on the edges (although commonly said to be infusible.) Becomes also magnetic after exposure to the blow-pipe, and is often feebly magnetic in its normal condition. One hundred parts contain: Oxygen, 30; Iron, 70. This mineral is one of the most valuable of the Iron Ores. In Canada, it is exceedingly abundant, more especially in our Laurentian rocks, although less so than the Magnetic Iron Ore. It occurs chiefly in these rocks in the Township of MacNab, on the Ottawa, where it constitutes a vast bed, twenty-five feet thick, in crystalline limestone; and also associated with crystalline limestone at Iron Island, Lake Nipissing (Mr. Murray.) In the Huronian rocks, it is found at the Wallace Mine, Lake Huron; and it occurs likewise in metamorphic chloritic schists (altered Silurian shales of the age of the Hudson River group), associated with magnetic iron ore, dolomite, &c., in the Eastern Townships of Sutton, Bolton, and Brome.

Ilmenite.—This substance, (normally, perhaps, a compound of the sesqui-oxides of titanium and iron,) has an iron-black or dark steel-grey colour, with black or dark reddish-brown streak. It closely resembles and passes into *Specular Iron Ore.* At Baie St. Paul, C.E., a large deposit of Ilmenite, three hundred feet in length and ninety feet broad, occurs in a feldspathic rock of the Laurentian series. It is associated with small orange-red grains of rutile. The same substance (according to Sir W. Logan,) occurs also, mixed with magnetic iron ore, in a thick bed in serpentine, in Vaudreuil, Beauce County, C.E.

Magnetic Iron Ore.—Iron-black, with sub-metallic lustre and black streak. Occurs in monometric crystals (octahedrons and rhombic dodecahedrons, *figs.* 26 and 27), in amorphous masses of a granular or lamellar structure, and also in small grains. Strongly magnetic, often with polarity. H. 5.5-6.5; sp. gr. 4.9-5 2. Infusible, or nearly so. One hundred parts contain: Oxygen, 27.6; iron, 72.4; (or sesquioxide of iron, 69; protoxide of iron, 31.) This when pure, is the most valuable of all the iron ores. Its black streak, and strong magnetism, (and, when crystallized, its form), easily distinguish it from specular iron ore. In the Laurentian rocks of Canada, it occurs in vast beds, rendering this Province one of the richest iron-containing countries of the world. It occurs also abundantly amongst the metamorphosed Silurian strata of the Eastern Townships. Its principal "Laurentian" localities comprise: the

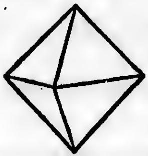

Fig 26.

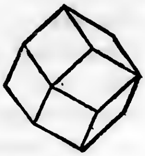

Fig. 27.

Townships of Marmora, Belmont, and Madoc, with those of South Sherbrooke, Bedford, and Crosby, in Canada West; and the Townships of Hull and Litchfield, on the Ottawa, in Canada East. The supply at these localities is apparently inexhaustible. The Townships of Bolton and Brome, and the Chaudière Valley, may be cited amongst the localities of this ore in the metamorphic district south of the St. Lawrence. In this district, however, as remarked by Sir William Logan, its value is much lessened by admixture with titanic iron, chlorite, &c. In the form of black magnetic sand (either alone or mixed with *iserine*,), this ore is also of exceedingly common occurrence on the shores of many of our lakes, islands, &c. The black iron-sand of the Toronto "Peninsula" is a well-known example.

Iserine.—This is a black titaniferous iron ore, bearing the same relation to *Magnetic Iron Ore* that *Ilmenite* bears to *Specular Iron.* It occurs chiefly in the form of magnetic sand, or in small granular masses, mixed with magnetic iron ore. It occurs with "iron sand" on our lake shores, &c., and probably with magnetic iron in the Eastern Townships. It can only be distinguished from the latter mineral by a blow-pipe (or other chemical) examination. Fused on charcoal with microcosmic salt in a reducing flame, the glass becomes, on cooling, deep red.

Chromic Iron Ore.—This substance is also closely related to Magnetic Iron Ore. It has a black colour, with sub-metallic lustre, and dark-brown streak. It occurs commonly in amorphous granular masses, and consists normally of sesqui-oxide of chromium and oxide of iron. H. 5.5; sp. gr. 4.3–4.6. Bolton and Ham, in the "metamorphic district" of the Eastern Townships (where it occurs in veins of about a foot in thickness, in serpentine) are its principal Canadian localities. It is found also in other places throughout this district, in small grains, in dolomite and magnesite rocks. When quite pure, it may be distinguished from magnetic iron ore by its brown streak and lower sp. gr.; as well as by its want of (or feeble) magnetism. Chromic Iron Ore is used for the preparation of chromium compounds, employed in dyeing, painting, &c.

Brown Iron Ore (*Limonite*).—Brown of various shades, with sub-metallic (or sometimes stony or silky) aspect, and yellowish-brown streak. Occurs chiefly in botryoidal masses with fibrous structure (a variety often called *Brown Hæmatite*), and also in vesicular and earthy amorphous masses (*Bog Iron Ore*). H. 5.0–5.5; sp. gr. 3.5–4.0.

Blackens before the blow-pipe, and becomes magnetic. In the bulb-tube (*fig.* 22) it gives off water. One hundred parts contain (if the substance be pure): Sesqui-oxide of iron, 85.6; water, 14.4. This is likewise a valuable ore of iron. The *Bog Iron Ore* variety (in addition to *yellow ochre* described in Section *D* 3) is that which chiefly occurs in Canada. This variety is a comparatively recent product; and its formation, indeed, is still going on in places, by deposition from water in the form of carbonate of iron oxide, this being afterwards converted into the hydrated sesqui-oxide. It occurs in great abundance in Post-tertiary deposits in the Three Rivers District, C.E., (yielding the celebrated "St. Maurice, or Three Rivers Iron," largely employed for castings); and also in the County of Norfolk, C.W.; besides many other localities. Altogether, the following Townships and Seigniories are enumerated by Sir William Logan (***Esquisse géologique du Canada***) as yielding this ore: Middletown, Charlotteville, Walsingham, West Gwillimbury, Fitzroy, Eardley, March, Hull, Templeton, Vaudreuil, St. Maurice, Champlain, Batiscan, Ste. Anne, Port Neuf, Nicolet, Stanbridge, Simpson, Ireland, Lauzon, St. Vallier, &c. These bog iron ores always contain a small amount of phosphoric acid, which becomes reduced during the process of smelting, and usually renders the iron (by the presence of phosphide or phosphuret of iron) "cold-short." Cold-short iron is more or less brittle, and, hence, as a general rule, it is only available for castings. The St. Maurice ores are said, however, to yield excellent malleable iron.

NOTE.—As the minerals of this Section (*A* 4) present, in many of their varieties, a somewhat doubtful metallic aspect,[*] they will be referred to again, under Group *C*.

B. Aspect metallic. Hardness insufficient to scratch glass.

B 1. *Malleable or Ductile.*

[Principal Minerals:—Colour yellow: *Native Gold.* Colour white, with dark tarnish: *Native Silver.* Colour dark lead-grey: *Sulphide of Silver.* Colour copper-red: *Native Copper.*]

Native Gold.—Rich golden-yellow; in small granular or sub-crystalline masses, scales, and dust. Sp. gr. varying from about 16.0

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[*] The term "aspect," as here employed, refers not merely to the "lustre" of the substance, but to its general appearance and characters, taken together. Thus but few, if any, specimens of Bog Iron Ore exhibit a metallic lustre properly so-called; and yet most persons, on taking up one of these specimens, would refer it at once to the metallic group, or, in other words, would consider it to be a metallic substance of some kind.

to 19.0. Easily fusible, but otherwise inalterable before the blowpipe. Distinguished by this latter character, and also by its high sp. gr., its malleability, &c., from copper pyrites, iron pyrites, and other substances of a similar aspect. Another salient character, applicable more especially to dust gold, is the quality of remaining unaffected by nitric acid. In Canada, native gold occurs over a wide area (in alluvial sands, &c.) in the metamorphic district south of the St. Lawrence, although not in sufficient abundance to cause the regular working of the auriferous sands of this district to be remunerative. The sands of the following streams and rivers, more particularly, are stated by Sir William Logan to contain gold: The Guillaume, Lessard, Bras, Touffe-des-Pins, Du Lac, Famine, Du Loup, Metgermet, and Poser's stream; with the Chaudière and St. Francis. These, with the exception of the St. Francis, belong chiefly to Beauce Co., C.E. Sir William Logan states also, that native gold has been found in small quantities in a vein with Specular Iron Ore, in the township of Leeds, Megantic Co., C.E.[*] Traces of gold have likewise been discovered in the native silver of Prince's Mine, Lake Superior. (See, also, auriferous varieties of Iron Pyrites, *A* 1; Copper Pyrites, *B* 3; and Blende, *B* 3.) The gold of the Eastern Townships contains, according to Professor Sterry Hunt, from 11 to 13 per cent. of silver. Small grains of *Platinum* and *Iridosmium* are mixed with it here and there, as in the sands of the Rivière du Loup, &c.

Native Silver.—Silver-white, often with dark or yellowish external tarnish. Found chiefly in crystalline arborescent groups, and in small, scaly, granular, or wire-like masses, associated with native copper, at St. Ignace and Michipicoten Islands; and with sulphide of silver, &c., in calcareous spar, at Prince's Mine, Spar Island, Lake Superior. Sp. gr. 10-11. Easily fusible.

Sulphide of Silver (or *Silver Glance*).—Dark lead-grey or black, with shining streak. Perfectly ductile. Chiefly in small masses with native silver, sulphide of copper, galena, malachite, &c., in a vein of quartz and calc spar, at Prince's Mine, Lake Superior. Sp. gr. about 7.2. Fusible and reducible to metallic silver *per se* before the blowpipe. One hundred parts contain: Sulphur, 13; silver, 87. It is easily distinguished from sulphide of copper, galena, &c., by its perfect malleability, as well as by its blow-pipe characters.

Native Copper:—Copper-red, with shining streak. Chiefly in arborescent and amorphous masses, more rarely in determinable crystal-groups (Monometric.) H. 2.5–3.0. Perfectly malleable. Sp. gr. about 8.9. Easily fusible, imparting a green colour to the flame. Native copper occurs in immense abundance on the south shore of Lake Superior, but on the Canada side of the lake it has been found in small quantities in St. Ignace and Michipicoten Islands. In the latter Island, at Maimanse and Mica Bay, accompanying *copper glance* and *copper pyrites*. It does not appear to occur at all amongst the extensive deposits of copper pyrites, &c., on Lake Huron. In the Eastern metamorphic district, native copper is said to have been noticed at St. Henri, Dorchester County.

B. 2. Yielding to the Nail

[Principal Minerals: Streak white, *Mica*. Streak black, colour, black or dark-grey: *Graphite*. Streak and Colour lead-grey; imparting a pale green tint to the blow-pipe flame: *Molybdenite*.]

Mica:—In laminar or scaly masses, with a false pearly-metallic aspect. Colour, various; streak, white. See Section *D*. 4.

Graphite:—Chiefly in black or dark-grey foliated masses or small scales. Feels somewhat greasy; marks on paper; sectile, and flexible in thin pieces; H. 1.0–2.0; Sp. gr. about 2.0. Inalterable before the blow-pipe. It occurs in small scales disseminated more or less throughout our Laurentain formation, and more especially in the crystalline limestone of that series; but its principal Canadian localities are the townships of Grenville (Addington County,) and Fitzroy (Carleton County,) on the Ottawa. At the former locality it constitutes several veins, each of an average thickness of about five inches; and is associated with garnets, zircon, feldspar, and other minerals. Graphite when of fine granular structure and dark colour, is extensively employed, under the popular name of Plumbago or "Black-Lead," in the manufacture of the so-called black-lead pencils. It consists, however, simply of carbon (or of carbon mechanically mixed with oxide of iron,) and does not contain a trace of lead. Our Canadian graphite is unfortunately too coarse and not sufficiently intense in colour for pencils, but, according to Sir William Logan, it may be used in the manufacture of refractory crucibles. Some samples that we have seen, might be employed also when ground to powder, as a polishing material for grates and stoves.

Molybdenite:—This substance much resembles graphite, but is of a lighter colour; and whilst it leaves a black trace on paper, it makes a dull greenish streak on smooth porcelain. It occurs chiefly in small scaly masses of a lead-grey colour. Like graphite it feels somewhat greasy, and it is also flexible. H. 1.0–2.0; Sp. gr. 4.4–4.8. Infusible, but it colours the blow-pipe flame pale-green, and volatilizes very slowly, depositing a white crust of molybdic acid on the charcoal. One hundred parts consist of: sulphur 41, molybdenum 59. It is not uncommon in small quantities amongst our Laurentian rocks generally, and in the intrusive granites of that formation. As special localities, we may cite from the Reports of the Geological Survey: Jerome, C. E.; Mud Turtle Lake, north of Balsam Lake; the River Doré near Gros Cap; and a granite vein on the west side of Terrace Cove, Lake Superior. Molybdenite is the principal source of molybdenum compounds, used in porcelain painting, and as a reagent in certain chemical experiments, &c.

To this section belong also, *Pyrolusite* or *Black Manganese Ore*, and *Sulphide of Antimony* or *Grey Antimony Ore.* The former (a compound of oxygen 36.7, manganese 63.3) occurs chiefly in radiating fibrous masses of a black or dark steel-grey colour, and is quite infusible. We have received a specimen said to have been found in the Eastern Townships or the neighbourhood, a district in which the Earthy or Bog Manganese Ore is of not uncommon occurence (see Section D.) Pyrolusite is found also in the adjoining State of Vermont. It is a valuable ore. *Sulphide of Antimony* has not hitherto been recognised in Canada It occurs principally in fibrous masses of a lead or steel-grey colour, often with a dark or iridescent tarnish. A thin splinter will melt in the flame of a candle without the aid of the blow-pipe. It has been found in Maine, New Hampshire, &c., in the United States.

B. 3. Not yielding to the Nail.

(Principal Minerals:—Colour reddish; garlic-like odour before the blowpipe: *Arsenical Nickel.* Colour reddish, with blue or variegated tarnish; *Purple Copper Pyrites* Colour, bronze-yellow; magnetic: *Magnetic Pyrites.* Colour, brass-yellow, often with variegated tarnish; streak, blackish-green: *Copper Pyrites.* Colour, dark-grey, often with green or blue tarnish; (Sp. gr. under 5.8). *Copper Glance.* Colour lead grey; breaking easily into rectangular fragments; (Sp. gr. over 7.0): *Galena.* Colour, dark brown or various; streak brown; Infusible: *Zinc Blende.*

Arsenical Nickel:—Colour light copper-red, sometimes with greenish-white coating; exceedingly heavy; yielding an arsenical or garlic-like odour before the blowpipe. Many (or most) specimens are just hard enough to scratch glass; hence, this substance is described in full under Section *A* 2, above. As a Canadian mineral, it is comparatively unimportant.

Magnetic Pyrites:—Colour brownish or bronze-yellow, with black streak. Chiefly in amorphous masses. Magnetic, and often exhibits polarity. H. 3.5–4.5; Sp. gr. 4.4–4.7. Fusible, with sulphur fumes. Easily converted, by roasting, into red oxide of iron. One hundred parts contain: sulphur 39.5, iron 60.5. This substance, like the common pyrites, is not employed as an ore of iron. It occurs in considerable veins in St. Jerome, C. E.; also in the Chaudière Valley, where it is in part auriferous; and, in large quantities, about Balsam Lake, &c., C. W.

Copper Pyrites:—Brass-yellow, often with a variegated tarnish; streak, dark green or greenish-black. Chiefly in amorphous masses; sometimes in small tabular and tetrahedral crystals (Dimetric.) H. 3.5-4·0; Sp. gr. 4.1–4.3. Fusible with sulphur fumes into a magnetic globule. One hundred parts consist of: sulphur 35, copper 34.5, iron 30.5. This mineral is one of the most important of the copper ores. It is the characteristic ore of our Huronian rocks.[*] It occurs abundantly in these, at the Bruce and Wallace mines, Root River, Echo Lake, &c., on Lake Huron; and in the Michipicoten Islands, Lake Superior. It occurs likewise, but in comparatively small quantities in the Laurentian formation: as in the Seigniory of Lanoraie, Berthier County, C.E.; &c.; and it has also been found in the metamorphic district of the Eastern Townships; more especially in Upton, Drummond County, (where an argentiferous variety occurs,) and in Acton, Bagot County. At the latter locality it is auriferous.

Purple Copper Pyrites, (*Erubescite*):—Colour pale brownish-red, but always more or less masked by a rich blue or variegated tarnish; streak, greyish-black, by which (as well as by its colour, &c.,) this

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[*] The following Table shows (in a descending order) the positions of the rock-groups recognised in Canada. These groups, with their various subdivisions, &c., will be discussed in detail in one of the succeeding Parts of this series of papers, but the present Table may prove useful in the mean time.

Modern or Post-Tertiary Deposits.
The true Drift Formation.
(Here a great break occurs in the geological scale as represented in Canada.)
Carboniferous Formation (developed in part only in Gaspé.)
Devonian Formation,
Silurian Formation,[*]
Huronian Formation,
Laurentian Formation.

[*] The great fossiliferous formation of Canada. Metamorphosed or rendered crystalline in part, in the so-called "metamorphic district" of the Eastern Townships and surrounding region.

species may be easily distinguished from the variegated specimens of copper pyrites or yellow copper ore. Chiefly in amorphous or small granular masses accompanying yellow copper pyrites in quartz. Sometimes, as observed by the writer (*Canadian Journal,* New Series: vol. 1, page 187) in pseudomorphs, or altered (Dimetric) tetrahedrons, after the yellow ore. H=4.0 ; sp. gr. 4.4–5.0. Fusible with sulphur fumes into a magnetic globule. One hundred parts contain (as a mean): sulphur 25, copper 60, iron 15. This mineral occurs with copper pyrites at most of the localities given in the description of that substance, above. It is found also in the townships of Inverness and Leeds, Megantic County, C.E.

Sulphuret of Copper, or Copper Glance:—Dark lead-grey often with blue or green tarnish; streak, black and slightly shining. Chiefly in amorphous masses, more rarely in small flat six-sided crystals (Trimetric.) H 2.5–3.0; sp. gr. 5.5–5.8. Fusible with bubbling, colouring the flame green, and leaving a copper globule surrounded in general by a dark scoria. One hundred parts contain: sulphur 20.2, copper 79.8. This valuable ore occurs in some abundance at the Bruce Mines, Lake Huron. It is also found at Prince's Mine on Spar Island, Lake Superior, as well as in the Michipicoten Islands and in the Island of St. Ignace on that Lake, associated with copper pyrites, native copper, &c. It occurs likewise (with purple copper pyrites, &c.,) in the eastern metamorphic district: as in the townships of Leeds and Inverness in Megantic county. In the former of these townships it lies, according to Sir William Logan, in a ferruginous dolomite, associated with specular iron ore and a small quantity of native gold.

Galena:—Lead-grey, with black and somewhat shining streak. In amorphous masses of lamellar or granular structure, and in monometric crystals—more especially in cubes and cubo-octahedrons, *fig* 28. It breaks easily, owing to its well-marked cubical cleavage, into rectangular fragments. H. 2.5 ; sp. gr. 7.2–7.7. Decrepitates before the blow-pipe and yields lead globules, with the deposition of a yellow coating on the charcoal. One hundred parts contain: sulphur 13.4, lead 86.6; but a portion of the sulphide of lead is generally replaced by sulphide of silver. The silver in most of the Canadian samples, however, is insufficient to meet the cost of its extraction. Galena is the source of nearly all the lead of commerce. It occurs in

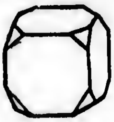

Fig 28.

Canada in very many places, but nowhere, apparently, in large quantities. It is chiefly found in connection with the crystalline limestones of the Laurentian formation, associated with crystallized calc-spar and sulphate of baryta, and sometimes also with zinc blende and iron pyrites. It occurs thus, occasionally forming thin veins, in the townships of Lansdowne and Bastard, (Leeds County, C.W. ;) Bedford (Frontenac County, C.W. ;) Fitzroy (Carleton County, C.W. ;) Ramsay (Lanark County, C.W. ;) Petite Nation (Ottawa County, C. E. ;) and, in smaller quantities, in many other townships lying more especially along the southern outcrop of the Laurentian country. Galena has been met with also in the Huronian rocks of the Michipicoten and Spar Islands, Lake Superior, associated with copper ores, calc-spar, amethyst-quartz, &c., and on the neighbouring shores. Also in the metamorphic district of Eastern Canada; more especially in the quartz veins of the Chaudière Valley (with zinc blende, common and magnetic pyrites, native gold, &c.) as in the seigniories of Vaudreuil and St. George.

Zinc Blende:—This substance varies in its aspect from sub-metallic to vitreo-resinous. The more metallic-looking specimens are dark-brown, black, brownish-yellow or brownish-red, with yellowish or reddish-brown streak, and high lustre. Found chiefly in lammellar and small irregular masses, and in more or less obscure crystals of the Monometric system. H. 3.5–4.0; sp. gr. 3.9–4.2. Infusible. One hundred parts contain: sulphur 33, zinc 67. Zinc Blende, although so abundant in many countries, can scarcely be called an ore of zinc: the attempts to employ it for the extraction of the metal, having hitherto proved of very partial success. It may be used however, when ground to powder, as the basis of a wash or paint for frame buildings and wood-work generally. In Canada, Zinc Blende occurs in some abundance at Prince's Mine on Spar Island, and at Maimanse, Lake Superior, with copper ores, galena, &c. Also in small quantities with galena, in the townships of Lansdowne, Bedford, &c., (see under *galena*, above); and in the eastern metamorphic district of the Chaudière Valley. The Blende of this latter locality (seigniories of Vaudreuil and St. George, Beauce Co.,) has been shewn by Mr. Sterry Hunt of the Geological Survey, to be slightly auriferous.

C. Aspect, non-metallic (stony, glassy, etc.) Hardness sufficient to scratch glass

C. 1—Infusible. Very hard, not yielding to the knife.

[Quartz is the only mineral of common occurrence, belonging to the present section. In colour, degree of transparency, and general appearance, this substance varies exceedingly; but its specific gravity is always under 2·9, whilst the other minerals (of Canadian occurrence) included in the section, exceed 3·0 in density. Feldspar is sometimes confounded by beginners with quartz; but the former in thin splinters, is more or less readily fusible. The two minerals may be distinguished also, at once, by the following characters: Quartz breaks with an uneven or conchoidal fracture, and never exhibits smooth cleavage planes. Feldspar, on the other hand, possesses a strongly-marked lamellar structure, and breaks easily in certain directions, so as to present a smooth, polished, and somewhat pearly fracture-plane.]

Corundum.—Red, blue, brown, greenish, black, &c. In small granular masses and hexagonal crystals. H. 9·0, and hence much above that of quartz; sp. gr. 3·9-4·1. Quite infusible. Corundum consists, normally, of pure alumina. The transparent red varieties constitute the *Ruby* of commerce, and the blue varieties the *Sapphire.* The coarser dull-coloured varieties are called *Adamantine spar;* and the opaque, black and dark grey varieties (often mixed with magnetic iron ore) form *Emery,* a substance used largely, from its great hardness, as a polishing material. Some of the finer kinds of corundum exhibit when cut, a beautiful opalescent six-rayed star. These are called *asteria sapphires, &c.,* according to their colour. Red (and blue) corundum occurs sparingly in the crystalline limestone (Laurentian series) of Burgess township, Lanark Co., C. W.

Spinel.—Red, blue, dull-green, black, &c. In small granular masses, but chiefly in regular octahedrons, simple or modified; figs. 29, 30. The latter figure represents a common twin-form, or combination of two octahedrons. Infusible, H. 8·0; sp. gr. 3·5-4·5. Spinel is an aluminate of magnesia, but a portion of the magnesia is usually replaced by oxide of iron, as in the black varieties called *pleonaste,* more especially; or by oxide of zinc, as in the Swedish dark green variety called *Gahnite* or *automolite.* Normally, it consists of alumina 72, magnesia 28. The clear red varieties are employed in jewellery under the name of Spinel or Balas ruby. Well-crystallized black speci-

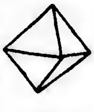

Fig. 29.

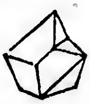

Fig. 30.

mens occur in the Laurentian limestone of Burgess township, C. W.; and bluish specimens with clintonite (a chloritic, altered mineral,) in D'Aillebout, Joliette Co., C. E.

Magnetic Iron Ore.—Black with black streak, and in general, a sub-metallic lustre. Massive, or in octahedrons and rhombic dodecahedrons. *Strongly magnetic,* often with polarity. See *A* 4, above.

Chromic Iron Ore.—Black; chiefly massive, and usually with sub-metallic lustre. Streak, dark brown. Imparts a fine green colour to borax before the blowpipe. See *A* 4. above.

Quartz.—A substance of a vitreous or more or less stony aspect; colourless, or of various colours, as purple, brown, red, green, yellow, &c. Occurring in crystals and crystalline groups, figs. 31, 32, and also in nodular, botryoidal, and amorphous masses. The crystals are commonly six-sided prisms, streaked across, and terminated by a six-sided pyramid. H. 7·0; sp. gr. 2·6-2·7. Infusible; but melting (with great effervescence) with carbonate of soda, into a clear glass. Quartz consists normally of pure silica, the coloured varieties owing their tints to minute and accidental admixtures of sesqui-oxide of iron, bituminous matter, and other inessential ingredients. Special names have been applied by lapidaries and others to the leading varieties of quartz. Thus we have, *Rock Crystal* (including the so-called "Quebec diamonds," &c.); *Smoky Quartz,* a brown variety of rock crystal; *Amethyst,* a purple or violet-coloured quartz, in which the edges of the crystals are usually more deeply coloured than the other parts; Cairngorm, a yellow transparent quartz; *Rose Quartz; Milk Quartz,* a white translucent variety; *Calcedony* and *Cornelian,* grey, white, bluish, yellow, and red, uncrystallized translucent varieties of quartz; *Cat's-eye,* an opalescent or chatoyant calcedony; *Chrysoprase,* a light green translucent variety; *Heliotrope,* a dark green variety, sometimes with red spots and then called *Bloodstone; Plasma* and *Prase,* other green varieties, the latter often mixed with actynolite; *Agate, Onyx, Sardonyx,* &c., uncrystallized varieties of various banded colours; *Jasper,* coarse, opaque, red, brown, and other coloured specimens, often striped, and with dull lustre on the fractured surface; *Flint* and

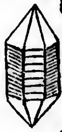
Fig. 31.


Fig. 32.

Hornstone, &c. Crystallized quartz occurs in various parts of Canada, more especially where Laurentian rocks prevail, and in the altered rocks of the eastern townships. Amethyst is found abundantly on Spar Island, where it forms a broad vein with calc-spar holding native silver, and at Thunder Bay and other spots on Lake Superior. Agates, also, in great variety, occur in the trap rocks and in the shingle beaches of that region (Michipicoten Isle, St. Ignace, Thunder Bay, &c.) A jasper-conglomerate, evidently an altered sedimentary rock, occurs on the north shore of Lake Huron. Agates and red and green jaspers occur also in Gaspé. Red jasper passing into jaspery iron ore, likewise near Sherbrooke; and, with veins of calcedony, on the river Ouelle (Kamouraska Co.) C. E. Silica often constitutes the fossilizing substance of organic remains, as in the Devonian corals of western Canada; and it is frequently found in crystal-groups in the inside of many fossil shells. Finally, it may be observed, quartz forms one of the essential components of granite, gneiss, and many other crystalline rocks. Sandstones also consist essentially of quartz grains cemented together, or consolidated by pressure; whilst in beds of sand and gravel we have the same substance in loose grains and pebbles, as explained more fully in Part III.

Zircon.—Red, brown, or grey, with resino-vitreous aspect. Chiefly in small crystals: (square-based prism-pyramids), fig. 33. H. 7·5; sp. gr. 4·0-4·7. Quite infusible. One hundred parts consist of: silica 33·2, zirconia 66·8. The transparent, yellowish-red varieties are employed in jewellery under the name of *Hyacinth.* Small crystals, sometimes of good quality, occur in the crystalline limestone (Laurentian Series) of Grenville township, Argenteuil Co., C. E. Those which have come under our observation are simply interesting as mineral specimens, but Sir William Logan has obtained some of fine colour and transparency, "constituting veritable gems." (Esquisse géologique du Canada.)

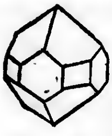

Fig. 33.

Andalusite.—Chiefly grey or pale red; in granular masses, and in rectangular or rhombic prisms. The latter are sometimes compound, presenting a cruciform figure on the cross section. These constitute the variety *Chiastolite*, (fig. 34.) H. (normally) = 7·0-7·5, but often less by alteration or weathering; sp. gr. 3·1-3·2. Quite infusible. General composition: silica 37, alumina 63. In Canada,

Fig. 34.

this mineral occurs in reddish crystals and small masses in micaceous schists (altered Silurian strata,) around Lake St. Francis in the counties of Megantic and Beauce. It may be distinguished from feldspar by its higher specific gravity, and also by its complete infusibility.

Staurolite :—Brown, red, greyish. Commonly in cruciform (Trimetric) crystals; otherwise in more or less simple, rhombic prisms. H 7-7·5, but sometimes less by alteration; sp. gr. 3·5–3·8. Quite infusible. General composition: silica, alumina, peroxide of iron. This mineral occurs sparingly in the metamorphic strata of the Eastern townships, although it is abundant in the mica slate of Maine, Vermont, &c.

Rutile :—In small crystalline scales and grains, and in flattened square-based prism-pyramids, of a red or orange colour, with semi-metallic lustre. H. 6·0-6·5; sp. gr. 4·15-4·25. Infusible. Forming with borax in a reducing flame a dark amethystine-blue glass, which by exposure to an intermittent flame, becomes transformed into a light-blue enamel. In Canada, Rutile, in a distinct form, occurs only in small quantities in the iron-ores of the Eastern metamorphic region, as in the townships of Sutton, Bolton and Brome; and with *Ilmenite* in the Laurentian rocks of Baie St. Paul, Canada East. It consists of Titanic acid (=Oxygen 39, Titanium 61.)

Condrodite :—Chiefly in small granular masses of a deep yellow colour, imbedded (usually with accompanying scales of graphite,) in crystalline limestone. H 6–6·5; sp. gr. 3·1-3·2. Infusible, but becomes white before the blowpipe. With borax, melts into a clear glass, which, if thoroughly saturated, may be rendered milky by flaming. This mineral is a silicate of magnesia, combined with a small proportion of fluoride of magnesium. It dissolves with gelatinization in hydrochloric acid. Condrodite occurs in some abundance in the crystalline limestones of our Laurentian rocks, more especially in the townships of South Crosby (Leeds Co.) C. W., and Grenville (Argenteuil Co.*) C. E. Also in St. Jerome, (Terrebonne Co.) in the Lower Province.

Olivine :—In green, yellow, or brownish grains and granular masses (sometimes crystalline) in the eruptive rocks of Montreal, Rouge-

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* This is incorrectly printed 'Addington Co.' in our description of *Graphite*, B 2, above.

mont, Moutarville, etc., in Eastern Canada, as first recognised by Mr. Hunt of the geological survey. H 6·0-6·5; sp. gr. 3·3-3·5. Infusible, gelatinizes in hydrochloric acid. Composed of silica and magnesia, the latter usually in part replaced by protoxide of iron.

Tourmaline:—(Infusible varieties): yellow, green, etc., mostly in three or nine-sided prisms. This mineral is described under C 3, the Canadian varieties being (chiefly) fusible.

Feldspar (Including *Orthoclase, Albite, etc.*,):—In white, red, green, or greyish cleavable masses and crystals. Fusible in thin splinters. See Section *C* 3.

The following minerals may also be referred to, in connection with this group:—

Opal.—Hydrated silica. A vitreous, or resino-vitreous mineral of various colours, occurring only in nodular or amorphous forms. Sp. gr. 2·0–2·2. Gives off a little water in the bulb-tube. The iridescent varieties constitute the *noble opal;* the colourless glassy variety in botryoidal masses, forms the *hyalite;* whilst the opaque, or faintly translucent varieties, of white, grey, red, brown, and other colours, comprise the *semi-opal*, *milk opal*, *wood-opal*, &c. Although this mineral, at least in its coarser varieties, is exceedingly common in the old world, (chiefly in amygdaloidal cavities in trap and volcanic rocks,) it appears to be of very rare occurrence in North America.

Beryl.—Chiefly in six-sided prisms and columnar masses of a light green colour. Fusible with great difficulty, and only on the thinnest edges. H. 7·5–8; sp. gr. 2·6–2·8. Common in many parts of the United States. The clear bluish-green varieties are employed in jewellery under the name of *Aquamarine*. The rich, deep green varieties (chiefly from New Grenada) form the well-known *Emerald*.

Topaz.—Chiefly in yellow, colourless, or bluish crystals and rolled pebbles, easily distinguished from quartz by their facile cleavage in one direction. The crystals are combinations of rhombic prisms and pyramids (see figs. 16 and 18 in Part I.) H. 8·0; sp. gr. 3·4–3·6. In the United States, Topaz occurs in Connecticut and North Carolina.

Tin-stone or Cassiterite.—Brown, grey, black, etc. In granular masses, pebbles, and Dimetric crystals, the latter often in twin combinations. Very hard and very heavy, (H. 6·0–7·0; sp. gr. 6·3–7·0.) Infusible, but yielding tin globules before the blowpipe, especially with carbonate of soda. The lustre is often semi-metallic. This is the "ore" of tin, properly so-called. One hundred parts consist of: oxygen 21·38, tin 78·62. In the United States it occurs but sparingly, and no traces of it have as yet been found in any part of Canada.

C. 2. Infusible. Yielding easily to the knife.

Cyanite.—Chiefly in lamellar and bladed or broad—fibrous masses of a pale-blue, or pearl-grey colour, though often white, reddish, &c. Lustre somewhat pearly. The edges of the lamellæ scratch glass with ease, whilst the flat surfaces yield readily to the knife. Sp. gr. 3·5-3·7. Infusible before the blowpipe, and very slowly soluble in borax. One hundred parts consist of: silica 37, alumina 63. Not met with, apparently, in Canada, but it occurs in mica slate in Vermont, and is of frequent occurrence in other States.

Apatite or Phosphate of Lime:—Chiefly in six-sided prisms (often with rounded edges) of a light green colour; or in green and brownish cleavable and concretionary masses. H. 5·0; sp. gr. 3·0-3·3. Infusible (or in some specimens fusible with difficulty on the thinnest edges), but it dissolves readily in borax and in salt of phosphorus, yielding a glass which becomes opaque on cooling or when "flamed." By this character, as well as by its inferior hardness (as it scratches glass but feebly, and may readily be scratched by a knife,) *Apatite* is easily distinguished from *green feldspar* and *beryl*. It differs from *Fluor Spar* in being hard enough to scratch glass: also by its infusibility, crystalline form, &c. Apatite occurs in the crystalline limestones of our Laurentian rocks. Amongst its more important localities, we may cite the townships of Burgess and Elmsley, in Canada West; with Grand Calumet Island on the Ottawa, and Hull township, in Eastern Canada. In the township of Burgess it occurs in a red-coloured coarse-grained limestone in such abundance as to form, according to the estimate of Sir William Logan, about one-third of the mass. In North Elmsley, a fine locality has recently been discovered by Dr. James Wilson, of Perth. Small nodular masses of phosphate of lime, presenting a brown colour and shining lustre, occur also in the sandstones of the Sillery group (at the top of the Lower Silurian series) on the river Ouelle, and in the shales of Point Lévi in Canada East. These are supposed to be coprolites. It is perhaps needless to observe, that phosphate of lime, whether derived from inorganic or organic sources, constitutes an agricultural fertilizer or manure of the highest value.

In this group, may be placed also, the *Silicate* and *Carbonate of Zinc*, but these minerals have not been discovered as yet in Canada. The *Silicate of Zinc* occurs chiefly in white or yellowish crystalline aggregations, or in botryoidal and sometimes earthy masses, often of a dull brownish yellow tint from intermixed peroxide of iron, and occasionally also coloured green by silicate of copper. The crystals are pyro-electric, and are slightly fusible on the edges. Sp. gr. 3·3-3·5; H. 5·0. Gives off water in the bulb-tube, and dissolves in heated hydrochloric acid. Composition: Silica 25, oxide of zinc 65·5, water 9·5. *Carbonate of Zinc*, in colour, etc., resembles the silicate, but the crystals are rhombohedrons. H. 5.0; sp. gr

4·0–4·4. Dissolves with effervescence in acids. Composition: carbonic acid 35·2, oxide of zinc 64·8. These minerals are frequently found intermixed. They constitute (with Red Zinc Ore) the essential "ores" of Zinc, properly so-called. See the remarks under *Zinc Blende*, *B* 3, (page 182) above.

C 3. *Fusible. Not yielding water in the bulb-tube.*

Garnet:—Colour, chiefly red of various shades, but also black, brown, green (both dark and pale,) yellow, and even white. Commonly in crystals (rhombic dodecahedrons and trapezohedrons, figs. 35 and 36); otherwise in granular and rounded masses, or amorphous, with lamellar structure. H. 6·5–7·5; sp. gr. 3·5–4·2. More or less easily fusible, the dark specimens yielding a magnetic bead. Composition, essentially silica and alumina, (or silica, alumina and sesquioxide of iron,) with either lime, or magnesia, or protoxide of iron or manganese, or several of these bases combined. (See a very complete series of analyses in Dana's "System of Mineralogy," vol. 2, pages 191–2.) Garnets are of comparatively common occurrence in the gneissoid rocks of the Laurentian formation, more especially in contact with beds of crystalline limestone. The mineral thus occurs in bands of gneiss properly so-called, quartz, hornblende rock, &c., along or near to the edges of the limestone beds in very many localities, although it is found also in various places more or less remote from these beds. Briefly, amongst other Laurentian localities of Garnet, we may mention the following:—Various spots along the Muskoka river, as the Lake of Bays, &c.; the townships of Marmora and Elzevir, Hastings County, C. W.; Barrie and other townships in Frontenac County, C.W.; Hull, Ottawa County, C. E.; Chatham, Chatham Gore, and Grenville townships (dark red and hyacinth-red varieties) in Argenteuil County, C. E; the parish of St. Jérome in Terrebonne County, C. E.; Rawdon township, Montcalm County, C. E.; Hunterstown, Maskinonge County, C. E.; &c. In some of these localities, (St. Jérome especially, see Sir William Logan's Report for 1853) the garnets are sufficiently abundant to be available as a polishing material in place of emery. Amongst the altered strata south of the St. Lawrence, Mr. Hunt has discovered certain white or light-coloured beds which exhibit the composition of a lime garnet. In the township of Oxford, one of these consists

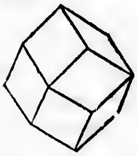

Fig. 35.

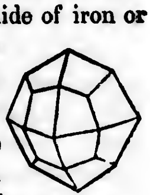

Fig. 36.

of irregular rounded masses of white garnet.—H. 7·0 ; sp. gr. 3·536 —associated with serpentine; and at the Falls of the River Guillaume in Beauce County, the same substance forms a compact homogeneous rock (See Mr. Hunt's Report for 1856.)

Idocrase.—This mineral is identical with *Garnet* in composition and general characters, but differs in crystallization. It occurs in modified square-based prisms and pyramids of the Dimetric system, at least when crystallized. In other respects it cannot be distinguished from garnet. Idocrase has been found, associated with crystalline limestone, in Clarendon township Frontenac county, C. W.; Calumet Island on the Ottawa; and Grenville township, Argenteuil County, C. E.

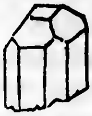

Fig. 37.

Tourmaline.—Of various colours, black, brown, yellow, green, blue, and pale red; sometimes colourless. The black variety is commonly known by the name of *Schorl.* Tourmaline occurs in modified three, six, nine, or twelve-sided prisms longitudinally striated, or in columnar or fibrous masses. The crystals are generally triangular on the cross fracture, owing to the predominance of three prismatic planes; and this character is usually sufficient to distinguish the mineral from other substances. H. 6·5–7·5 ; sp. gr. 3·0–3·3. The black, and most of the brown varieties fuse easily, the others, as a general rule, being either infusible, or fusible on the edges only. Tourmaline presents a somewhat complex composition, but its essential constituents comprise: silica, boracic acid, alumina (or alumina and sesqui-oxide of iron) with lime or magnesia, or one of the alkalies, or several of these bases combined. Fine examples of this mineral occur in connection with the crystalline limestones of the Laurentian rocks at Calumet Island on the Ottawa (greenish-yellow crystals); in the township of Fitzroy, Carleton County, C. W.; in Clarendon township, Frontenac County, C. W.; in the townships of Bathurst and Elmsley, Lanark County C. W.; in Hunterstown, Maskinongé County, C. E.; at St. Jérome, Terrebonne County, C. E; and other localities. In addition to the general triangular form of its crystals and columnar concretions, tourmaline may be distinguished from hornblende and other minerals of this section, by exhibiting electrical properties when heated. The clear varieties moreover, are

Fig. 38.

generally translucent when viewed transversely, and quite opaque when viewed longitudinally, even in the shortest fragments.

Sphene.—This mineral, as regards Canadian localities, occurs in small masses or little sharp-edged crystals of an amber-yellow colour in the crystalline limestones of the Laurentian series generally; and in the eruptive trap rocks of the eastern Province. H. 5·5; sp. gr. 3·4–3·6. Fusible on the edges with bubbling into a dark glass: Essential components: silica, titanic acid, and lime. Our best known localities comprise Grand Calumet Island on the Ottawa; Burgess township, Lanark County, C. W.; Grenville township in Argenteuil County (in crystalline limestone and also in trap); St. Jérome parish, in Terrebonne County, C. E.; and the eruptive rocks of Mount Johnson, Yamaska, &c., of the district of Montreal.

Epidote.—Chiefly in modified oblique prisms, and in fibrous and lamellar masses of a dark or light-green colour, passing into greenish-yellow, brown and grey. H. 6·0–7·0; sp. gr. 3·2–3·5, expands before the blowpipe into a slag-like mass, which melts upon its edges but resists further fusion. By this latter character it may be easily distinguished from hornblende, augite, idocrase, and other minerals of this section. Epidote occurs in many of our eruptive rocks, as in the greenstones of Lake Superior and the north shore of Lake Huron, and in some of the traps of Eastern Canada, although nowhere, apparently, in very prominent specimens. Mr. Murray, in his report for 1858, cites the east shore of Portage Harbour, Lake Huron, as a locality of this mineral.

Hornblende.—Dark or light-green, black, brownish, and sometimes light-grey or colourless. In prismatic crystals (of the Monoclinic System) figs. 39 and 40, or more frequently in amorphous masses of a fibrous or lamellar structure. The dark varieties are commonly known as *Hornblende* or *Amphibole;* the bright or light-green varieties, as *Actynolite*; and the greyish or colorless varieties, as *Tremolite,* H. 5·5–6·0; sp. gr. 3·0–3·4. Easily fusible, the dark specimens yielding magnetic beads. Composition: silica and magnesia, the latter in part replaced by protoxide of iron or lime; alumina being also sometimes present. This mineral forms one of the essential components of many

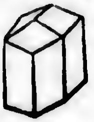
Fig. 39.

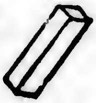
Fig. 40.

metamorphic and eruptive rocks. It thus occurs in syenitic gneiss, hornblende-slate, &c., throughout the large area occupied by the Laurentian strata, and in the intrusive syenites associated with these—as in the township of Grenville, Argenteuil county, C. E., and other localities. It occurs also in crystals and fibrous masses in the beds of crystalline limestone belonging to this series. Amongst other Laurentian localities, we may enumerate, Grand Calumet Island (Tremolite, &c.); Blasdell's Mills, river Gatineau; Grenville, &c.,—in Canada East; with the neighbourhood of Perth, &c., in Lanark County, C. W. (the acicular variety termed "Raphilite"); Elzevir township, Hastings County (dark-green, and in places, black fibrous masses which have been taken for coal); Barrie and other townships in Frontenac County; the Muskoka river, the Falls of the Madawaska, &c.,—in Canada West. In the more modern metamorphic district south of the St. Lawrence, hornblende occurs largely as a rock constituent, as in Beauce and other counties. Also in crystals and crystalline grains in the eruptive masses of Shefford, Belœil, &c., of that district.

Augite.—This mineral in colour and all general characters, as well as in composition and blowpipe comportment, closely resembles *Hornblende*. The crystals belong likewise to the Monoclinic Sytem, but differ in aspect, as shown by fig. 41, one of the most common combinations. The front prism-angle (and the angle of cleavage-masses) = 124°30′ in *hornblende*, and 87°5′ in *augite;* but some of the lightcoloured (*diopside*) crystals belonging to the latter, occur in flat rhombic prisms like fig 40 above, and give an angle of 141°21′*. Structure, lamellar or fibrous. H. 5·0–6·0; sp. gr. 3·2–3·5. Fusible, the dark varieties yielding magnetic globules. Composition, as in Hornblende: see above. The dark-green, black, and brown varieties commonly bear the name of *augite* (proper) or *pyroxene;* the clear green varieties, that of *sahlite;* and the white, greyish, or pale-green varieties, that of *diopside*—but many additional names have been bestowed on this mineral, in relation to locality, structure and other conditions. Both *hornblende* and *augite*, it should be remarked, offer a transition to

Fig. 41.

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* If we denote the first prism in augite by V, this latter prism = V½. It is the most common form of the diopside prisms imbedded in our crystalline limestone.

serpentine: one stage in this transition producing the peculiar varieties, *asbestus* and *amianthus*. These are chiefly of a light-green or white colour, fibrous, silky, and flexible—often to such an extent as to admit of being woven into cloth. *Diallage*, described below, appears to be a transitional form of this kind. Augite occurs in the bands of crystalline limestone—and in some places as a rock component, forming, in admixture with *Wollastonite*, distinct beds—interstratified with the gneissoid rocks of the Laurentian Series, as in the counties of Argenteuil, Terrebonne, &c. In Argenteuil county, a green, granular variety (*Coccolite*) is also found. This mineral occurs likewise in the metamorphic schists of the eastern townships, and in crystals and granular masses in the eruptive rocks of Montarville, Rougemont, &c., belonging to that section of the Province.

Hypersthene. Bronzite. Diallage.—These are generally regarded as varieties of Augite. They occur in cleavable masses of a pinchbeck-brown, green or greenish-grey colour, usually with a pseudo-metallic lustre. Sp. gr. 3·2–3·5. Fusible more or less readily, the dark varieties yielding a magnetic bead. *Diallage* is of low hardness, and it yields almost always a little water in the bulb-tube, and hence will be referred to amongst the minerals of *D* 4 and *D* 5 below. In composition, these minerals, like augite, are essentially silicates of magnesia (or of magnesia and protoxide of iron.) Hypersthene occurs in small quantities in the feldspar bands of the Laurentian strata, as in the counties of Terrebonne, Lanark, &c. Also in foliated masses in a mixed feldspathic rock, in the parish of Château-Richer, (Montmorency County,) below Quebec, (T. Sterry Hunt: Report for 1854.)

Wollastonite (*Tabular Spar.*)—White or light-grey, (rarely red or brownish.) Chiefly in tabular masses with fibrous structure. H. 5·0; sp. gr. 2·77–2·9. Fusible more or less easily. Composition: silica 52, lime 48. Found principally in the Laurentian limestones, as in the parish of St. Jérome, and in Morin township, Terrebonne County, C. E.; in Grenville township, Argenteuil County, and other localities. Wollastonite forms also, in union with augite, a distinct rock belonging to the Laurentian metamorphic series, (See the "*Esquisse géologique du Canada*," by Sir W. E. Logan and T. Sterry Hunt.)

Orthoclase or Potash Feldspar.—This mineral occurs in white, red, pink, light-green, and greyish cleavable masses, and in crystals (frequently twins,) of the Monoclinic System, figs. 42 and 43. The cleavage planes meet at an angle of 90°. H. 6·0; sp. gr. 2·5–2·6. Fusible with difficulty, although the edges of a thin splinter become easily rounded. By this character, as well as by its lamellar cleavable structure, feldspar may be readily distinguished from quartz. Composition, essentially: silica, 64·8; alumina, 18·4; potash, 16·8. Feldspar is one of the component minerals of granite, syenite, gneiss and other eruptive and crystalline rocks—and, as such, occurs abundantly throughout the area occupied by the Laurentian deposits; and also amongst the eruptive masses of the more modern metamorphic region, including the district of Montreal, &c. Amongst special localities, we may cite the following:—Lanark County, C. W., where the beautiful "avanturine" variety termed "Perthite," and green and other specimens, occur. Grenville, and Chatham, in Argenteuil County: red and other crystals in porphyritic trap. Chambly, in the County of that name: large yellowish-white crystals in porphyritic trap. The Yamaska Mountain; &c. Feldspar yields by decomposition a white clay or earthy mass termed "Kaolin" or "porcelain clay,' largely used in the arts.


Fig. 42.

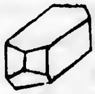
Fig 43.

Albite or *Soda Feldspar.*—This mineral closely resembles common feldspar in colour and general characters, but differs in belonging to the Triclinic System, and by containing soda in place of potash. Its cleavage planes do not meet at right angles, but at inclinations of 93° 36′ and 86° 24′. It enters generally into the composition of trap rocks, and replaces the orthoclase of some granites and syenites. In Lanark County, C. W., a beautiful iridescent variety, the so-called "*peristerite*," is met with.

Labradorite or *Lime Feldspar.*—Chiefly light or dark grey, greenish, or lavender-blue, with frequently a beautiful reflection of green, blue, orange, and other colours. Commonly in cleavable, lamellar masses, the cleavage planes (one of which is usually striated) meeting at angles of about 93½° and 86½°. H. 6·0; sp. gr. 2·67–2·77. Somewhat easily fusible in thin splinters. Composition: essentially—silica, alumina, and lime, with a portion of the latter replaced by soda. Labradorite (or a mixture of various triclinic feldspars,) forms one of the metamorphic rocks of the Laurentian series, interstratified with the gneissoid and other crystalline rocks of that age. Fine examples of the mineral occur in Lanark County, C. W.; and in St. Jérome, Morin, Abercrombie, and the seignory of Mille Isles, in Terrebonne County, C. E. Many of these examples are (externally) opaque-white, by weathering. Boulders containing opalescent feldspar masses, occur also abundantly in Grenville, &c., in the neighbouring County of Argenteuil.* Labradoritic rock occurs also in the parish of Château Richer in Montmorency County, C. E.; and opalescent specimens are cited from islands off the north-east shore of Lake Huron.

Note.—Mineralogists have established under the names of *Anorthite, Andesine, Oligoclase* &c., various additional species of lime feldspar. These are triclinic in crystallization, and more or less closely related. As a general rule, indeed, they are only to be distinguished by accurate chemical analysis. Practically, they may be classed with *Albite* or *Labradorite.* To Anorthite, the so-called *Bytownite* is referred. This is a greenish-white feldspathic mineral, found in boulders about Ottawa city. Another smoky or greenish-blue mineral, of a somewhat feldspathic character, from Perth, Canada West, is referred also to the same species.

Scapolite or *Wernerite.*—White, greenish, reddish, &c. Chiefly in lamellar and fibrous masses, and in crystals of the Dimetric System, of which an example is given in fig. 44. H. 5·5 (but much less in weathered specimens); sp. gr. 2·6–2·8. Easily fusible. Composition, essentially: silica 49, alumina 28, and lime 23, the latter in part replaced by a little soda. Scapolite occurs in the Laurentian limestone-bands, as in Calumet Island on the Ottawa; Grenville township, on that river, (Argenteuil County); Hunterstown in Maskinongé County, C. E.; and Golden Lake (with graphite, &c., Mr. Murray: Report for 1854) in Algona township, Renfrew County, C. W. A peculiar mineral, or rather rock, of a peach-blossom-red colour, occurring in Lanark County, C. W., and known as *Wilsonite,* (after Dr. James Wilson of Perth,) is an altered or semi-decomposed scapolite containing carbonate of lime and a little water.

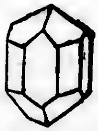
Fig. 44.

C 4.—*Fusible. Yielding water in the bulb-tube.*

Prehnite.—Green of various shades, generally pale, and sometimes colourless. Chiefly in botryoidal and globular masses with radiated-

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* A beautiful vase worked from one of these boulders may be seen in the Museum of the Geological Survey in Montreal.

fibrous structure; or in closely aggregated, flat, prismatic crystals belonging to the Trimetric System. H. 6–6·5; sp. gr. 2·8–3·0. Fuses easily, and with continued bubbling; and yields from 4 to 5 *per cent.* of water in the bulb-tube. Composition: silica, alumina, lime, and water. Prehnite occurs most commonly in association with trap rocks, and is occasionally found in the veins which traverse the Huronian formation on the north shores of Lakes Huron and Superior. On the south (and also on the north-west) shore of the latter lake, it occurs in great abundance, [illegible] associated with the native copper of that region. At Isle Royale, a beautiful variety occurs in small water-worn, nodular pieces of a rich green colour and radiated-fibrous structure. The fibres radiate from many central points, and these often consist of a nucleus of magnetic iron ore. This variety is commonly known by the name of Chlorastrolite (signifying green star-stone.) It is considered by some observers to be a distinct species, as its sp. gr. (2·98–3·20,) is somewhat higher, and its amount of water somewhat greater than that of prehnite. The former arises however from the intermixed iron ore (to the presence of which, also, the deeper colour is to be attributed,) and the latter I find to be exceedingly variable. Five specimens in selected fragments, yielded respectively the following per-centage of water;—4·86, 5·51, 4·11, 4·18, 4·60. Chlorastrolite forms, when polished, a handsome (though opaque) stone, fit for rings and brooches. In some directions, a slight chatoyance is observable.

Datolite.—Chiefly pale green or colourless, in botryoidal and fibrous masses, and in monoclinic crystals. H. 5·0–5·5; sp. gr. 2·95–3·0. Fusible with bubbling; imparting a greenish tint to the flame; and yielding in the bulb-tube about 5 or 6 per cent. of water. Composition: silica, boracic acid, lime and water. Occurs with prehnite, laumonte, &c., in association with the traps of the north shores of Lakes Huron and Superior. Fine crystals are found at Isle Royale, and on the south shore of Lake Superior, in the copper region.

Thomsonite.—Chiefly in white or light-coloured acicular crystals and fibrous masses, in (or connected with) the traps of Lakes Huron and Superior. H. 5·0–5·5; sp. gr. 2·3–2·4. Fusible, with previous intumescence. If free from weathering, in which case it will be translucent, it yields about 13 per cent. of water in the bulb-tube. Composition: silica, alumina, lime, soda, and water.

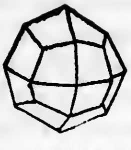

Fig. 46.

Analcime.—Chiefly in trapezohedrons (fig. 45,) of a white or greyish colour, associated with the traps of Michipicoten Island and the shores of Lakes Huron and Superior. H. 5·0–5 5; sp. gr. 2·0–2·1. Fusible quietly, *id est*, without intumescence or bubbling. Yields in the bulb-tube from 8 to 9 per cent. of water. Composition: essentially, silica, alumina, soda, water.

Apophyllite.—In lamellar masses and dimetric pyramidal crystals of a white or light colour, with pearly opalescence on the top or basal plane. H. 4·5–5·0; sp. gr. 2·32–2·37. Exfoliates before the blowpipe and fuses with bubbling. In the bulb-tube, yields about 16 per cent. of water. Composition: silica, lime, potash, and water. Found here and there in connection with the traps of Lakes Huron and Superior. Fine crystals come from the copper region of the south shore of the latter lake. Thomsonite, apophyllite, and other "zeolitic" minerals, occur also, it may be observed, both abundantly and in fine examples, in the trap rocks of Nova Scotia. These are sometimes red, greenish, &c., as well as colourless.

[*Wilsonite—Altered Scapolite.*—In columnar masses of a peach-blossom-red colour, from Lanark County, C. W. See under "Scapolite," *C* 3, above.

D. *Aspect Non-metallic (stony, glassy, etc.) Hardness insufficient to scratch glass.*

D 1. *Soluble (sapid) minerals.*

To this group, belong: Rock Salt, Sulphate of Iron or Green Vitriol, Sulphate of Copper or Blue Vitriol, Epsom Salt, and other soluble minerals, none of which have been discovered, as yet, in Canada. Rock Salt occurs in lamellar masses and in cubes, either colourless or coloured brown, red, etc. It has a strongly saline taste, and it is deliquescent. Green Vitriol occurs chiefly on decomposing iron-pyrites, in white or greenish crusts and acicular crystals. Blue Vitriol, as a blueish efflorescence or in crystalline groups on decomposing copper ores; and also in solution in mine waters, from which the copper may be precipated on pieces of iron. Both yield a strongly metallic taste.

D. 2. Taking fire when held in thin splinters in the flame of a candle.

The minerals belonging to this group admit of a natural subdivision into two sections, according to the following arrangement:—§ 1. *Burning with blue flame and odour of Sulphur or of Garlic:*—Native Sulphur, (aspect, resinous; yellow, sp. gr. about 2·0); Orpiment, (golden or lemon-yellow, paler in the streak, sp. gr. 3·4–3·5); Realgar, (red, with orange-yellow streak); Cinnabar or sulphide of Mercury, (red, with red streak; sp. gr., in pure specimens, 8·0–8·2). Orpiment and Realgar are compounds of sulphur and arsenic, and yield, when burning, an alliaceous or garlic-like odour. § 2. *Burning with yellowish flame and bituminous or resinous odour:*—Amber, and also the various kinds of Bituminous Coal, including Jet, with Brown Coal or Lignite, and Bitumen or Asphaltum, may be placed in this section. Of these minerals, two only have been met with in Canada: (1.) A kind of indurated bitumen, occurring in small, black, and more or less friable masses, in crevices in the Trenton Limestone and other fossiliferous rocks, sometimes filling, indeed, the interior of fossil shells, and much resembling coal in its general aspect; and, (2.) A dark variety of Petroleum, becoming viscous and even solid on continued exposure to the atmosphere. This latter substance, which occurs abundantly in springs and wells traversing the Devonian beds of Inniskillen, Mosa, &c., of the western peninsula of Canada, and which has also been discovered in Gaspé, will be noticed fully in its geological relations, under Part V., of the present Essay. The bituminous and more or less inflammable shales of these Devonian beds, and those belonging to the Utica Slate subdivision of the Lower Silurian series, will come under review, also, in the same place.

D. 3. Not exhibiting the reactions of D. 1 or D. 2. Streak coloured.

Earthy Manganese Ore:—Black or Brown; in earthy masses, which usually soil the hands. Streak, chiefly dark-brown, sometimes black. Infusible, yielding water in the bulb-tube. When fused with carbonate of soda, it forms a "turquoise enamel," blue whilst hot, and green when cold. Composition very variable, but essentially: hydrated sesquioxyd of manganese. Earthy or Bog Manganese Ore, sometimes called "Wad," occurs in the Eastern Townships of Bolton and Stanstead; in Aubert-Gallion, Tring, and Ste. Marie, in Beauce County; and at Ste. Anne, in Canada East.

Scaly Iron Ore (A variety of *Red Iron Ore*):—In glistening, red masses, of a scaly or laminar structure; streak, red. Soils the hands, more or less. Becomes magnetic before the blow-pipe. This variety of Red Iron Ore occurs in small quantities at many of the localities in which the latter mineral is found. See A. 4, (page 25). Some specimens have recently been sent to us from the back of Peterboro', Canada West.

Red Ochre (An earthy variety of *Red Iron Ore*):—Chiefly in amorphous masses of a dull red colour, with earthy aspect, red streak, and low degree of hardness; but sometimes occurring as a red powder. It leaves a red trace on paper. Blackens and becomes magnetic before the blow-pipe, or when held (in the form of a thin splinter) in the flame of a candle or ignited match. Red Ochre occurs at Point-du-Lac (St. Maurice County), St. Nicholas, Ste. Anne, and other localities in Eastern Canada, accompanying Bog Iron Ore and Yellow Ochre. With the latter, it is largely employed as a wash or paint for wood-work, and also in the preparation of various pigments.

Bog Iron Ore (A variety of *Brown Iron Ore*):—Chiefly in amorphous masses with sub-metallic aspect. Colour dark brown; streak, yellowish-brown. Gives off water in the bulb-tube, and becomes magnetic after ignition. For more complete description, see A. 4, (page 27.)

Yellow Ochre (An earthy variety of *Brown Iron Ore*):—In amorphous and earthy masses of a dull yellow colour and streak. Leaves a yellow trace on paper; gives off water in the bulb-tube, and becomes magnetic after ignition. Localities and uses, the same as those of Red Ochre, described above. Of the two ochres, however, the present is by far the more abundant, and is the principal basis of the pigments manufactured at Point-du-Lac, in St. Maurice County. Quite recently it has been found, in some abundance, in the County of Middlesex, C. W.

Humboltine, (Oxalate of Iron):—In yellowish crusts or thin layers in the bituminous shales (Devonian) of Kettle Point, Lake Huron, and the township of Inniskillen, Canada West. Streka, pale yellow or greyish. Turns black and red before the blow-pipe, and becomes magnetic. Yields about 16 per cent. of water in the bulb-tube.

Uran-Ochre, (Hydrated Oxide of Uranium):—In small earthy masses of a yellow colour, accompanying actynolite in the magnetic iron-ore of Madoc, C. W. Blackens before the blow-pipe, but does not fuse.

Vivianite or *Phosphate of Iron*:—In blue pulverulent masses, associated with bog iron ore in Vaudreuil County, on the St. Lawrence and Ottawa, C. E. Composition: phosphoric acid, protoxide of iron, and about 28 per cent. of water.

Malachite or *Green Carbonate of Copper*:—Chiefly in green masses of a fibrous or lamellar structure, sometimes with botryoidal surface and banded shades of colour. Otherwise, in earthy coatings on copper ores, &c. Streak, pale green. H. 3·5—4·0 (or less); sp. gr. 3·7—4·0. Yields water in the bulb-tube, and becomes reduced *per se* to metallic copper before the blow-pipe, tinging the flame green. Composition: carbonic acid, 20; oxide of copper, 72; water 8—the latter, however, usually somewhat higher. Malachite occurs in small quantities, with native silver, &c., in quartz and calc-spar at Prince's Mine, Spar Island, Lake Superior. Also occasionally, as an incrustation, amongst the copper ores of Lake Huron and those of the Eastern Townships. The blue carbonate, in an earthy state, is sometimes mixed with it.

The following minerals may also be referred to, in connexion with this group:—*Red Copper Ore* (sub-oxide of copper.) Red, with red streak; often in octahedrons and rhombic dodecahedrons, converted on the surface into green melachite; fusible and reducible *per se*, colouring the flame green.—*Black Oxide of Copper.* Chiefly in black, earthy, or amorphous masses, (or cubical crystals) from the south shore of Lake Superior. Blowpipe characters like those of red copper ore.—*Red Zinc Ore.* In granular or lamellar masses of a red colour, with orange-yellow streak. Lustre inclining to semi-metallic. H. 4·0–4·5. Quite infusible. Hitherto found only in New Jersey. Normal composition: Oxygen 19·75, zinc 80·25; but sesquioxide of manganese, to the amount of 3 or 4 per cent., is present, also, in most specimens.

D 4. *Streak, white. Anhydrous. Not yielding water in the bulb-tube.*

The Canadian minerals of this group may be conveniently arranged in several sections, as follows: § 1. YIELDING TO THE NAIL: *Mica* of different kinds; certain varieties of *Talc*; *Asbestus*.—§ 2. EFFERVESCING STRONGLY IN COLD HYDROCHLORIC ACID: *Calcite* or *Calc Spar*.—§ 3. EFFERVESCING FEEBLY IN COLD, BUT SENSIBLY IN HOT ACID: *Dolomite*, *Magnesite*.—§ 4. FUSIBLE: *Fluor Spar* (phosphoresces); *Heavy Spar* (colours flame pale green); *Celestine* (colours flame red). —INFUSIBLE: Light-coloured varieties of *Zinc Blende*.

§ 1. YIELDING TO THE NAIL.

Mica.—The term "mica" includes properly, a series of distinct though closely allied silicates, presenting equally a metallic-pearly lustre and a strongly-marked foliaceous or fissile structure, the thin, component laminæ of which are flexible and elastic. These distinct species being, however, in many instances, of very difficult separation—frequently requiring indeed, for that purpose, the aid of accurate chemical analysis, and minute optical and crystallographic investigation—they may be grouped together in an Essay like the present, more especially with regard to their geological bearings, and treated practically as one species. Thus considered, mica occurs in foliated and scaly masses, and occasionally in six-sided and rhombic prisms, of a white, brown, black, grey, green, red, or yellow colour, with pseudo-metallic or pearly aspect. The prisms are often tabular, as in figure 46. H. 1·0 on the faces or broad surfaces of the laminæ, and sometimes as high as 5·0 on the edges. Cleavage very strongly marked in one direction, so that by means of the finger-nail, or the point of a knife, leaves of extreme tenuity may be obtained. These are flexible and elastic. Sp. gr. 2·7—3·1. Some varieties are fusible; others become opaque before the blowpipe, but do not fuse. Common mica is essentially composed of silica, alumina, and potash; but other micas contain magnesia, oxides of iron, lithia, &c. Mica is a component of granite, of ordinary gneiss, mica slate, and other eruptive and metamorphic rocks, besides being of frequent occurrence in trachytes, lavas, &c. In Canada it occurs in more or less distinct specimens throughout the area occupied by our Laurentian rocks, and also in the metamorphic district of the Eastern Townships, both in the stratified-crystalline and in the trappean or trachytic rocks there present. In the crystalline limestone (Laurentian Series) of the township of Grenville, Argenteuil county, C.E., plates are obtained of sufficient size to be employed for stove-fronts, lanterns, &c. We possess some crystals of a yellowish-green colour, over half-an-inch in length, and perfectly translucent in a transverse direction or parallel with the cleavage-plane. They are imbedded in crystalline limestone and are said to have come from the Upper Ottawa. A lithia-containing mica, known as *Lepidolite*, in granular-scaly masses of a pink or reddish-grey colour, and pearly lustre, occurs in Maine, and elsewhere in the United States, but has not been found, as yet, in Canada. It fuses very easily and with continued bubbling, tinging the flame red.


Fig. 46.

Talc (certain varieties.)—In white or greenish foliated masses, somewhat unctuous to the touch, and yielding readily to the nail. Most varieties give off water when heated, and hence this mineral is described more fully under division *D* 5 below.

Asbestus.—In soft, fibrous, and more or less flexible masses, of a green, white, or other colour. Easily fusible. See under *Hornblende* and *Augite*, *C* 3, above. (Pages 42–44.)

§ 2. Effervescing strongly in Cold Acids.

Calcite or Calc Spar.—Of all colours—white, grey, yellow, black, &c., with white streak. Occurs in lamellar, fibrous, and granular masses, in stalactites, &c., and in crystals of the hexagonal system, some of which are shewn in the accompanying figures. Cleavage strongly marked in three directions, producing a rhombohedron of 105° 5′ and 74° 55′,—fig. 47 *a*. H. 3·0; sp. gr. 2·5—2·75. Infusible, but glows strongly before the blowpipe, and becomes caustic. Soluble with effervescence in acids. Composition: carbonic acid 44, lime 56; but a small portion of the carbonate of lime is generally replaced by carbonate of iron or magnesia. This substance, in the form of rock masses, (limestone, marble, &c.,) is perhaps the most abundantly distributed of all minerals, quartz only excepted. In Canada, in the crystalline limestones of the Laurentian Series, and in the vast calcareous deposits of the Huronian, Silurian, and Devonian formations, it occupies extended areas, although much concealed by the overlying clays and gravels of the Drift. Rhombohedrons, scalenohedrons, and other crystals are frequently met with in cracks and hollows in these limestone and other rocks.* Stalactitic masses are also found under similar conditions; and nodular concretions occur in the amygdaloidal traps of Lake Huron and Lake Superior. Fine crystallizations, also, amongst the copper deposits of these lakes. White and variously coloured marbles of much beauty are obtained from our Laurentian rocks, and from the more modern metamorphic series south of the St. Lawrence; but these, with the other economic limestones of Canada, will come under review in Part V. of this Essay. It should be observed, however, that many of our so-called

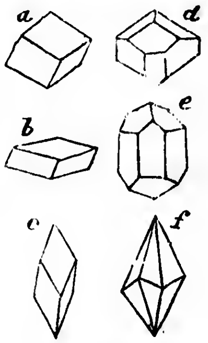

Fig. 47.

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* Whilst writing this description, for example, we have received some large crystals (combinations of a rhombohedron and two scalenohedrons) from a cavity in the Trenton limestone (Lower Silurian Series) of Huntingdon township, in the county of Hastings, C.W. The cavity contained an immense number of these crystals.

limestones are dolomites or dolomitic limestones, containing magnesia. See under *Dolomite* below.

NOTE.—Carbonate of lime is a dimorphous substance, occurring under two distinct series of crystal-forms: the crystallographic difference being accompanied, moreover, by a difference of hardness and other physical characters. It thus forms two distinct minerals: *Calc spar* and *Arragonite*. Whilst the former, or normal condition of carbonate of lime, is exceedingly abundant, the latter is comparatively rare. Arragonite crystallises in rhombic prisms and other trimetric combinations (the compounds of which often present a pseudo-hexagonal aspect) and also in fibrous, coralloidal and botryoidal masses. Small splinters, when heated, become immediately opaque, and crumble or decrepitate gently into powder, a peculiarity by which this mineral may be distinguished from calc spar. Fibrous arragonite appears to occur sparingly amongst the Lake Superior traps, and occasionally in thin coatings on the sides of cracks in some of our limestone rocks, but nowhere in very distinct specimens.

§ 3. EFFERVESCING IN HEATED HYDROCHLORIC ACID, BUT NOT AT ALL, OR ONLY FEEBLY, IN COLD ACIDS.

Dolomite.—White, grey, brown, &c., in lamellar and granular masses, and in rhombohedrons, closely resembling calc spar. H. 3·5–4·0; sp. gr. 2·8–2·95. Infusible, but becoming caustic after ignition. Effervesces feebly in cold, but vigorously in heated acids. Composition: carbonic acid, lime, and magnesia; or, carbonate of lime 54·35, carbonate of magnesia 45·65; a certain portion of the lime and magnesia being, however, generally replaced by protoxide of iron or manganese. Dolomite occurs (in small groups of rhombohedrons) amongst the copper ores of Lake Huron, and also in fissures and cavities in many of our limestone rocks, as at Niagara Falls and elsewhere. Many of our so-called limestones indeed, consist, in themselves, of dolomite, pure, or nearly so. Those of Galt, Guelph, &c., in Canada West, may be cited as examples. Others are dolomitic limestones, or mixtures of limestone and dolomite. Very few are wholly destitute of magnesia. Crystalline dolomite and dolomitic limestone, again, exactly resembling the ordinary crystalline limestones, occur in beds amongst the gneissoid rocks of the Laurentian Series, as at Lake Mazinaw, &c. These rocks come properly under discussion in PART V.

Magnesite.—White, grey, &c., in granular-crystalline masses and in rhombohedrons, much like those of calc spar and dolomite.* H.

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* In calc spar, the cleavage rhombohedron measures 105° 5′ over a polar edge; in dolomite, 106° 15′; and in magnesite 107° 29′. In carbonate of iron (a mineral also belonging, with

3·5–4·5; sp. gr. 2·8–3·0. Infusible, but becoming caustic after strong ignition. Composition: carbonic acid 52·5, magnesia 47.5; but most specimens contain a small amount of carbonate of iron, lime, &c. Magnesia does not efferversce in cold hydrochloric or nitric acid, and dissolves but slowly in these acids under the aid of heat. In Canada, this mineral occurs in beds amongst the altered Silurian strata of Bolton and Sutton townships, in Canada East. (See analyses by T. Sterry Hunt in the Geological Report for 1856.)

§ 4. Fusible.

Fluor Spar.—Chiefly in cubes, either simple, or modified on the edges and angles (Fig. 48, *a* to *c*). These cubical crystals break readily at the corners, owing to their strongly-pronounced octahedral cleavage, and the regular octahedron (Fig 48 *d*) may thus be obtained from them. Specimens occur of all colours, but chiefly, dark violet-blue, lilac, yellow, green, white, and grey: the edges of the crystals being often of a deeper or lighter shade, or even of a different colour, from the central parts. Streak, white. H. 4·0; sp. gr. 3·1–3·2. Fusible before the blowpipe into a white enamel, but most specimens decrepitate on the first application of the flame. —(See Part I., pages 17–18). When crushed to a coarse powder and gently heated, a greenish or other coloured phosphorescence is usually exhibited. Composition: fluorine 48·7, calcium (the metallic base of lime) 51·3. Fluor spar occurs in some of the crystalline limestones of our Laurentian rocks; and here and there in the metalliferous veins of the Huronian formation; also, in small cavities in the limestones of the Silurian series. The best known localities comprise Fluor Island in Prince's Bay, on the north shore of Lake Superior, where fine green crystals occur; Iron Island on Lake Nipissing, where blue crystals were discovered by Mr. Murray*; the township of Ross in Renfrew County, on the Ottawa;

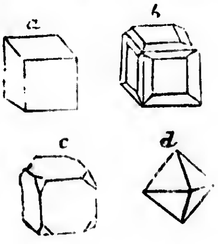

Fig. 48.

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carbonate of manganese, carbonate of zinc, &c., to the natural group of Rhombohedral Carbonates), the same angle equals 107°.

[*] See *Canadian Journal*, Vol. III, New Series, p. 325. Also Geological Report for 1854. The crystals occur in crevices and fissures of a cavernous limestone associated with specular iron ore.

the Niagara limestone about the Falls, &c. In Europe, fluor spar occurs, more especially, in association with lead, tin, and silver ores, in metallic veins.

Heavy Spar or *Sulphate of Baryta.*—White, grey, yellow, reddish, etc., with white or uncoloured streak. In lamellar, laminar, and fibrous masses; and also in trimetric crystals, of which a common example is given in figure 49. H. 3·0–3·5; sp. gr. 4·3-4·7. Decrepitates (in general) before the blowpipe, (see PART I., pages 17–18), and fuses into a white enamel, tinging the point of the flame pale green. This latter character is well-marked, and serves to distinguish, very readily, small pieces of heavy spar from other minerals of a similar aspect. With carbonate of soda in the yellow flame, it forms an alkaline sulphide, which imparts, when moistened, a dark stain to silver.* Composition: sulphuric acid 34·33, baryta 65.67. This mineral occurs abundantly in many parts of Canada. In the Laurentian series of metamorphic strata, it forms considerable veins, usually accompanying galena: as in the townships of Lansdowne, Leeds Co., C. W.; Bathurst, Lanark Co.; McNab, Renfrew Co.; Dummer, Peterboro' Co.; and elsewhere. Red crystals were discovered by Mr. Murray on Iron Island, Lake Nipissing. It occurs likewise, in connection with the trap dykes of Lake Superior and the north shore of Lake Huron, as at Spar Island, &c., besides being found in some of the copper-ore veins of the Bruce mines. Heavy spar has also been met with in the serpentines and other rocks of the eastern metamorphic region, south of the St. Lawrence; and occasionally in cavities in the Niagara limestones of the west. It is employed somewhat largely in the manufacture of paints, and is too often used in this connection as a fraudulent substitute for white lead. Heavy spar is also the principal source of the baryta salts of the laboratory.

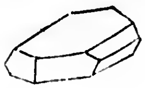

Fig. 49.

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* To detect sulphur, in any form in mineral bodies, fuse a small quantity of the substance under examination, with carb. soda and a very little borax, on charcoal, in a good reducing flame. Detach the fused mass, moisten it, and place it on a piece of bright silver, or on lead test-paper. (A coin or glazed visiting-card may be substituted for the purpose.) If sulphur be present, a yellowish, brown, or black stain will result. See *Canadian Journal*, New Series, Vol. III., p. 217-18. Both sulphate of baryta and sulphate of strontia dissolve readily in carbonate of soda before the blowpipe, resembling, in this respect, alkaline sulphates. Sulphate of lime (with all lime salts) on the other hand, requires the addition of a little borax to promote solubility.

Celestine or *Sulphate of Strontia*:—White, grey, pale-blue, &c. In lamellar and fibrous masses, and in Trimetric crystals, often closely resembling those of Heavy Spar. A common combination is shewn in Figure 50. H. 3·0-3·5; sp. gr. 3·9–4·0. Before the blow-pipe, it (generally) decrepitates, fuses, and imparts a red coloration to the point of the flame. (See also the note under *Heavy Spar.*) Composition: sulphuric acid 43·6, strontia 54·4. Celestine occurs with small crystals of dolomite, gypsum, fluorspar, blende, and other minerals, in cavities of the Niagara limestone, as in the district around the Falls, and in the vicinity of Owen Sound, &c. Drummond's Island, Lake Huron, is likewise a noted locality of this mineral. It occurs also, occasionally, in crystalline limestone, as in the neighbourhood of Kingston. Celestine is the chief source of strontia salts, used in pyrotechny to impart a red colour to rockets and signal lights, and for laboratory purposes.

Fig. 50.

§ 5. INFUSIBLE.

Zinc Blende (Sulphide of Zinc):—This mineral has been already described under sub-division *B* 3, (page 33,) but it is mentioned again in this place, as some of the light-coloured varieties present a vitreo-resinous or other non-metallic lustre. These are chiefly light brown or yellow, with colourless or very pale-brown streak. H. 3·5–4·0. Infusible. Sometimes phosphorescent when rubbed or scratched. Small bright-yellow crystals and crystalline masses occur sparingly in cavities and fissures of the Niagara limestone in the vicinity of the Falls. For other localities, &c., see *B* 3, above.

D 5. *Streak, white. Yielding water in the bulb-tube.*

The minerals of this sub-division (many of which, however, are merely altered varieties of other species) may be conveniently grouped in three sections, as follows: § 1. YIELDING TRACES ONLY, OR A VERY SMALL AMOUNT OF WATER: *Mica*, (some few varieties): *Talc*, (including *Steatite*); *Renselaerite*; *Diallage*. § 2. YIELDING A CONSIDERABLE AMOUNT OF WATER; SLOWLY DISSOLVED BY BORAX BEFORE THE BLOWPIPE: *Serpentine*; *Chlorite*; *Loganite*; *Pholerite*. § 3. YIELDING A LARGE AMOUNT OF WATER: READILY DISSOLVED BY BORAX BEFORE THE BLOWPIPE, THE BEAD, WHEN SATURATED, BECOMING OPAQUE: *Gypsum*.

Mica:—In foliated masses, &c., with pearly pseudo-metallic lustre. Normally, anhydrous,—but specimens occasionally yield a little water when heated in the bulb-tube. See sub-division *D* 4 (§ 1) above.

Talc; (including *Steatite*):—Greenish-white, green, greyish, &c. In foliated, and also in compact masses, which feel more or less greasy, and which yield to the nail; sp. gr. 2·55–2·8. Very sectile. Flexible in thin foliæ, but not elastic. Infusible. Composition: silica 62, magnesia 33, water 5. Talc occurs in the form of talcose slate, in foliated masses, and more especially in the form of steatite or compact talc, principally amongst the metamorphic rocks of the more modern series, south of the St. Lawrence. Under the latter condition, or that of steatite, it forms extensive beds in the townships of Potton, Sutton, Bolton, Stanstead, Leeds, Ireland, Broughton, &c., throughout this region. It occurs also, though far less abundantly, amongst the older metamorphic rocks of the Laurentian series, as in the townships of Marmora, Elzevir, &c., in Canada West. It is used as a fire-brick or refractory stone, and also as a coarse paint or wash.

Renselaerite (a variety of *Steatite*, or *Altered Augite*):—Greenish-white, brownish, &c.; in granular and compact masses much resembling steatite, and in pseudo morphous crystals after augite. H. 2·5–4·0; sp. gr. about 2·7–2·8. Very sectile. Lustre, somewhat waxy. Infusible, yielding about 4 or 5 per cent. of water in the bulb-tube. Composition: silica, magnesia, and water. Renselaerite cannot be regarded as a distinct mineral species. The crystals are evidently augite pseudomorphs, and the substance agrees essentially in composition with steatite. It occurs in beds associated with the crystalline limestones of the Laurentian rocks, as in the township of Grenville, Argenteuil County, C. E. Also in the townships of Ramsey, Rawdon and Lansdown. In Grenville, it contains (in fissures) a soft, yellowish-white, and earthy variety of serpentine (— *aphrodite*.)

Diallage:—This substance is generally regarded as a variety of Augite. (See *C* 3, above, page 43.) Normally, it is anhydrous; but it is frequently more or less altered, and contains 3 or 4 per cent. of water. It forms lamellar or foliated masses, chiefly of a green or greenish-grey colour H., sometimes, 5·0, but usually rather less; sp. gr. 3·0 to 3·1. Fusible into a greyish slag, though not easily. Canadian specimens give off a little water in the bulb-tube, and become in general red or reddish-brown. A variety from the township of Oxford, analysed by Mr. Sterry Hunt, contained: silica 47·20, magnesia 24·53, protoxide of iron 8·91, alumina 3·40, lime 11·36, water 5·80; with traces of the oxides of nickel and chemium. Occurs chiefly in the altered strata of the Eastern Townships, as in Oxford, Ham, and elsewhere, associated with serpentine, chromic iron ore, &c.

§ 2. YIELDING A CONSIDERABLE QUANTITY OF WATER IN THE BULB-TUBE. SLOWLY SOLUBLE IN BORAX BEFORE THE BLOWPIPE.

Serpentine, (including ***Retinalite***, ***Picrolite***, ***Chrysotile***, *&c.*) :—This substance occurs chiefly in amorphous or rock masses of a green, red, brown, bluish-grey, yellowish, or other colour, frequently veined or mottled. Also, occasionally, in small granular and fibrous masses, the latter sometimes producing a ***serpentine-asbestus***. Lustre, usually somewhat waxy. H, in general, about 3·0; sometimes 4·0–5·0. Very sectile, sp. gr. 2·2–2·6. Some of the fibrous varieties fuse on the edges, the others are infusible. All yield water (and harden) in the bulb-tube. Composition, essentially: silica, magnesia, and about 12 to 15 per cent. of water. Serpentine occurs in association with the crystalline limestones of the Laurentian rocks, as in the township of Grenville, Argenteuil county, C.E., where it occurs in disseminated grains; Calumet Island on the Ottawa; the township of Burgess, Lanark County, C.W.; Marmora and adjacent townships, with magnetic iron ore; and in other places where these rocks prevail. It is met with, however, far more extensively amongst the altered Silurian strata of the Eastern Townships, both alone, and forming, in some localities, especially in the townships of Oxford and Broughton, serpentine marbles of great beauty. Fine varieties of green serpentine occur about Brompton lake, in the former of these townships. A tough, fibrous variety occurs in Bolton township, Brome County. In Bolton and Ham also, serpentine rock, carrying thin beds of chromic iron ore, is met with; and in the county of Beauce, this rock contains a bed of mixed magnetic and titaniferous ore, fifty feet in thickness. To these localities must be added Mount Albert in Gaspé, where, as described by Mr. Richardson of the Geological Survey of Canada, an inexhaustible supply of green, brown, and variously striped and mottled serpentine, capable of economic employment, occurs in association with chromic iron. In its rock relations, serpentine will be discussed more fully in a succeeding part of this Essay.

Chlorite.—This mineral occurs chiefly in foliated, scaly, and granular masses of a dark green colour; or in greenish-grey slaty beds, forming the so-called *potstone*, a name also sometimes applied to varieties of steatite. H. 2·0—2·5; sectile; sp. gr. 2·6—2·8. Fusible (or fusible on the edges only, in some varieties,) and yielding water in the bulb-tube. Composition, essentially: silica 32·5, alumina 18·5, magnesia 36, water 13: hence, the chloritic potstones differ from the workable steatites in containing alumina as an essential constituent. In union with quartz, forming chlorite slate, this mineral is of common occurrence amongst metamorphic strata. In Canada, it occurs chiefly in the altered rocks of the Eastern townships, associated with magnetic and specular iron ores, sphene, &c., and with beds of dolomite. In this region, as in the townships of Potton, Bolton, &c., it is met with also in thick beds of a slaty or more or less compact structure, forming an aluminous potstone of good workable quality. Chloritic schists, probably of Huronian age, occur likewise, according to Sir William Logan, in great force in the valley of Lake Temiscaming, within the northern geological-basin of Canada. (See Part V. of this Essay.)

Loganite.—This substance named by Mr. Sterry Hunt, in honour of the Director of the Geological Survey of Canada, is a very doubtful species. It occurs in subresinous brownish masses, and in apparently pseudomorphous crystals (after Hornblende? Dana,) in the crystalline limestone of Calumet Island on the Ottawa. H, 3·0; sp. gr. about 2·6. Composition, according to the analysis of T. Sterry Hunt: Silica 32·49, alumina 13·18, sesqui-oxide of iron 2·14, magnesia 35.77, lime 0·95, water (and carbonic acid) 16·92. Dana places it under Pyrosclerite, a mineral closely related to Chlorite, if, indeed, truly separable from that species.

Pholerite.—The substance thus named, is usually looked upon as a product of alteration, arising from the decomposition of one of the feldspar species, (see *C.* 3, above: page 45,) or, more directly, from the alteration of clay-slate.—Under this view, it is a kind of *Kaolin*, with which substance it agrees in general composition. It presents, however, peculiar physical characters, much resembling those of talc, a mineral with which it is often confounded. Pholerite occurs in soft, unctuous, and scaly masses of a pearly aspect, and of a white or pale greenish or yellowish colour. Sp. gr. 2·3—2·6. Before the blowpipe, it exfoliates and curls up, but remains infusible. It consists essentially, of silica, alumina, and water: the latter varying from 13 to 15 per cent. Nacreous scales of this mineral occur, in fissures, in sandstone strata of Silurian age, near the Chaudière Falls in Canada East; and many of the altered slates of the adjoining metamorphic region appear to owe their talcose aspect to its presence, or to that of closely related non-magnesian silicates of more or less indefinite composition.

§ 3. YIELDING A LARGE AMOUNT OF WATER. READILY DISSOLVED BY BORAX BEFORE THE BLOWPIPE: THE BEAD, WHEN SATURATED, BECOMING OPAQUE.*

Fig. 50.

Gypsum.—(Hydrous Sulphate of lime.)—This important mineral occurs chiefly in lamellar, fibrous, and granular masses, of a white, grey, yellowish, or other colour, and also in crystals of the Monoclinic System, a common example of which is shown in the margin: fig. 50. Lustre often pearly. H=1·5—2·0, (and thus, all specimens of gypsum may be scratched by the nail,) Sp. gr. 2.25—2·35. Sectile; and, in thin lamellæ, somewhat flexible. Yields a large quantity of water in the bulb-tube; becomes opaque in the flame of a candle; and exfoliates and fuses before the blowpipe, into a white enamel. Composition: sulphuric acid 46·51, lime 32·56, water 20·93. The transparent cleavable varieties are often called "selenite," and the fibrous and fine granular varieties are known by lapidaries as "satin spar," and "alabaster,"--names, however, sometimes applied to varieties of calc spar. Gypsum, when deprived of its water by a low heat, forms the well known *plaster of Paris.* In Western Canada, this most useful mineral occurs abundantly in the Gypsiferous or Onondaga Salt Group of the Upper Silurian Series (see Part V. of this Essay): as in the townships of Dumfries, Brantford, Oneida, Seneca, and Cayuga, more especially, along the valley of the Grand River. The gypsum does not occur in beds, properly so-called, but in vast irregular masses, supposed by Mr. Sterry Hunt, (*Comptes Rendus*, 1855, and *Esquisse géologique du Canada,*) to arise from the action, on the surrounding limestone strata, of springs containing free sulphuric acid. In these localities the gypsum is more or less mixed with carbonate of lime. Fibrous and other varieties occur also in the vicinity of Owen Sound, and throughout the tract of country, generally, between the eastern extremity of Lake Erie and the mouth of the Saugeen. Likewise, here and there, in small cavities and fissures in the Niagara limestone and older rocks.

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* The same result is produced with a moderate amount of the assay substance, when the bead is exposed to the action of an intermittent flame: a process technically termed "flaming."

APPENDIX.

A Classified List of the Canadian Minerals described above.

In this list, which is intended to serve as a kind of Index to the minerals described in the present Part of our Essay, each substance will be found arranged under the chemical sub-division to which it belongs. The letters and numerals within brackets, refer to the groups and sub-groups of the Arrangement adopted above.

1. *Simple Substances.*

Native Gold, (*B.* 1.) Native Platinum and Osmium-Iridium, (*B.* 1.) Native Silver, (*B.* 1.) Native Copper, (*B.* 1.) Graphite, (*B.* 2.)

2. ***Arsenides*** and ***Sulphides,*** (Combinations of arsenic, or sulphur, with metallic bases.)

Arsenical Nickel, (*A.* 2.) Sulphide of Silver, (*B.* 1.) Galena or Sulphide of lead, (*B.* 3.) Sulphide of Copper, (*B.* 3.) Purple Copper Pyrites, (*B.* 3.) Copper Pyrites, (*B.* 3.) Zinc Blende, (B. 3, and *D.* 4.) Molybdenite, (*B.* 2.) Magnetic Pyrites, (*B.* 3.) Iron Pyrites, (*A.* 1.) Arsenical Pyrites, (*A.* 3.)

3. *Oxides of Iron, Manganese, &c.*

Specular or Red Iron Ore, (*A* 4, and *D* 3.) Ilmenite (*A* 4.) Brown Iron Ore (*A* 4, and *D* 3.) Magnetic Iron Ore (*A* 4, and *C* 1.) Iserine (*A* 4.) Chromic Iron Ore (*A* 4, and *C* 1.) Earthy Manganese Ore (*D* 3.) Uran Ochre (*D* 3.)

4. *Alumina* and *Aluminates.*

Corundum (*C* 1.) Spinel (*C* 1.)

5. *Silica* and *Silicates**.

Quartz (*C* 1.) Zircon (*C* 1.) Andalusite (*C* 1.) Cyanite (*C* 1.) Staurolite (*C* 1.) Garnet (*C* 3.) Idocrase (*C* 3.) Epidote (*C* 3.) Mica (*D* 4.) Tourmaline (*C* 3.) Chondrodite (*C* 2.) Olivine (*C* 2.)

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* Keeping in view the popular and explanatory character of this Essay, it may not be inappropriate to observe that the term "Silicate" signifies a combination of silica or silicic acid with one or more oxidized bases, such as a lime, magnesia, oxide of iron, alumina, &c. In like manner (to cite a few more examples of this nomenclature.) a "carbonate" is a combination of carbonic acid.—a "phosphate," of phosphoric acid,—a "sulphate," of sulphuric acid—with one or several of these oxides. Thus, *Gypsum*, consisting of sulphuric acid, lime, and water, is a hydrous sulphate of lime. The term "sulphide," or "sulphuret on the other hand, denotes a compound of sulphur with some simple substance, as lead, copper, iron, &c., or with several of these.

Hornblende, Actynolite, Tremolite (*C* 3.) Augite, Diopside, Asbestus (*C* 3, and *D* 4.) Hypersthene, Bronzite (*C* 3.) Diallage (*C* 3, and *D* 5.) Wollastonite or Tabular Spar (*C* 3.) Talc (*D* 5.) [Renselaerite (*D* 5.)] Serpentine (*D* 5.) Chlorite (*D* 5.) [Loganite (*D* 5.)] Orthoclase or Potash Feldspar (*C* 3,) [Pholerite, Kaolin (*D* 5.)] Albite (*C* 3.) Labradorite (*C* 3.) Scapolite or Wernerite (*C* 3.) Prehnite (*C* 4.) Datolite (*C* 4.) Thomsonite (*C* 4.) Analcime (*C* 4.) Apophyllite (*C* 4.)

6. *Titanic acid and Titaniates.*

Rutile (*C* 1.) Sphene (*C* 3): usually regarded as a silico-titaniate of lime, but its true atomic constitution is still uncertain.

7. *Carbonates.*

Calcite or Calc Spar (*D* 4.) Dolomite (*D* 4.) Magnesite (*D* 4.) Arragonite (*D* 4.) Malachite and Blue Carbonate of Copper (*D* 3.)

8. *Sulphates.*

Barytine or Heavy Spar (*D* 4.) Celestine or Sulphate of Strontia (*D* 4.) Gypsum (*D* 5.) Epsom Salt (*see Supplement.*)

9. *Phosphates.*

Apatite or Phosphate of Lime (*C* 2.) Vivianite (*D* 3.)

10. *Fluorides.*

Fluor Spar (*D* 4.)

11 *Salts of Organic Origin.*

Humboldtine (*D* 3.)

12 *Bituminous substances.*

Asphaltum and Indurated Bitumen (*D* 2.)

CONCLUDING NOTE TO PART II.

The minerals of Canadian occurrence—including both the very rare and the doubtful species, such as native Platinum, occasionally found in small grains with the Native Gold of the Rivière du Loup; and the altered substances, Renselaerite Pholerite, &c.,—amount in number to about seventy. Many of these are of more or less local occurrence, but others, on the contrary, are comparatively common. These latter are collected together, and arranged in accordance with their more obvious characters, in the Table annexed to this Note. The less experienced reader, consequently, may avoid some trouble in the determination of an unknown mineral, by consulting this Table in the first instance. If the specimen under examination do not agree with the species here cited, the regular Table given at page 21, can then be referred to. In case of agreement also, recourse may be had to the latter as a confirmatory test.

CANADIAN MINERALS OF MORE COMMON OCCURRENCE.

* *Aspect Metallic or Sub-Metallic.*

** *Hard enough to scratch glass.*

Brass-yellow :—*Iron Pyrites* (*A* 1.)
Steel-grey ; powder, reddish :—*Specular Iron Ore* (*A* 4.)
Iron-black ; powder, black ; magnetic :—*Magnetic Iron Ore* (*A* 4.)

*** *Too soft to scratch glass* :

Bronze-yellow ; slightly magnetic :—*Magnetic Pyrites* (*B* 3.)
Brass-yellow ; streak, greenish-black :—*Copper Pyrites* (*B* 3.)
Reddish, with blue tarnish ; streak, greyish-black :—*Purple Copper Pyrites* (*B* 3.)
Lead-grey ; breaking into rectangular fragments :—*Galena* (*B* 3.)
Lead-grey ; in soft scales ; marking :—*Molybdenite* (*B* 2.)
Black ; in soft scales ; marking :—*Graphite* (*B* 2.)
Lustre, metallic-pearly ; brown, silvery-white, etc. ; in scales or foliated masses with white streak :—*Mica* (*D* 4.)

† *Aspect, vitreous, stony, or earthy.*

†† *Hard enough to scratch glass.*

Colourless, amethystine, red, &c. ; No lamellar structure. Infusible :—*Quartz* (*C* 1.)
White, red, green, &c. ; Lamellar structure. Fusible on the edges :—*Feldspar* (Orthoclase *C* 3.)
Dark-red ; in 12-sided crystals, &c. Fusible :—*Garnet* (*C* 3.)
Black ; fibrous, or in triangular crystals. Fusible :—*Schorl* (*C* 3.)
Black or green, (sometimes colourless in crystalline limestone.) Fusible :—*Hornblende* and *Augite* (*C* 3.)

††† *Too soft to scratch glass.*

White, grey, &c. Effervescing strongly in acids :—*Calc Spar* (*D* 4.)
White, grey, brownish, &c. Effervescing feebly in acids :—*Dolomite* (*D* 4.)
White, blueish, &c. Fusible. Often accompanying Galena :—*Heavy Spar* (*D* 4.)
White, greenish, mottled, &c. Very soft. Infusible. Yielding water in bulb-tube :—*Steatite* (*D* 5.) Also *Serpentine* (*D* 5.)
White, &c. Very soft. Fusible. Yielding water in bulb-tube :—*Gypsum* (*D* 5.)
Brown. Streak, yellowish-brown. Magnetic after exposure to heat :—*Bog Iron Ore* (*D* 3.) Also *Yellow Ochre* (*D* 3.)
Red. Streak, red. Magnetic after ignition :—*Red Ochre* and *Scaly Iron Ore* (*D* 3.)

PART III.

HOW ROCKS ARE CLASSIFIED AND DISTINGUISHED: WITH SPECIAL REFERENCE TO THE ROCKS OF CANADA.

In different localities, as a general rule, different kinds of rock occur. This must be familiar to the most casual observer. Thus, around the Falls of Niagara, and extending for miles across that section of the country, we find vast beds of limestone. About Hamilton, with other rocks, we have sandstone or freestone. At Toronto, our rock-masses consist of beds of clay and gravel, overlying grey and greenish shales. Near Collingwood, and again at Whitby, we observe dark-brown and highly bituminous shales, containing the impressions of trilobites in great numbers. At Kingston, we meet with limestone rocks differing from those at Niagara, and giving place, as we proceed north and east of the city, to beds of crystalline rock of granitic aspect, geologically known as Gneiss. Some of the "Thousand Islands" consist of a very ancient sandstone. At Montreal, again, together with limestone, &c., we find in the picturesque Mountain, a dark and massive (or unstratified) rock, termed Trap, and more or less closely allied to the lavas of volcanic districts. These examples, without proceeding further, are sufficient to shew the diversity which prevails with regard to the rock-matters of comparatively neighbouring localities. But if we look, not to the mineral characters of these and other rocks, but to their respective origins or modes of formation—as evidenced by what is now going on in Nature in different parts of the world—it will be found that they fall naturally into three groups, as follows:

Eruptive Rocks.
Metamorphic Rocks.
Sedimentary Rocks.

In each of the above groups, the included rocks are of various periods of formation, as explained in the Chronological Classification at the close of the present Part of our Essay. Before proceeding, however, to a discussion of this question, and in order more especially to prepare the general reader for a proper understanding of Part V, in which the geology of Canada first comes properly under review, it is necessary to consider these groups separately, and to enter into a few of their more practical details.

ERUPTIVE ROCKS.

The rocks of this division are of Igneous or of Aqueo-Igneous origin. That is to say, their present form is due to solidification from a fluid or plastic condition brought about by the agency of heat, assisted, in most (if not in all) cases, by that of steam or heated water. They have been formed beneath the earth's surface (whence the term "Endogenous" applied to them by Humboldt), and they have been driven up or erupted, at various geological epochs, through cracks and fissures in the overlying rocks. They are distinguished by never occurring in true strata, but always in the form of irregular, protruded masses, which sometimes present a columnar structure, or in that of broad overlying or intercalated sheets, or in straight veins called "dykes" (see further on), or in ordinary tortuous veins. Secondly, by never exhibiting in their structure the marks of a sedimentary origin, such as rolled stones, grains of sand, &c. And, thirdly, by never containing organic remains.

Where eruptive rocks traverse or lie in contact with other formations, these latter are usually found to be more or less altered, as though by the agency of heat, near the points of contact. Coal-beds are thus for some distance often burnt into cinder or converted into coke; soft limestones changed into crystalline marbles; sandstones altered in colour, hardened, and changed into quartz-rock, and so forth.

These rocks are arranged by Sir Charles Lyell in two broad divisions: Volcanic and Plutonic rocks; but it is impossible to draw a distinct line of demarcation between the two. Granite and syenite, for example, belong to the Plutonic series; but certain granitic trachytes connect the granites with the volcanic rocks; and in like manner, certain greenstones merge on the one hand into syenite, and on the other (the distinction between augite and hornblende being now essentially broken down) into augitic lavas. This equally affects the sub-division into Volcanic, Trappean, and Granitic rocks, adopted by other observers. I would therefore propose, as an arrangement of convenience, the distribution of the Eruptive rocks into the six following groups:—1. Lavas; 2. Obsidians; 3. Trachytes; 4. Traps and Greenstones; 5. Serpentines; 6. Granites. On each of these it is necessary to make a few observations.

1. *Lavas.*—These comprise the actual rock-matters which issue in a molten condition from volcanic vents. During the solidification of lava currents, dense volumes of steam are emitted from the cooling mass. Lavas are of two general kinds: feldspathic, and feldspatho-augitic. The first, and by far the more common of the two, are composed essentially of feldspar, and are mostly of a dark or light grey colour. They pass into trachytes. The second are composed essentially of feldspar and augite,* are dark green or almost black in colour, and undistinguishable, except by their actual conditions of occurrence, from many traps or basalts. As examples of these rocks are not found in Canada, we need not describe their varieties, or enter into further particulars respecting their conditions of occurrence.

2. *Obsidians.*—The rocks grouped under this division, are lavas, or other igneous products, in a vitreous or glassy state. They are entirely feldspathic in composition. When in connexion with volcanic cones, and of a grey, black, green, brown, or varied colour, and breaking into sharp-edged fragments, they constitute the variety properly called Obsidian. Pearlstone is a closely-related variety, containing small spherical concretions of a more or less pearly aspect. Another form, of a black, dull-red, green, or dark colour, and of a somewhat pitch-like aspect, is called Pitchstone or Retinite. This latter is stated by Sir. W. E. Logan to occur on the north shores of Lakes Huron and Superior. It should be observed, however, that the term Retinite is applied by some authors to a bituminous substance of a very different character.

3. *Trachytes.*—These rocks have normally a harsh, rough texture (whence their name from τραχυς), and a white or light colour; and they are either entirely or essentially feldspathic in composition. They offer three principal varieties, exclusive of Pumice, which may be placed either here or amongst the lavas. These varieties merge, however, into one another. They comprise: common Trachyte and compact Trachyte, composed normally of Orthoclase or potash feldspar, and Granitic Trachyte, a rock of a granitic structure, made up of orthoclase feldspar, with small crystals or grains of hornblende, augite, or mica. Common Trachyte occurs chiefly in active or extinct volcanic districts. It often contains crystals of glassy feldspar, and sometimes scales and crystals of mica, &c. Occasionally, also, free silica or

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* See descriptions of these minerals in Part II. of this Essay.

quartz is found in it, although accidentally, as it were, and only in small quantity. Compact Trachyte, or feldspar trap, as this variety has been termed, is found in broad straight veins or "dykes," of a white colour, traversing the Montreal mountain, and occurring also (of a pale-reddish colour) at Chambly, &c. Granitic Trachyte (in some instances closely resembling granite, but differing from that rock by the absence of quartz) forms the eruptive mountains of Brome, Shefford, Yamaska, Rougemont, Belœil, Mount Johnson, &c., of the Eastern Townships. These granitic trachytes (or granitic diorites, as they might be termed with equal justice, see below) differ a good deal in colour and appearance, according to the amount of hornblende, mica, &c., which they contain. Like the compact trachyte of Lachine and Chambly, they are sometimes "porphyritic" —containing more or less distinct and large crystals of feldspar. (See Mr. Hunt's Report for 1856, and that for 1858; also *Can. Journal*, Vol. V. page 426.) Many of the trachytes of these localities are in a partially altered state, effervescing in acids from the presence of carbonates. By weathering, also, they become reddish-brown, dull-white, &c., and tend to decompose into clay-stone or "Domite." This latter term is derived from the partially-decomposed trachytes of the Puy-de-Dôme, in central France.

4. *Traps and Greenstones.*—The rocks of this group chiefly affect the form of intrusive dykes (*i.e.* broad and more or less straight or simply-forking veins (as in fig. 52), or otherwise occur in overlying, intercalated, and irregular masses, which frequently present a columnar structure. The traps proper, or dolerites, are always of a black or dark colour, and consist essentially of a more or less uniform mixture of lime feldspar (or soda feldspar) and augite, with in general a mixture of zeolitic minerals and magnetic iron-ore. The green-stones or diorites, consist normally of soda feldspar (or of a feldspathic mixture) and hornblende, and have usually a more or less decided green colour. It is sometimes impossible, however, to distinguish greenstone from trap, more es-

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pecially as late researches have shewn that augite and hornblende possess the same atomic composition. Hence the two rocks should properly be classed together.

When the rock is of a black or dark colour, more or less compact, and amorphous in form, it is termed *Trap.* This variety occurs in numerous dykes on the north shore of Lake Huron and on the shores of Lake Superior. When a trap-rock contains distinctly imbedded crystals of any mineral distributed through its mass, the name of this mineral may be conveniently attached to it. Thus, the Montreal mountain consists principally of *Augitic Trap.* The same variety, containing olivine[*] in addition, forms the mountains of Montarville and Rougemont. When the rock assumes a columnar or basaltiform structure, it becomes *Basalt.* This variety does not appear to be common in Canada, but it occurs, here and there, on the north shore of Lake Superior, and probably in other parts of the Province. When, again, as frequently happens, a trap or basalt is of a more or less coarsely-vesicular structure, or contains oval or other shaped cavities usually filled with calc-spar, amethyst-quartz, agates, various zeolites, &c., the rock is called an *Amygdaloid,* or *Amygdaloidal Trap.* Numerous examples occur in the northern district of Lakes Huron and Superior; and the agates of Michipicoten Island and other localities of this region, are derived from the disintegration and washing away of the amygdaloidal traps in which they were originally enclosed.

The greenstones, or diorites, occur under the same conditions as the traps. Compact and amygdaloidal varieties are common about Lake Huron, &c.; and Sir William Logan, in his Report for 1853, has described the occurrence of a columnar greenstone in the Township of Grenville, Argenteuil Co., C. E. In some greenstones, the component minerals, feldspar and hornblende, become individually perceptible. This variety might be called, indifferently, a granitic trachyte, or a granitic diorite, and placed in either of these groups.[†] A latitude of this kind, in the classification of these eruptive rocks,

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[*] The student should refer to the descriptions of these minerals in the preceding Part of this Essay. See the Index, pages 62-3, above.

[†] If minute distinctions be advisable, the term *granitic trachyte* might be restricted to such of these rocks as contain orthoclase or potash feldspar, whilst those in which triclinic feldspars are present might be called granitic diorites; but it is not always possible to carry out these distinctions.

is unavoidable. Their frequent transitions and irregularities of composition, render the drawing of very definite lines a complete impossibility. For this reason, the attempt to frame a number of so-called species out of the trappean and other eruptive rocks, and to bestow upon these distinct names, becomes both useless and unphilosophical.

Finally, it may be observed, that many varieties of trap and greenstone are very subject to decomposition, yielding soils of much fertility. By weathering, they become mostly dull-grey, brown, or red.

5. *Serpentines.*—The rocks of this series are essentially hydrated silicates of magnesia. They consist, strictly, of varieties of one mineral substance, *serpentine*. (See above, p. 59.) Their colour is somewhat variable, but chiefly green, brown, reddish, or greenish-grey—these tints frequently occurring together in veins and patches. They are more or less soft and sectile, and somewhat granular or compact in structure; forming dykes and irregular masses, although comparatively of rare occurrence as eruptive rocks. Most serpentines are found in large beds, and are evidently altered sedimentary deposits or metamorphic rocks, but undoubted instances of eruptive serpentines occur in Tuscany and elsewhere. In some cases, however, massive serpentines of this kind may have been derived from the alteration of trap and greenstone rocks. The serpentines which occur in Canada, are considered to belong entirely to the Metamorphic series, and are described, consequently, under that division.

6. *Granites.*—These rocks possess normally a crystalline aspect and strongly-marked granular structure, whence their name. They are also especially characterized by the presence of free silica, or quartz, as an essential component. They occur in irregular, unstratified masses (often breaking through and tilting up the surrounding rocks), or in tortuous branching veins. Some are of very ancient date; whilst others are of comparatively recent formation, at least in a geological point of view. Hence the obvious objections which apply to the use of the terms "Primary" or "Primitive," often bestowed indiscriminately on all granitic rocks, as well as on strata of metamorphic origin—these latter, like the granites, and all other rocks, indeed, being of various periods of formation. Under a subsequent section, it will be shewn that the age of a rock is in no way indicated by mineral characters or composition. Where two granitic

or other veins intersect, the intersected vein (which is generally displaced moreover, one portion being thrown up or down) will, of course, be the older of the two. In like manner, where a granitic or other eruptive rock underlies another rock of any kind, this latter will necessarily be the older of the two if veins pass into it, or if it be altered by chemical or mechanical action.

The more important rocks of this section, comprise granite and syenite.

Granite, properly so-called, is composed of three minerals: Quartz, Feldspar, and Mica, full descriptions of which are given in Part II. of this Essay. The quartz is colourless and vitreous; the feldspar, usually white or flesh-red, with smooth and somewhat pearly cleavage planes; the mica, white, grey, brown, black, or sometimes green, in scales, specks, or foliæ, of a pearly-metallic aspect. In the fine-grained granites, these component minerals become so intimately blended as to be individually undistinguishable. When crystals of feldspar are distinctly imbedded in a fine or coarse-grained granitic mass, a variety termed *Porphyry*, or better, *Porphyritic Granite*, is produced. The term "porphyry" (from πορφυρα) as the name would indicate, was originally applied to rocks of this kind in which the base or imbedded crystals were of a red colour; but it is now conventionally bestowed on all rocks containing distinct crystals of feldspar or other minerals. Thus, we have porphyritic granite, porphyritic trachyte, &c. Occasionally, the mica in granite is replaced by talc, giving rise to *Talcose Granite*. Sometimes, also, the mica dies out, when a granitic mixture of quartz and feldspar results. This has been called *Pegmatite*.

Examples of intrusive granite occur amongst the strata of the Laurentian and Huronian series in the Lake Superior region and on the north shore of Lake Huron, and elsewhere, but apparently in no very prominent masses; although veins composed of quartz and feldspar, or of quartz alone, are of exceedingly common occurrence throughout the entire area occupied by the gneissoid Laurentian rocks. Fig. 53 is a sketch of some quartzo-feldspathic veins in gneiss, near the right bank of the river Severn,

53.

C. W. In the more modern metamorphic district south of the St. Lawrence, however, granitic masses (which appear to pass into granitic trachytes or diorites) constitute the Megantic mountains, and occur also in force in Hereford, Stanstead, and other townships of that district. (The localities cited by Sir William Logan, in his *Esquisse Géologique du Canada*, comprise: Stanstead, Barnston, Hereford, Marston, Megantic Mountains, Weedon, Winslow, Stafford, and Lambton.)

Syenite.—This eruptive rock is composed of a granitic mixture of quartz, feldspar, and hornblende, the latter being green or black in colour. When mica is also present, the rock becomes *syenitic granite;* and when the quartz grows gradually less and less abundant, there is a transition into granitic diorite or greenstone. Some syenites are of a red colour from the prevalence of red feldspar, and many syenites are porphyritic. Intrusive syenite occurs amongst the Laurentian rocks in various localities. An enormous mass of this rock, covering an area of thirty square miles, is cited by Sir William Logan, as occurring in the townships of Grenville, Chatham, and Wentworth, in Argenteuil County, on the Ottawa.

Granitic rocks frequently become converted, by the decomposition of the feldspar, into white or light-coloured clays, largely used, under the name of *Kaolin*, in the manufacture of porcelain.

METAMORPHIC ROCKS.

The rocks thus named are *stratified rocks* of a more or less granitic, trappean, or crystalline aspect, and of various periods of formation. It has been already stated, that where a dyke, vein, or erupted mass of trap or granite traverses other rocks, these latter are very generally altered in character, and, to some extent, in composition. Earthy or common limestones are thus near the points of contact transformed, in some localities, into hard marbles or crystalline limestones, and are frequently filled with crystals of garnet, tourmaline, hornblende, and other minerals. In like manner, sandstones are changed in colour and texture, and are often converted into quartz-rock, whilst clay-slates are transformed into gneiss, mica-slate, talc-slate, and other so-called "crystalline schists." Although analogous effects are sometimes produced artificially in the walls of smelting furnaces, these metamorphic results, as seen in Nature, are probably due not so much to the simple agency of heat, as to that of various gases and heated vapours accompanying the protrusion of the eruptive mass. In many localities, on the other hand, these effects appear to have been produced without the direct intervention of eruptive rocks, in which case the alteration or metamorphism has probably proceeded from steam and gases transmitted from below, from heated chemical solutions percolating the altered rocks, or from other causes more or less immediately dependent on the presence of subterraneous heat. Be this as it may, it is now universally conceded that the crystalline stratified rocks are altered sedimentary deposits—sandstones, slates, limestones, and so forth. In Canada (as explained more fully in PART V.) there are two distinct series of metamorphic rocks. One, including the Laurentian and in part the Huronian series, belongs to the Azoic Age, and constitutes the most ancient group of rocks of this continent. The Laurentian series is made up of vast beds of gneiss, crystalline limestone, and other rocks described below, and it extends over almost the entire northern portion of the Province. For geographical limits, geological and other characters, see PART V. of this Essay. The Huronian rocks of the north shore of Lake Huron, &c., are also in part metamorphic, and include, amongst other more or less altered deposits, some remarkable quartz and jasper conglomerates. The other series of metamorphic strata are of more recent, although still of ancient, date. They belong to the Silurian and Devonian periods of the Palæozoic Age (see the close of this PART, and also PART V.), and they occur in the Eastern Townships and adjoining district south of the St. Lawrence. On the edge of this latter metamorphic region, the passage of the unaltered into the altered strata may be traced in many localities.

The following are the more important metamorphic rocks of Canadian occurrence:

Gneiss.—This crystalline rock only differs (lithologically) from granite and syenite by occurring in beds or strata. It is of two kinds: *micaceous or ordinary gneiss*, and *syenitic* or *hornblendic gneiss*. The former consists of quartz, feldspar, and mica; the latter, of quartz, feldspar, and hornblende. When the mica or the hornblende predominates, and the feldspar diminishes in quantity, these pass into mica slate and hornblende slate (or hornblende rock), respectively. Gneissoid rocks of this kind prevail everywhere amongst the Laurentian strata, and sometimes contain garnets and other minerals. They constitute, moreover, the greater number of the boulders scattered so abundantly over the surface of Canada (see PART V.) Gneiss may generally be distinguished from granite, even in hand specimens, by its striped or banded aspect, the colours being usually various shades of grey and red.

Mica Slate.—This rock consists normally of quartz and mica. It is more or less fissile or schistose, somewhat pearly or silvery in aspect, and usually of a white or greyish colour, though sometimes almost black. It passes into gneiss on the one hand, and into clay-slate on the other. It is often called *mica schist*. It occurs more or less, throughout the Laurentian formation (Lake Huron, north shore; French River; Baie St. Paul, &c.)

Feldspar Rock.—This is a mixture of various feldspars. It is usually of a greenish-blue or slightly-shaded white colour; or, otherwise, pale reddish, greenish, brownish-yellow, &c. Fine-grained and porphyritic varieties occur. In the latter, the enclosed, grey, cleaveable masses sometimes present the green and other reflections peculiar to the characteristic examples of labradorite. (See Part II.) At other times, these enclosed masses or crystals are of a red, lavender blue, or brownish colour. Hypersthene, also, in laminar masses of a brown sub-metallic tint, is frequently present, forming the variety sometimes called *Hypersthene Rock*. Mica, augite, garnet, titaniferous iron, and some other minerals, are likewise of occasional occurrence in these feldspathic beds. The Laurentian deposits of the counties of Montmorenci (below Quebec), Terrebonne, &c., afford good examples of Feldspar Rock. (See Analyses, &c., in Mr. Hunt's Report for 1854.)

Hornblende Rock.—This rock, frequently of a schistose structure, and then called "Hornblende Slate," or "Hornblende Schist," is normally a compound of quartz and hornblende. Very often, however, it is nothing more than a highly hornblendic variety of syenitic gneiss. It has a dark-green or black colour, and frequently contains garnets in sharply-defined crystals. Hornblende rock occurs in some abundance amongst the Laurentian strata, as in the counties of Lanark, Frontenac, Lennox, &c. Also in the valley of the Bonne-chère (Mr.

Murray); on French River, Lake Huron; and at other localities in which these strata prevail. It occurs likewise amongst the more modern metamorphic series south of the St. Lawrence. In the latter district, a rock made up of greyish-green actynolite, in interlacing fibres, is found in Beauce County. (Mr. Hunt's Report for 1856.)

Wollastonite Rock.—Wollastonite, or tabular spar, is a mineral closely related to augite. (See its description in Part II. above, page 44.) Mixed with the latter species, it forms subordinate beds, associated with crystalline limestones, amongst the Laurentian strata of certain localities.

Garnet Rock.—Beds of light-coloured massive garnet occur amongst the metamorphic series of the Eastern Townships. (Mr. Hunt's Report for 1856.) Certain subordinate beds, made up in chief part of granular garnets of a red colour, are found likewise in connexion with crystalline limestone amongst the Laurentian strata, as in the County of Argenteuil, and elsewhere. (See Part II. page 40; and Sir W. E. Logan's Report for 1856.) Mr. Richardson, in his Report for 1857, describes also the occurrence of garnet rock in association with micaceous schists, at Baie St. Paul.

Chlorite Slate.—This rock, of a greenish colour, and normally of a schistose structure, occurs both amongst the Laurentian and Huronian series, and the more modern metamorphic strata of the Eastern Townships. All of these chlorite-slates contain a certain amount of water. In the Eastern Townships they pass into more or less compact "potstones." (See Part II. above, page 60.)

Talc Slate.—The rock thus named occurs principally in the Eastern Townships, forming both semi-crystalline and compact or steatitic beds. (See Part II. above, page 58.) These are of a light-green, silvery-white, or greenish-grey colour. Some of the beds of the Laurentian series, as in the neighbourhood of Marmora, &c., are also somewhat talcose, or contain interstratified layers of talc. Talcose slates occur likewise amongst the Huronian strata.

Serpentine.—Serpentine rock, or Ophiolite, occurs in extensive beds amongst the metamorphic strata of the Eastern Townships. Its minerelogical characters have been already given (*ante*, page 59), but the rock, it may be stated here, is essentially a hydrated silicate of magnesia, more or less sectile, and of various colours, but chiefly dark-green, greenish-grey, or greenish-white, often with red or bluish veins, or variously mottled. It is very commonly mixed with carbonate of lime or dolomite, forming serpentine-marbles of green, chocolate-brown, and other colours. In Bolton, Ham, and other townships of this district, beds of chromic iron-ore are associated with these serpentine rocks; and a bed of magnetic and titaniferous ore, fifty feet in thickness, occurs in the serpentine of Beauce. A large development of serpentine rock, fit for economic purposes, occurs also with chromic iron-ore at Mount Albert, in Gaspé. According to Mr. Richardson (Report for 1850), the rock-exposure at this locality presents vertical cliffs of several hundred feet in height, and covers an area of not less than ten square miles.

Diallage Rock.—This rock consists principally of the mineral called diallage (see page 58, above), or of diallage and chlorite. It has a clear green or pale-bronze colour, is more or less fissile, and occurs in association with the serpentines of the Eastern Townships, to which, also, it is very closely allied.

Quartz Rock, or Quartzite.—The rock thus named appears to have been formed by the alteration of sandstone strata. It has a more or less vitreous aspect on newly-fractured surfaces, is very hard, and is either colourless, or yellowish, greenish, pale red, brownish, &c. It occurs abundantly amongst the Huronian rocks of the north shores of Lakes Huron and Superior; and also amongst the Laurentian strata of many localities, as at St. Jérome and elsewhere. A remarkable quartz-conglomerate, containing pebbles of red jasper and white quartz in a colourless or pale-yellowish quartzose base, is met with in the Huronian formation of the Bruce Mines district; and other conglomerates of a somewhat similar character occur in the Laurentian series. These shew clearly the metamorphic origin of the rocks in question.

Crystalline Limestone.—This rock consists of carbonate of lime in a semi-crystalline condition. It is usually white or pale reddish, and is sometimes veined or clouded with yellow, blue, green, and other coloured streaks and patches. Its structure is fine or coarse granular, somewhat resembling that of loaf sugar, whence the term "saccharoidal limestone," bestowed on this rock. Crystalline limestone occurs in beds amongst the metamorphic strata of the Laurentian and Huronian series, and also amongst those of the more modern series south of the St. Lawrence. The serpentine marbles of the Eastern Townships have already been alluded to. These limestone bands are not only of economic employment,—many yielding marbles of superior quality,—but, when occurring amongst the gneissoid rocks of the Laurentian series, they impart fertility to the otherwise too generally unproductive soil. Where the gneiss rocks are uncovered by Drift deposits, it is only indeed in connexion with the crystalline limestones or beds of feldspar-rock, that soils of any depth or fertility can be expected to occur. It is perhaps needless to observe, after what has been stated in PART II. of this Essay, that crystalline limestone may be distinguished from quartz and feldspar by being easily scratched by a knife, and also by dissolving with effervescence in diluted acids. For special localities of Canadian marbles, see PART V.

Crystalline Dolomite and Magnesite.—In external characters and conditions of occurrence, the crystalline dolomites resemble the ordinary crystalline limestones, but consist of carbonate of lime and carbonate of magnesia. A fine saccharoidal variety occurs amongst the Laurentian strata of Lake Mazinaw. Beds of Magnesite, consisting of carbonate of magnesia mixed more or less with feldspathic or quartzose matters, occur amongst the altered Silurian strata of the Eastern Townships. These beds are chiefly white, greenish, or bluish-grey in colour, and generally resemble crystalline limestone. Some, by weathering, become reddish-brown. (T. Sterry Hunt, Report for 1856.)

SEDIMENTARY ROCKS.

The rocks of this division make up by far the greater portion of the Earth's surface. Having been formed by the agency of water, they are often called *Aqueous Rocks*. They are chiefly of mechanical formation, consisting of muddy, sandy, and other sediments, collected by the mechanical action of water, and subsequently consolidated by processes described a few pages further on. Various limestones, however, and certain other rock matters of this division, are of chemical origin, or, in other words, have been deposited from waters in which their materials were chemically dissolved.

These sedimentary or aqueous rocks are characterized by always occurring in beds or strata (with the occasional exception of certain irregularly-heaped masses of drift materials); secondly, by exhibiting in many instances, a more or less clearly-marked detrital or sedimentary structure; and thirdly, by often containing organic remains. These latter, comprising shells, bones, leaf-impressions, &c. (see PART IV.), are the fossilized parts of animals and plants which lived upon the Earth, or in its waters, during the periods in which these rocks were under process of formation, as indicated below.

The sedimentary rocks may be conveniently discussed under the following heads: Composition or mineral characters; Modes of formation; Changes to which they have been subjected after deposition.

(1) *Composition of Sedimentary Rocks.*—Viewed as to their composition, these rocks comprise:

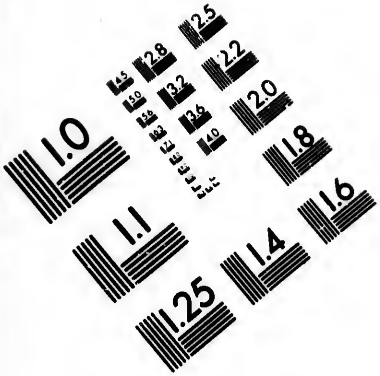
Sandstones, sands, and gravels—or arenaceous rocks.
Clays and clay-slates—or argillaceous rocks.
Limestones and Dolomites—or calcareous rocks.
Conglomerates and Breccias: rocks of mixed composition (see below).
Trap tufas: stratified deposits formed out of materials derived from the denudation of trap and greenstone rocks.
Rock matters of purely organic origin, as coal, &c.

To these may be added a few other substances of subordinate occurrence, as gypsum and rock-salt.

Sandstones are nothing more than beds of consolidated sand. They are of various colours, but chiefly white, or dull shades of yellow, red, brown, or green. The harder and purer kinds, as some examples of our "Potsdam sandstone," are called *quartzose sandstones.* In other kinds, a certain amount of carbonate of lime is present, cementing together the component grains of sand, and forming calcareous sandstones. For special Canadian localities of these and other rocks mentioned under this division, consult PART V. Certain siliceous rocks, called "tripoli" and "infusorial marls," are formed entirely of the tests of diatoms and other infusoria. (See Part IV.)

Clay Slates are merely consolidated clays. They have a fissile structure, and are chiefly of a grey, greenish, brown, or black colour. Clays are also of various colours, as white, greenish, yellowish, bluish, black, and red. Those which contain little or no iron, burn white, and yield consequently white bricks. Many clays are highly calcareous; others, bituminous, &c. *Note.*—The term *shale* is often applied to fissile consolidated clays; but this term is applied equally to fissile or slaty limestones and sandstones. When the term is used, therefore, the kind of shale should also be signified: as *an argillaceous shale, an arenaceous shale,* and so forth. *Bituminous shales,* as regards their mineral base, may be also arenaceous, calcareous, &c.

Limestones and *Dolomites* are principally, perhaps, of chemical formation. Water containing free carbonic acid (derived from decaying vegetable matters, &c.) dissolves a certain amount of carbonate of lime, but the bicarbonate, thus formed, is easily decomposed by various natural agencies, even by mere exposure to the atmosphere, and a precipitation of calcareous matter takes place. In this manner, calcareous tufas (so common in many of our swamps, streams, &c.), together with stalactites and stalagmites, are produced; and similar processes, acting on a larger scale, may have given rise to extensive depositions of limestone strata in ancient seas and lakes. Some limestones, again, are formed almost wholly of the calcareous shells or tests of crinoids, foraminifera, and other organisms (see PART IV.); but others are, undoubtedly, mechanical or rock deposits, derived from the wasting of coral reefs and older limestone formations. Limestones consist of carbonate of lime, more or less pure; dolomites, of carbonate of lime and carbonate of magnesia in equal atomic proportions; and dolomitic limestones of these two carbonates in other proportions, the lime carbonate generally predominating. Dolomites and dolomitic limestones appear in many cases to have been simple chemical precipitates, and, in others, to have originated from the alteration of limestone rocks by the action of soluble magnesian salts. These calcareous rocks are of various colours: grey, white, black, yellowish, &c. Their texture is sometimes very close and uniform. At other times, the stone is made up of small spherical concretions, when the texture is said to be "oolitic." Oolitic limestones are of all geological ages. Some limestones, again, are of an earthy texture: the well-known chalk of Europe is an example; also our own "calcareous tufa," or "shell marl." Many of the dark limestones, as those of Niagara, &c., are more or less bituminous. All effervesce in acids; but the dolomites produce merely a feeble



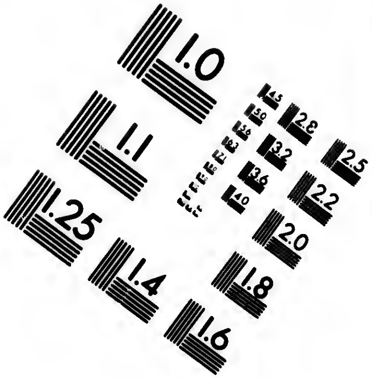
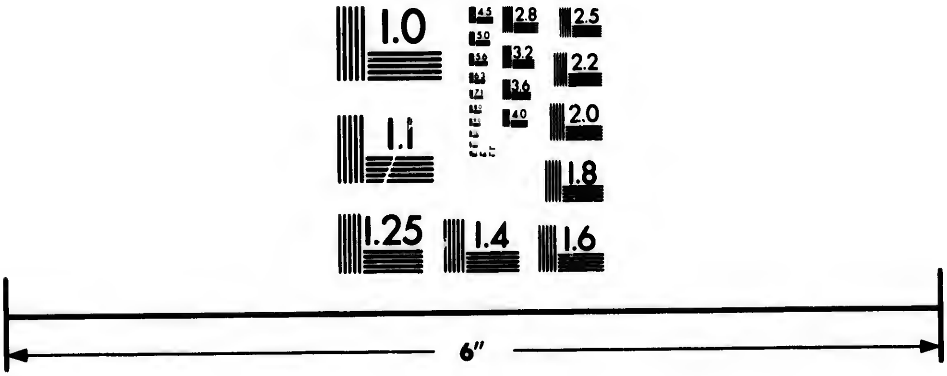
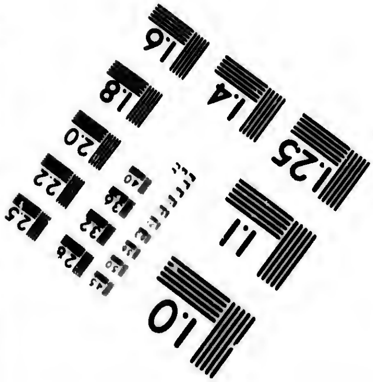
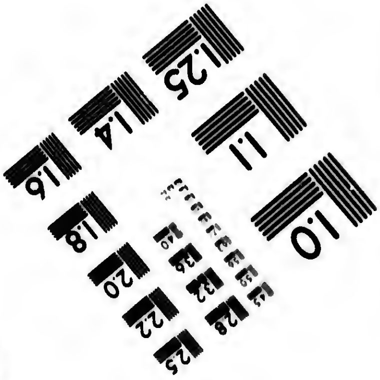


IMAGE EVALUATION
TEST TARGET (MT-3)







4.5
5.0
5.6
6.3
2.8
3.2
3.6
2.5
2.2
2.0
1.8

1.1
1.0

effervesence unless the acid be heated. Limestones which contain from 15 to 25 per cent. of argillaceous matter in intimate admixture, yield hydraulic or water lime. Beds of this kind occur at Thorold, Cayuga, Loughboro', Kingston, Hull, Quebec, and other localities. (See PART V.)

Conglomerates consist of rounded stones or masses of quartz, sandstone, &c., cemented together, or imbedded in a paste of finer sandstone, limestone, or other rock substance. The imbedded masses are sometimes of great size, a fine example of which may be seen at Quebec. Conglomerates, both altered and unaltered, are abundant amongst the Huronian rocks.

Breccias consist of angular masses or fragments of rock, cemented together, chiefly of some kind of limestone. Whilst conglomerates frequently consist of materials brought from a greater or less distance, true breccias are necessarily formed in place. Examples of calcareous breccias occur in the Eastern Townships. Also with imbedded trap and slate fragments, near the Bruce Mines, Lake Huron, and elsewhere.

(2) *Formation of Sedimentary Rocks.*—The manner in which the ordinary sedimentary rocks, sandstones, shales, &c., have been formed, or built up as it were, is rendered clear by the observation of certain natural processes still in action. We find for example, at the present day, that sediments of various kinds are constantly being carried down by streams and rivers into lakes and seas, and are there deposited. We find, moreover, that the cliffs of many sea (and lake) coasts are being continually abraded and washed away by the action of the waves. Observation shews also, that the sedimentary matters thus obtained, are always deposited or arranged in regular layers or beds, and that they frequently enclose shells and sea-weeds, together with bones and leaves, drifted from the land, and other organic bodies. Hence it is now universally admitted, that, with the exception of certain limestones and dolomites, beds of rock-salt, gypsum, coal, and other chemical or organic deposits of small extent, all the sedimentary rocks have been formed directly out of previously-existing rock-masses, by the wearing away or destruction of these; and secondly, that they have all been formed or deposited under water.

In pursuance of this inquiry, consequently, we have to consider, first, the origin or derivation of the sediments of which these rocks are made up; and, secondly, the processes by which the consolidation of the sediments into rock, properly so-called, was effected.

The sediments of which these rocks originally consisted, were derived from previously-existing rocks, by decomposing atmospheric agencies,—rain, frost, and so forth; by the action of streams and rivers on their beds; and by the destructive action of the waves and breakers of the sea.

Action of the Atmosphere.—All rocks, even the most solid, are constantly undergoing decomposition and decay. The exposed face of a rock of any kind, for example, soon changes colour, and becomes in general more porous than the other portions of the rock. This effect is technically termed "weathering." Its action gives rise to the production of soils, and frequently causes the fossils contained in the rock to stand out in relief, these being in many cases less easily decomposed than the mass of the rock itself. Every shower of rain that falls, takes part in this decomposing or disintegrating action, and carries off something, in solution or suspension, to lower levels—*id est,* into streams, lakes, and seas. Frost, and, in certain districts, carbonic acid and other gases issuing through crevices in the rocks, assist this destructive process.

Action of Streams and Rivers.—The action of streams and rivers in wearing their channels is both chemical and mechanical. Calcareous river-beds are wasted bit by bit by the dissolving power of the water, especially during the autumnal season, when dead leaves and other decaying vegetable matters yield the water a large supply of carbonic acid. On the other hand, a mechanical waste is also very generally taking place to a greater or less extent: and thus numerous rivers are continually cutting back their beds, and forming ravines. It is thought by many geologists, that the Falls of the Niagara River have in this manner gradually receded from the escarpment at Queenston to their present site; and there is scarcely a river, or small stream indeed, in any part of Canada, that does not exhibit in its banks indications of erosive action. Where streams wind through the sands and gravels of our Drift deposits, as in the neighbourhood of Toronto, to cite a single amongst so many instances, examples of this action are especially apparent. The River Don, it is said, during a three days' freshet, about fifty years ago, greatly enlarged its channel, and added much in places, to the steepness of its banks. The amount of detrital matters borne down by some rivers to the sea, is, at first thought, almost incredible. This is well shown by the formation of deltas. The delta of the Mississippi, on this continent, for example, like all other deltas, is formed almost entirely out of the sandy and other matters brought down by the stream. On entering the sea, the velocity of the river is necessarily checked, and the sediments are thus thrown down. Much of the coarser matter is indeed deposited on the bed of the river itself, raising this, and compelling the formation of artificial banks, or levées, to prevent inundations. Finally, as a well-known illustration of the immense amount of sedimentary matters borne seawards by certain rivers, the case of the Ganges, as described so fully by Sir Charles Lyell, in his "Principles of Geology," may be here cited. That river, it has been demonstrated, by actual observation and experiment, conveys annually to the sea an amount of matter that would outweigh sixty solid pyramids of granite, each, like the largest of the Egyptian pyramids, covering eleven acres at its base, and standing 500 feet in height. A considerable quantity of sediment is also produced by the slow movements of glaciers in Alpine and other districts in which these remarkable ice-rivers prevail. The glacier of the Aar, which covers with its tributaries an area of only six or seven square miles, thus furnishes daily, according to some recent researches of M. Collomb, at least 100 cubic yards of sand. This is carried off by its terminal stream or torrent.

Action of the Sea (and of large bodies of Water generally.)—Vast in amount as are the sediments collected by rivers, they are far surpassed by the accumulation of detrital matters obtained by the waves and breakers of the sea. All who have resided for any length of time on an exposed and rocky coast, must be well aware of the destructive action of the waves. The cliffs subjected [illegible] this action, gradually become undermined and hollowed out; and thus large masses of rock are brought down by their own weight. These, sooner or later, are broken up, and spread in the form of sediment along the shore, or over the sea-bottom. On some coasts, the amount of land destroyed in this manner almost exceeds belief.* On some

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* It would obviously be out of place in an Essay like the present, to enlarge on this point. The reader unfamiliar with geological details of this character, should consult, more especially, Lyell's *Principles of Geology*, and also the *Cours Élémentaire* of the late Alcide d'Orbigny.

parts of the eastern shores of England, and the opposite or western shores of France, for example, the sea has thus carried off, within the present century, from fifty to over one hundred yards of coast—measured backwards from the shore-line—and for a distance of many miles. Grave-yards, shewn by maps of no ancient date to have been located at considerable distances from the sea, have become exposed upon the cliff-faces; and forts on the French coast, built by the First Napoleon, at two hundred metres and upwards from the edge of the cliff, now lie in ruins on the beach, or have altogether disappeared. These localities are mentioned as being more especially known to the writer; but in all parts of the world examples may be found of the same destructive process. In the clay and sandy bluffs of our own lakes, as at Scarbro' Heights on Lake Ontario, and elsewhere, the effects of this action may be equally studied.

On a subsequent page it will be shewn that these results of denudation, however striking in themselves, were greatly surpassed by those of former geological epochs; but confining our view at present to modern effects only, it must be evident to all that an enormous amount of sedimentary matter is annually, or even daily, under process of accumulation. The question then arises as to what becomes of this. The reply is obvious. The detrital matter thus obtained, is deposited in lakes or at river-mouths, or along the sea-shore, or over the sea-bed—contributing day by day to the formation of new rocks. In other words, existing rock-masses, worn down by atmospheric agencies, by streams and rivers, and the action of the sea, supply the materials for other and, of course, newer deposits. And thus, when we look upon a piece of stone derived from one of these, we may picture to ourselves the scene of its formation, and, with the poet, hear—

The moaning of the homeless sea,
  The sound of streams that swift or slow
  Draw down Æonian hills, and sow
The dust of continents to be—

—for truly, is it the dust of new continents that is thus being deposited, atom by atom, by these slow but continued processes.

All sediments diffused through deep or quiet water, arrange themselves, under general conditions, in horizontal or nearly horizontal beds: the latter, if deposited on gently-sloping shores. Professor H. D. Rogers, in his recently-published Report on the Geology of Pennsylvania, contests to some extent this usually-received view, and maintains that certain inclined strata of mechanical formation were originally of inclined deposition. This may be true under local or exceptional, but certainly not under general, conditions. (See proofs, further on.) Where, however, sands and gravels are thrown down by currents and running streams, an oblique arrangement commonly takes place; but this is more or less confined to the subordinate layers of which the larger beds consist, as shewn in the annexed figure. The inclined layers have sometimes different degrees of inclination, and even dip (in different beds of the same strata) in opposite directions, indicating changes in the tidal or other currents by which they were thrown down. This inclined arrangement is termed "false bedding," or "oblique stratification." It may be seen in some of the more ancient, and also in some of the more modern deposits of this continent, as in the Potsdam Sandstone of the south shore of Lake Superior, and in the Drift gravels of many parts of Canada.

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Having thus rapidly traced out the formation of the mechanically-formed sedimentary rocks up to their deposition in the state of detrital matter on the beds of seas, lakes, or estuaries, we have now to inquire how these accumulations of mud, sand, &c., become hardened into rock, properly so-called.

Consolidation of Sediments.—Most sediments hold within themselves the elements of their own consolidation, in the form of particles of calcareous or ferruginous matter, which act upon the other substances in the manner of a cement. Frequently, also, a large amount of calcareous matter is derived from the decomposition or solution of imbedded shells and other organic remains made up of carbonate of lime. In the majority of strata, and in sandstones more especially, merely casts or shell-impressions are thus left, in place of the originally imbedded shells. Masses of solid conglomerate are daily under process of formation, in places where springs containing calcareous or ferruginous matter infiltrate through the gravels and pebble-beds of our Drift deposits. Many thermal springs (and even ordinary river-water) also contain considerable quantities of silica in solution; and there is reason to believe that in former periods of the Earth's history, springs of this kind must have prevailed to a very great extent. These flowing into seas and lakes where sediments were under process of deposition, must also have lent their agency towards the consolidation of such deposits. Many of our Canadian limestones, it may be observed—as those, more especially, which occur at the base of the great Trenton group (see PART V.)—are highly siliceous.

The enormous pressure exerted upon low-lying sedimentary beds by those above them, must likewise have been sufficient in many instances to have effected consolidation. Loose materials, as graphite powder used in the manufacture of the so-called "black lead" pencils, are thus rendered solid by artificial pressure. Spongy platinum, again, by the same process, is converted into the solid metal.

The heat transmitted in earlier periods from subterranean depths, or generated amongst low-lying sediments by natural causes, may also have been concerned in the work of consolidating the originally loose materials of stratified rocks. It may be remarked, likewise, that sediments occasionally become solidified by simple desication. The shell-marl, or calcareous tufa, of our swamps, &c., becomes thus hardened on exposure to the air.

(3) *Changes to which the Sedimentary Rocks, collectively, have been subjected.*—These changes comprise, principally: (*a*) Elevation above the sea level, with alternations of upheaval and depression; (*b*) Denudation; (*c*) Tilting up and Fracturing; and (*e*) Metamorphism and Cleavage. It is, of course, to be understood that whilst certain strata may have experienced all of these effects, others, on the contrary, have been subjected to upheaval, or to upheaval accompanied by denudation, only.

(*a*) *Elevation above the Sea Level.*—The stratified rocks, it has been shown, must have been deposited originally in the form of sediments, under water; and from the marine remains which so many of them contain, it is evident that as a general rule they were laid down on the bed of the sea, either in deep or in shallow water. We find these rocks, however, now, at various heights above the sea-level, and frequently far inland. Hence of two things, one: either the sea must have gone down, or the land must have been elevated above the water.

The sinking of the sea would appear at first thought to be the more rational explanation of this phenomenon; but if we look to existing Nature, we find no instance of the going down of the sea, whilst we have many well-proved examples of the actual rising and sinking of the land. In connexion with this inquiry, it must be borne in mind that the sea cannot go down or change its level at one place without doing the same generally all over the world.

To afford a few brief illustrations, it may be observed that on several occasions within the present century, large portions of the Pacific coast of South America have been raised bodily above the sea, leaving beds of oysters, mussels, &c., exposed above high-water mark. The phenomenon, to the inhabitants of the coast, appeared naturally to be due rather to a sinking of the waters than to an actual elevation of the land; but at a certain distance north and south of the raised districts, the relative levels of land and sea remain unaltered: and hence, if the sea had gone down within the intervening space, its surface must have presented an outline of this character , a manifest impossibility.

The land is also known to be slowly rising and sinking in countries far removed from centres of volcanic activity. Careful observations have shown, for example, that the northern parts of Sweden and Finland are slowly rising, and the south and south-eastern shores of the Scandinavian peninsula are slowly sinking: whilst around Stockholm there is no apparent change in the levels of land and sea. The whole of the western coast of Greenland is slowly sinking; buildings erected on the shore by early missionaries, being now in places under water. A slow movement of depression, it is likewise inferred, is taking place along a considerable extent of the Atlantic sea-board of the United States. (See *Canadian Journal,* vol. ii. new series, p. 480.) On the shores of Newfoundland, of Cornwall, and other districts, examples occur of sub-marine forests, or of the remains of modern trees, in their normal position of growth, below low water-mark; whilst in neighbouring localities no change of level appears to have taken place. Besides which, without extending these inquiries further, we know that many fossiliferous strata are hundreds, and even thousands, of feet above the present sea-level:—on the top of the Collingwood escarpment, for example, we find strata containing marine fossils at an elevation of over 1500 feet above the sea; and on the Montreal mountain, shells of existing species occur at an elevation of about 500 feet. And hence, if these strata had been left dry land by the sinking of the oceanic waters in which they were deposited, an immense body of water, extending over the whole globe, must in some unaccountable manner have been caused wholly to disappear. It is therefore now universally admitted, that the sedimentary rocks have come into their present positions, not by the sinking and retiring of the sea, but by the actual elevation of the land.

Many strata afford proofs of having been elevated and depressed above and beneath the sea, successively, at different intervals. Many sandstones, for example, exhibit ripple-marked surfaces, and some, impressions of reptilian and other tracks, through their entire thickness. This indicates plainly that they were formed slowly in shallow water, and that they were left dry, or nearly so, between the tides. And it indicates, further, that the shore on which they were deposited layer by layer, was undergoing a slow and continual movement of depression, otherwise the process of formation would necessarily have ceased, and the strata would present a thickness only of a few inches, or of a few feet at most. Afterwards a period of upheaval must have commenced, bringing up the rocks to their present level. In certain strata, also, the upright stems of fossil trees occur at various levels; and in some localities, beds containing marine fossils are overlaid by others holding lacustrine or fresh-water forms; and these again by others with marine remains. Finally, to bring this section to a close, we have a striking example of alternations of land-upheaval and depression in the geology of Canada generally. Around Toronto, for example, we have strata of very ancient formation, belonging to the Lower Silurian series, overlaid by deposits of clay, gravel, and sand. Between the two, a vast break in the geological scale occurs. In other parts of this continent, many intervening formations are present (see the Table of Rock Groups, a few pages further on); and hence, it is concluded, that the Silurian deposits of this locality. after their elevation above the sea, remained dry land for many ages, whilst the intervening groups were under process of deposition in other spots; and that, finally, at the commencement of the Drift period, the country was again depressed beneath the ocean, and covered with the clays, sands, and boulders of this latter time. Another period of elevation must then have succeeded, bringing up both the Silurian and the Drift formations to their present levels above the sea.

(*b*) *Denudation.*—This term, in its geological employment, signifies the removal or partial removal of rock masses by the agency of water. The abrading action of the sea, of rivers, &c., acting under ordinary conditions, has already been alluded to; but the erosive effects of water, under conditions now no longer existing, may be seen in numerous localities. Sections of the kind shewn in the accompanying figure, for instance, are met with almost everywhere, producing undulating or rolling countries. Here it is evident that the strata were once continuous in the space between *a* and *b*. Valleys thus resulting from the removal of strata, are termed "valleys of denudation." Some of these valleys are many miles in breadth. Their excavation, consequently, could not have been caused by the streams which may now occupy their lower levels. Their formation is universally attributed to the denuding action of the sea during the gradual uprise of the land in former geological epochs. Frequently isolated patches of strata are left by denudation, or are cut off by wide distances from the rocks of which they originally formed part. These are termed "outliers." Thus in Western Canada, small isolated areas, occupied by bituminous shales of the Devonian series, occur in the townships of Enniskillen, Mosa, &c., and constitute outliers or outlying portions of the Chemung and Portage group (see Part V.), as largely developed in the adjoining peninsula of Michigan. The matter carried off in some districts by denudation, must have been of enormous amount; and when it is considered that most of the inequalities on the Earth's surface—those at least not immediately connected with mountain chains—have arisen from this action, it will readily be perceived that materials for the formation of newer strata were abundantly provided by this means alone.

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(*c*) *Tilting up and Fracturing of Strata.*—Whilst some strata retain their original horizontality, others are more or less inclined, and some few occupy a vertical and even a recurved position. That strata were not originally inclined, at least to any extent, is proved by the known arrangement of sediments when diffused through water,—these (with the exceptional cases already pointed out) always depositing themselves in horizontal, or nearly horizontal, layers. The same fact

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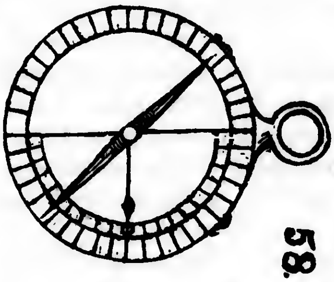
57.

is shewn also by the frequent presence of rows of pebbles, fossil shells, &c., parallel with the planes of stratification, as in fig. 56; by the occasional presence of the fossilized stems of trees (evidently in their positions of growth) standing at right angles to these planes (fig. 57); and sometimes by the presence of stalactites suspended in a similar position.

The inclination of strata is technically termed the *dip;* and the direction of the up-turned edges, the *strike.* The dip and strike are always at right angles. In observing the dip, we have to notice both its angle or amount, and its direction,—as north, north-east, N10°E, and so forth. The direction of the dip is of course ascertained by the compass; the rate of inclination, by the eye, or by an instrument called a clinometer. The most convenient instrument for both purposes, is a pocket compass, furnished, in addition to the needle and graduated limb, with a moveable index hanging from the centre of the compass and playing round a graduated arc, as in the annexed outline (fig. 58.) When the line *A—B* is held horizontally, the index *I* hanging perpendicularly, cuts the zero mark of the graduated arc. From each side of this point, the graduation is carried up to 90°. If, consequently, the line *A—B* be placed parallel with the dipping beds of any strata, the angle of the dip will be at once shewn by the index. A contrivance of this kind, exclusive of the compass, may be easily made out of a semicircle of hard wood. The index may consist of a piece of twine extending below the graduated limb, and kept taut by a lead plumb or by a stone.



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When strata dip in two directions, the line along the culminating point of the strata is termed an *anticlinal* or *anticlinal axis* (= *a* in fig. 59); and the line from which the strata rise (= *s* in fig. 59), is called a *synclinal* or *synclinal axis.* Synclinals when of a certain magnitude, constitute "valleys of undulation." Anticlinals are also often hollowed out by denudation, forming valleys or troughs called "valleys of elevation" (= *e* in fig. 59.) The term "elevation" applies here, however, to the raised strata, and not to the actual position of the valley, as many of these so-called valleys of elevation lie in the beds of rivers, or occupy comparatively low ground. The city of Cincinnati is situated in a remarkable valley of this kind. Finally, it must be observed, that when strata lie in parallel beds (as in fig. 59), the stratification is said to be *conformable* or *concordant*. When on the other hand, the beds are not parallel, the stratification is said to be *unconformable*. The accompanying section, in which the inclined beds belong to the Laurentian, and the overlying beds to the Lower Silurian series (see PART V.), as shown on Crow Lake, north of Marmora village) is an example of unconformable stratification, or of want of concordance between these two series of rocks. As explained further on, a want of conformability always indicates a geological break, or the commencement of a new geological period.

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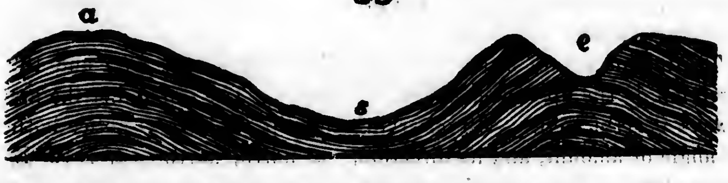

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Both horizontal and inclined strata frequently exhibit fractures of greater or less extent. Mineral veins, it may be mentioned, consist essentially of cracks or fractures running through the surrounding rocks, and filled up, by various agencies, with sparry, earthy, and metallic matters. The strata on one side of a fracture are often displaced, being thrown up or down, as it were. This peculiarity is technically termed a *fault*. An example is shewn in the annexed diagram. The levels occupied by a displaced bed are sometimes only a few inches, and at other times upwards of a thousand feet, apart. At the first formation of a fault or slip, an escarpment or terrace of greater or less height must necessarily have arisen; but in very few cases (if in any case unconnected with existing earthquake phenomena) is anything of this kind now observable, the ground having

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been levelled down by the agency of denudation. In mountainous districts, the fracturing of strata has sometimes given rise to narrow valleys or gorges, called "valleys of dislocation," most of which have been subsequently widened by the atmospheric disintegration of the surrounding rocks, and by the streams or torrents of which they usually form the channels.

(e) *Metamorphism and Cleavage.*—The subject of metamorphism has already been sufficiently explained, under the head of Metamorphic Rocks, above. It is merely alluded to here as one of the changes to which strata of various geological ages have been subjected. The term "cleavage" is applied to a peculiarity affecting many clay-slates, and occasionally other strata. The rocks thus affected, are rendered eminently fissile or slaty by numerous cleavage planes which run through them in a direction generally inclined to that of the lines of bedding. The latter, in inclined strata especially, are sometimes distinguished with difficulty from the planes of cleavage, but they may be discovered by tracing out lines of fossils, or intercalated bands of a slightly different mineral composition, colour, &c., which mark, of course, the planes of deposition, and across which the cleavage lines usually pass without interruption. That cleavage is a superinduced effect, is shewn by this latter circumstance, and more particularly by the fact that imbedded fossils and stones are frequently elongated in the direction of the cleavage planes. The cause of the phenomenon is still exceedingly obscure; but it is now very generally regarded as due to long continued pressure acting at right angles to the lines of cleavage, whilst the rock was permeated by water or steam, or whilst it still retained its sedimentary condition. Many of the slates of the Eastern Townships, as those of Richmond, Kingsey, Melbourne, Westbury, &c., owe their fissility to superinduced cleavage.

CLASSIFICATION OF ROCKS IN ACCORDANCE WITH THEIR RELATIVE AGES.

Our preceding illustrations have shewn us the distribution of rocks into three great groups—Eruptive, Metamorphic, and Sedimentary rocks—in accordance with their modes of derivation or general formative processes. But these rocks admit of another and far more interesting classification: one based on their relative ages or periods of formation.

It is now universally admitted, on proofs the most unanswerable, that the various sedimentary and other rocks which make up the solid portion of our globe, were not formed during one brief or unbroken period, but were gradually elaborated and built up during a long series of ages. In areas of very limited extent, for example, even in the same cliff-face, or in excavations of moderate depth, we often find alternations of sandstones, limestones, clays, &c., lying one above another, and thus revealing the fact that the physical conditions prevailing around the spot in question must have been subjected to repeated changes. The same thing is also proved by alternations of marine and fresh-water strata in particular localities; and of deep-sea and shallow-sea deposits, in others. Again, the sedimentary rocks are frequently found in unconformable stratification, as explained above: horizontal beds resting upon the sloping surface or upturned edges of inclined strata. (See fig. 60.) Here it is evident that the inclined beds must have been consolidated and thrown into their inclined positions before the deposition of the horizontal beds which rest upon them. In the absence of particular sets of strata in special localities, proving extensive denudation or long-continued periods of upheaval and depression—in the vast metamorphic changes effected throughout many districts—in the upward limitation of faults (fig. 62), as sometimes seen—and, briefly, in the worn and denuded surface which a lower formation often presents in connexion with strata resting conformably upon it,—we have additional evidence of the lapse of long intervals of time during the elaboration of these rocks generally.

62.

But a still more conclusive proof of this fact is to be found in the limited vertical distribution of fossil species of plants and animals, the remains of which are entombed in so many of the sedimentary rocks. The sediments now under process of deposition in our lakes, river-estuaries, and seas, frequently enclose, it will be remembered, the more durable parts, if not the entire forms, of various plants and animals belonging to existing creations. In like manner, the sedimentary deposits of former geological periods have enclosed also various organic forms peculiar to those periods. Each group of strata has thus its own characteristic fossils, except that in the lowest or earliest-formed series of deposits we meet with no traces of ancient life. These deposits belong to the *Azoic Age* of geological history. All the succeeding periods have left us, in the rocks then under process of formation, vestiges, at least, of their organic types—those of each period differing more or less entirely from the forms which occur in both underlying and overlying strata. These facts are brought out more fully in the succeeding part of this Essay, in which the leading questions connected with the subject of Organic Remains, come under review. For present purposes, it will be sufficient to observe that by the careful study and comparison of these remains, geologists have subdivided the rock-groups into a certain number of formations, indicating the bygone ages and periods of the Earth's history. Without entering at present into minute or controverted subdivisions, we may group these various formations as in the annexed tabular view :

Modern Formations.	
Drift Deposits.	
Cainozoic or Tertiary Rocks.	
Mesozoic or Secondary Rocks.	Cretaceous Series.
	Jurassic Series.
	Triassic Series.
Palæozoic Rocks.	Permian Series.
	Carboniferous Series.
	Devonian Series. (For Canadian Sub-divisons, see Part V.)
	Silurian Series. (For Canadian Sub-divisions, see Part V.)
Azoic Rocks.	Huronian Series.
	Laurentian Series.

Notes on the above Table.

(1) The formations enumerated in this table, are never found altogether: that is to say, they never exhibit a complete series at any one locality. But they are known to occur in this order, by a comparison of their relative positions at different places. Thus, in one district, we find (in ascending order) the Silurian and Devonian series; in another, the Devonian and Carboniferous, and so on.

(2) In Canada proper, the following series alone occur:

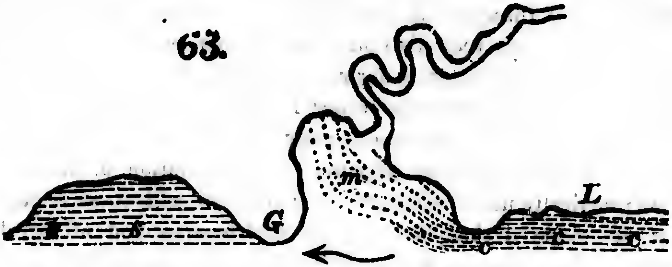
Modern formations.
Drift deposits.
Carboniferous series (in part only, in Gaspé.)
Devonian series.
Silurian series.
Huronian series.
Laurentian series.

These comprise, lithologically, various sedimentary and metamorphic strata, with, in some cases, accompanying eruptive rocks, as described fully in PART V.

(3) One or more of several consecutive formations (as shewn in Note 2) are often "wanting" or absent at a given spot. The Carboniferous rocks may thus, in certain districts, be found resting on the Silurian, without the intervention of the Devonian series. But the relative positions of these groups are never reversed. The Devonian beds are never found under the Silurian, for example, nor the Cretaceous under the Jurassic. The absence of particular strata, at a given locality, is accounted for by the elevation of the spot above the sea-level during the period to which the strata in question belong; by denudation, or by the district having been situated beyond the area of deposition to which the sediments extended. (See some of the preceding observations under "Formation of Sedimentary Rocks," "Denudation," &c.)

(4) A formation of a given age may be represented in one place by a limestone; in another, by a sandstone; in a third, by argillaceous shales, and so on. This will be easily understood, if we reflect that at the present day these different kinds of rock are being formed simultaneously at different places. Many of our preceding observations have amply illustrated this, but the fact may be rendered still clearer by the accompanying diagram. In this sketch, the dark outline is intended to represent a somewhat extended line of coast, with a river debouching into a deep bay. In the latter, the argillaceous or muddy sediments (*m*), brought down by the river, may be deposited. At G, we may suppose a granitic headland. The arenaceous or siliceous sediments (*s*) derived from the disintegration of this, will be arranged along the shore beyond it, by the set of the current. Finally, at L, we may suppose the occurrence of exposed cliffs of

63.



limestone, yielding calcareous sediments (*c*). These various sedimentary matters will be also in places more or less intermingled, producing rocks of intermediate or mixed composition. But these rocks will be shewn to be of the same period of formation, by the identity of some, at least, of the organic bodies enclosed in them. As recent formations, moreover (although many of the enclosed shells, &c., would necessarily be distinct, owing to the diverse nature of the sediments, the more or less exposed character of the coast, the varying depths of water prevailing at different parts, &c.,) we might expect to find in one and all, coins, pieces of pottery, and other objects of human workmanship, proving their contemporaneous origin. Hence, the age of a rock is in no way indicated by mineral composition: sandstones, limestones, &c., are of all geological periods.

(5) From time to time, during the gradual deposition of these sedimentary formations, various eruptive rocks were driven up amongst them, producing (in general) chemical or mechanical alterations of greater or less extent. This action is still going on, as witnessed in volcanic phenomena.

PART IV.

SOME REMARKS ON ORGANIC REMAINS, WITH SPECIAL REFERENCE TO CANADIAN FORMS.

Many stratified rocks, it has already been explained, contain the fossilized remains or impressions of vegetable and animal forms—vestiges of departed races of plants and animals which peopled the Earth and its waters during the epochs in which these rocks were under process of deposition. So numerous in some instances are the remains in question, that certain strata appear to be almost entirely made up of them, either in a perfect or in a fragmentary condition. The study of these fossils has a three-fold value: first, in enabling us to recognise one rock division from another, each division holding its own proper and separate forms; secondly, in elucidating obscure points in the structural and other relations of existing types; and thirdly, in shedding light upon many of the past conditions of the globe, both physical and organic. In illustration of the first or more practically useful character in connexion with these remains, it may be observed that in the great coal-bearing and all overlying strata, we do not meet with a single trace of the peculiar group of Crustaceans termed *Trilobites* (see figures of these a few pages further on), although in earlier-formed or lower strata these forms occur generally, and often in great abundance. Hence, in a rock containing trilobites, no matter how similar such rock may be in aspect and mineral characters to coal-strata, we may be assured that it will be useless to bore or excavate for coal, at least with the expectation of finding great workable beds of that material, such as occur in the proper coal formation.

Some fossil remains, belonging to the most recent geological deposits, are identical with existing species; others are akin to these, without being actually identical with them; and others, again, are wholly without representatives in existing Nature. These various bodies comprise chiefly: the casts or impressious of sea-weeds, fern-fronds, and leaves of higher vegetable types, with occasional fruits and stems of trees; the remains of corals, star-fishes, and other radiated animals; the shells of mollusca; tests of crustaceans; and teeth, bones, and more or less complete skeletons of vertebrated animals. In some cases, these remains have evidently been entombed where the plants, corals, mollusks, &c., were actually living; whilst in others, they have been drifted to a greater or less distance with the sediments of which they now form part. The process of fossilization is a gradual replacement, atom by atom (as in the case of many mineral pseudomorphs), of the original organic substance of the body by mineral matter. The fossilizing agents comprise the general substance of the enclosing sediments, together with certain special substances, of which the more common include—silica, carbonate of time, and carbonate of iron, the latter being frequently converted into peroxide of iron, and also into iron-pyrites. (See page 23 above.)

Fossilized Vegetable Remains:—The fossil plants obtained from the generality of Canadian rocks, are comparatively of little interest. Throughout the broad areas occupied by our Silurian strata, (as in other parts of the world,) only fucoids or seaweeds appear to occur. It is in the Devonian formations that land plants are first met with; but in Canada, with the exception of Gaspé in the extreme east of the Province, obscure traces of these forms have alone been discovered. In Western Canada, as in the case of the underlying Silurian strata, our lower Devonian beds have only yielded fucoidal types, and it is merely in the limited patches of the Chemung and Portage Group (see Part V.) that fragmentary remains and impressions of terrestrial forms occasionally occur. Long furrowed stems, several feet in length, and varying in diameter from an inch to three inches, occur in the dark bituminous shales of that formation, at Cape Ipperwash (Kettle Point,) on Lake Huron. These have been referred to *Calamites*, a genus of sub-aquatic or marsh plants of common occurrence in the coal strata, but their character is still obscure. The fossil plants of Gaspé are described in valuable papers by Dr. Dawson of Montreal, in the fifth and sixth volumes of the *Canadian Naturalist*. In fig. 64 we give a sketch of a common but still unnamed fucoid from the Trenton limestone of Belleville and other parts of Canada. Fig. 65 represents another supposed fucoid, the *Scolithus linearis* of Hall, from the Potsdam sandstone of the County of Leeds, C. W., and other districts (see Part V.) It forms, in general, cylindrical or flattened reed-like casts, varying in length from a few inches to a couple of feet, and traversing the strata across the direction of their bedding. The true nature of these casts, however, is still involved in doubt. By some palæontologists they are looked upon as resulting from holes or tubes made by sand-burrowing annelides. Finally, it may be observed that impressions of modern leaves (*Thuja*, *Populus*, *Acer*, *&c.*, *&c.*,) are occasionally found in our drift clays and shell marl deposits (see Part V.)

Fig. 64.

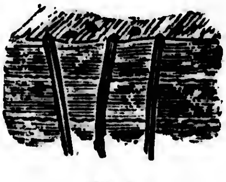


Fig. 65.

Fossilized Animal Remains:—Keeping always before us the fact that this Essay is addressed strictly to the general reader, it will be necessary, before adverting to the animal remains occurring in Canadian rocks, to pass briefly in review the classification-characters of the leading zoological groups as recognised in existing Nature. Animal organisms appear to be constructed after five principal types: the so-called Protozoic type, the Radiated type, the Molluscous type, the Articulated type, and the Vertebrated type.

PROTOZOA stand upon the extreme and oscillating limit of the Vegetable and Animal worlds. They include a series of *Infusorial forms*, in great part of vegetable origin, *Sponges* and *Rhizopods*. RADIATED ANIMALS exhibit, at least in their typical forms, a radiated arrangement of their structural parts, as seen in the coral polyp, the sea-urchin, and the starfish. They are all aquatic, and chiefly marine. MOLLUSCOUS ANIMALS, as the name implies, are soft-bodied, and the greater part secrete an external calcareous shell, as in the oyster and the snail. In some few, however, the shell is internal, as in the cuttle-fish; and some again, as the common slug, are without a shell, or possess merely the rudiments of one. ARTICULATED ANIMALS comprise insects, crustaceans (as the lobster, crab, &c.,) and other forms with usually a distinctly jointed body, covered in many instances by a hard integument or even by a shell. Finally, VERTEBRATED ANIMALS possss an internal skeleton, of which the principal and most persistent part is the vertebral column. They include fishes, batrachians, (as newts and frogs,) reptiles, birds, and mammals.

Since the first creation of living things, representatives of each of these great types—that is to say, of the Radiated type, the Molluscous type, &c.,—probably peopled the earth in each and all of its varied periods of development; but hitherto, traces of vertebrated forms have escaped detection in the lowest fossiliferous rocks, fishes first appearing in Europe at the extreme top of the Upper Silurian deposits, and with us, in the Devonian strata.

Protozoa.—This sub-kingdom includes: INFUSORIA, SPONGES, and RHIZOPODS.

INFUSORIA.—These are microscopic organisms, for the greater part, if not wholly, of vegetable origin, although (as in the case of the well-recognized spores or earlier stages of development of many cryptogams) possessing powers of locomotion. Recent Infusoria occur in all waters in which decomposed matters are present, and they are frequently found also in clear running streams. Some are entirely soft-bodied, but others are protected by a calcareous, siliceous, or ferruginous shell. The microscope has shewn that many bog-iron deposits, siliceous marls and tripolis are almost entirely made up of the remains of these creatures. Beds of tripoli occur at Laval and Lanoraie (Sir W. E. Logan) in the Lower Province, but their infusorial forms do not seem to have been specially examined.

Sponges.—Modern sponges consist of a gelatinous mass, full of pores, and possessing in general the power of secreting a horny framework or kind of skeleton—the "sponge" of commerce. This horny framework is commonly strengthened by a number of sharp spines or spicula, crossing each other in various directions. The spicula are either siliceous or calcareous, according to the species. Fossil spicula often occur in flints and in infusorial deposits. Dr. Dawson has also detected them in the Drift deposits of Montreal, (see Part V.) The ancient sponges appear to have secreted a hard calcareous framework, and to have been more nearly related to corals. If we except the doubtful *Stromatopora* (see under "corals," page 102), our Canadian rocks do not appear to have yielded any characteristic forms, but some obscure species occur in the Mingan Islands and elsewhere. (See *Appendix.*)

Rhizopods (or **Foraminifera.**)—The animals of this class are aquatic, and, with few exceptions, of extremely minute size. They swarm in many of our seas. Their soft gelatinous body is sometimes naked, or enclosed in a horny capsule; but more commonly it is protected by a calcareous and usually many-chambered shell, perforated for the passage of long and delicate filaments, whence the name of the class, from *ριξα*, a root. The latter forms, or those possessing shells, are generally known as *Foraminifera*. The only representatives of these in Canadian Deposits occur in the Drift or Post-Pliocene accumulations of Montreal and its vicinity, where they were discovered by Professor Dawson. (See illustrations and descriptions in the Canadian Naturalist, vols. 2 and 4.) All have been recognised as identical with existing forms. Fig 66 is a greatly enlarged view of one of the most common species, *Polystomella umbilicatula*.

Fig. 66.

Radiated Animals.—The following Classes belong to this division: **Polypifera** or **Corals**, **Acalepha**, and **Echinodermata.**

Corals.—The fossil forms of Canadian occurrence referred to this class may be conveniently arranged in two groups: *Graptolites* and

Corals proper. The true position of the graptolites, however, is exceedingly uncertain; but the general opinion allots them a place near the Virgulariæ or sea-pens, belonging to the lower of the two great orders or divisions in which modern forms of this class are mostly arranged. It should be observed, nevertheless, that some naturalists divide the POLYPIFERA into three Orders—*Hydroida, Alcyonaria* and *Zoantharia* (or groups with other names synonymous with these)—and place the graptolites (with the modern *Sertularia,* &c.,) in the first order. Agassiz, again, removes this order to the class ACALEPHA.

Graptolites.—The common form of the graptolite-structure is that of a narrow band or "stipe," with a row of "teeth," *i.e.*, the mouths of cells, on one or on both sides. The teeth or serratures are pointed or even mucronate in some species, and obtuse in others. Sometimes in place of forming a narrow band, the cell-structure takes a leaf-like shape, and at other times it assumes a spiral or convolute form. Specimens have also been found, more especially in the Quebec group of rocks in the vicinity of Point Levi, in which several stipes cross each other or radiate from a common centre, around which there is a thin connecting membrane. Our ordinary examples, it is thus evident, are merely fragments of the true graptolite-structure; and as some of these occur in branching forms, of which the branches are only toothed on one side whilst the main stem is toothed on both margins, it is more than probable that the same species has been described in some instances under different names. *Being entirely confined to the Silurian strata,* the graptolites are especially interesting and valuable as geological test-forms. On this continent they are chiefly characteristic of the Lower Silurian division, (see PART V.) By some authors, the forms with serratures on each side of the stipe are described under the generic name of *Diplograpsus*; and those with serratures on one side only, under that of *Graptolithus.*

As examples of Canadian forms, we may cite at present *Graptolithus Logani,* Fig. 67, from the base of the Lower Silurian formation; *Graptolithus* (or *Diplograpsus*) *pristis,* Fig. 68, with acute or submucronate serratures, from the Trenton limestone, Utica Slate, and Hudson River group of the same formation; *G.* (=*Diplograpsus*) *ramosus,* with obtuse or somewhat truncated serratures, Fig. 69, from the Utica Slate and Hudson River group (Lower Silurian); and *G. priodon,* (=*G. clintonensis,* Hall) Fig. 70, with reversed serratures, from the Clinton and Niagara group of the Upper Silurian series.

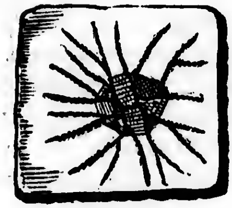


Fig. 67.

Fig. 68.

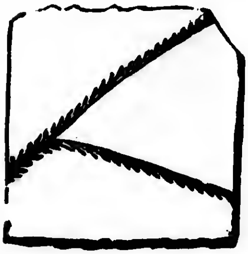


Fig. 69.

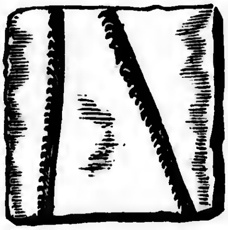


Fig. 70.

Corals proper :—The animal substance of corals consists of a soft gelatinous mass containing one or many digestive sacks or stomachs, each provided at the opening or upper part with a number of retractile tentacles. These sacks with their tentacles are technically known as "polyps." The gelatinous mass possesses likewise (in the majority of cases) the power of secreting amidst its tissues a calcareous or horny framework, the "coral" of popular language. As a general rule, this secreted solid portion consists of one or more cavities or cells, in and around which the organized fleshy sack or polyp is contained. This, however, is not always the case. Sometimes, as in the celebrated "Red Coral" of the Mediterranean, the polyp-cavity is fashioned in the midst of the gelatinous matter, without any corresponding cavities in the support. When cells occur in this support or "corallum," they exhibit either a round, oval, or polygonal opening; and, if more than one in number, they are either in juxtaposition, or connected by short transverse tubes, or by a mass of more or less porous tissue called "cœnenchyme." The cell is sometimes smooth within, but more commonly it is furnished with a number of radiating plates or lamellæ. These, in some forms, are but slightly developed, or occur only in a rudimentary condition; whilst in others they extend far into the cell, and even unite there in a central column. A central column or "axis" sometimes, however, exists by itself, and may have radiating lamellæ of its own projecting towards the circumference of the cell; but this latter modification is not observed in any of the Palæozoic types. Whether radiating lamellæ are present or not, the cell is very generally divided horizontally by a series of transverse plates or "diaphragms," either extending across the entire cell (Fig. 71, *a*, which shows three cells thus divided) or occupying the central portion of this, whilst the sides are filled with small and more or less irregular plates, called "vesicular tissue," (Fig. 71, *b*). In the genus *Cystiphyllum*, again, the interior of the cell is entirely filled with these irregular vesicular plates (Fig. 71, *c*). Finally it may be mentioned that many corals possess an enveloping wall or sheath. This is termed an "epitheca."

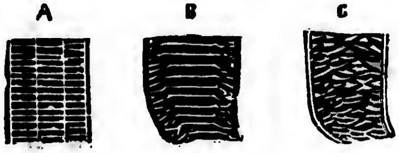


Fig. 71.

The following are the more important or characteristic fossil species met with in Canadian rocks:

Fig. 72.

1. *Stromatocerium rugosum*, Fig. 72.—In this form, there are no apparent cells, but the corallum is made up of numerous concentric and wavy lamellæ. Lower Silurian: Trenton group*; more especially abundant at the lower part. This fossil is also known as *stromatopora rugosa*, and is sometimes classed as a sponge. A closely related species, *Stromatopora concentrica*, occurs in the Niagara group of the Upper Silurian series, and passes in some districts into the Devonian rocks.

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* The subordinate divisions of our Silurian and Devonian strata will be found described in full in Part V.

2. *Stenopora fibrosa* (= *Chætetes lycoperdon*) Fig. 73. This form is made up of long fibrous or acicular tubes, with numerous transverse diaphragms. These latter, however, to be properly seen, require the aid of a magnifying glass. The corallum is either globular, hemispherical, dendritic, or irregular. The dendritic forms often resemble sea-weeds, but, except in much weathered specimens, a magnifying glass will generally show their punctured surface (the openings of the cells), and their delicately fibrous structure. Very common throughout the Trenton Group, Utica Slate, and Hudson River Group of the Lower Silurian Series. Found also in the Upper Silurian rocks.

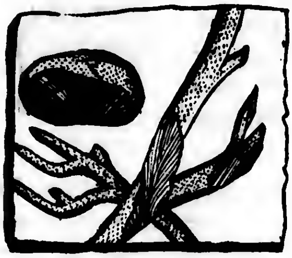
Fig. 73.

3. *Favosites Gothlandica* (= *F. Niagarensis*) Fig. 74.--The corallum in this species is properly hemispherical and sometimes of large size, but specimens are generally obtained in the form of irregular masses. These are made up of hexagonal or polygonal cell-tubes with numerous transverse diaphragms, and with pores in the cell walls. They are the "petrified honeycombs" of quarrymen, &c. Principally Upper Silurian; but found occasion- in the Lower Silurian and frequently in the Devonian Series.


Fig. 74.

4. *Michelinia convexa*, Fig. 75.—The corallum in this species consists of large but shallow polygonal cells, with convex and in part vesicular diaphragms, and pores in cell walls. Devonian strata, Canada West.

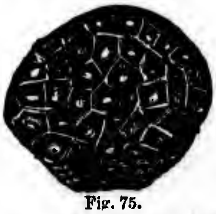
Fig. 75.

5. *Halysites catenulatus* (= *Catenipora escharoides*), fig. 76.—In this species, the well-known "chain coral," the oval cell-tubes are united in chain-like groups. There are numerous diaphragms, and some rudimentary radiating-lamellæ. Chiefly characteristic of the Clinton and Niagara group (Upper Silurian), but found also of late years in the Lower Silurian series.


Fig. 76.

6. *Syringopora tubiporoides*, Fig. 77.—The corallum in this form consists of round, elongated, and somewhat flexuous tubes, connected by tranverse tubes of short length. Another species, *S. Hisingeri*, resembles this, but its tubes are of much smaller diameter. Both occur in the Devonian rocks of Western Canada.


Fig. 77.

7. *Columnaria alveolata*. Fig. 78.—This species much resembles *Favosites Gothlandica*, the corallum being made up of hexagonal and polygonal cells in close juxtaposition, but the mouths of the cell-tubes are bordered by short radiating lamellæ. Numerous diaphragms are also present, but the cell-walls have no pores. Trenton group (Lower Silurian), and principally met with at the lower part of this group (= Black River limestone, see PART V.)

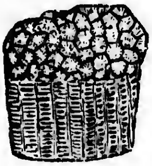
Fig. 78.

8. *Petraia cornicula* (= *Streptelasma* of Hall) Fig. 79. Corallum horn-shaped, simple, consisting of one large cell with well-developed radiating lamellæ, but without diaphragms. Trenton Group (Lower Silurian). A closely related species from the Niagara Group (Upper Silurian) has been named *P. calicula*. Another species, *P. profunda*, from the base of the Trenton Group, has a conical and nearly straight form. All of these vary in length from about half an inch to an inch and three-fourths.


Fig. 79.

9. *Zaphrentis prolifica*, Fig. 80.—Corallum, horn-shaped, simple; with alternating large and small radiating lamellæ, and transverse diaphragms. A "septal fossette" or indentation passes down the interior of the cup on one side; and externally, the corallum is enveloped in a thin epitheca. This is a comparatively large species, varying in length from about an inch and a half to over five inches; but a still larger species, *Z. gigantea*, is often found accompanying it. This latter form is two or three inches in diameter, and two feet


Fig. 80.

or more in length. Both occur in the Devonian series (Corniferous limestone (see PART V.) of Western Canada.

10. *Cystiphyllum Senecaense* (Billings) Fig. 81 (a fragment); Corallum horn-shaped, simple, slender, and usually curved. Interior filled with vesicular tissue. Radiating lamellæ quite rudimentary. Diameter three-fourths of an inch, to an inch and a half. Length, varying from three or four inches to two feet (Billings). Devonian rocks (corniferous limestone) of Canada West. Various other species of Cystiphyllum occur in these rocks. Amongst others, *C. aggregatum* (Billings), in groups of irregularly cylindrical tubes covered by a wrinkled epitheca.

Fig. 81.

These corals represent our most abundant and characteristic species, but numerous others occur in special localities. For information respecting many of these, the reader is referred to the Reports of Mr. Billings in the publications of the Canadian Geological Survey, and also to valuable memoirs by that palæontologist in the fourth and fifth volumes of the *Canadian Journal.* An extended analysis of these forms would not only exceed our proposed limits, but would be altogether out of place in an Essay like the present.

ACALEPHA.—Until lately, this class was held to include only a series of soft-bodied marine animals (*Medusæ,* &c.,) of which no fossil representatives have as yet been obtained. The recent researches of Professor Agassiz, however, render it very probable that the Graptolites and some of the lower forms usually classed amongst the corals may belong to this division.

ECHINODERMATA.—The echinoderms constitute a class of marine animals provided with an external test or shell, composed of many pieces, or with a tegumentary semi-calcareous skin. Some are free, and others, fixed animals. These latter are attached to the sea-bottom by a jointed calcareous stem; but in some instances the animal is only thus attached during a portion of its life, and becomes free in the adult condition. The class may be subdivided into the following Orders: 1, Crinoida; 2, Blastoida? 3, Cystidea; 4, Thyroida; 5, Asterida; 6, Ophiurida; 7, Euryalida; 8, Echinida; 9, Holothurida.

1. *Crinoida.*—In the majority of fossil crinoids or encrinites ("sea-lilies"), the general form consists of a body or digestive sack, covered by calcareous plates, and furnished at its upper part with a series of jointed arms or tentacles, and at its lower part with a jointed and perforated stem (composed of numerous round or pentagonal plates) by which it was attached to the sea-bottom: see fig. 82. This Order is of great palæontological interest. In the seas of the Palæozoic and Mesozoic periods, its representatives swarmed in vast numbers; whilst but few forms belonging to it have been obtained from Tertiary rocks (see the Table of Formations on page 93 above); and in existing seas the order is almost extinct, two or three species alone remaining to represent it. The best known of these is the *Pentacrinus caput-Medusæ* of the West Indian seas. A small species of *Comatula* exists also in the Irish Channel, and of late years has been carefully studied. This form is fixed by a stem in the early condition, and afterwards becomes free. The fixed stage was originally thought to be permanent, and the species was known as *Pentacrinus Europæus.* The genus *Marsupites,* of the Cretaceous rocks, was also a free form, during a portion, if not during the entire period, of its life.

Fig. 82.

The cup-shaped body of the crinoid animal is technically termed the "calyx." It is enclosed by numerous polygonal plates, arranged, for each genus, in definite order. The plates in a row immediately above the stem are commonly known as "basals." These are usually three or five in number. The next series, absent, however, in many genera, are called sub-radials, and the next, supporting the base of the arms, are known as "radials." The radials always range in five vertical rows, each row being made up of one or several plates, between which occur other plates, termed inter-radials and anal plates. The upper part of the calyx is covered (in most genera) by numerous small and irregular plates, termed, collectively, the "vault." The vault-plates are sometimes prolonged into a so-called "trunk," the office of which is still undetermined. In some species the vault has two openings, in others only one.

Numerous stem-fragments of crinoids occur throughout our Silurian and Devonian rocks, but entire or even tolerably perfect forms are exceedingly rare. As the character of the stem differs frequently in the same species, and in different parts even of its own length, and is more or less alike again in different species, these fragments can only be described as "crinoid stems." Fig. 83 represents a piece of arenaceous shale, from below the Drift clay of Toronto, covered with portions of crinoid stems, some being seen in transverse section, whilst others are shewn longitudinally. This shale belongs to the Hudson River Group of the Lower Silurian Series (see PART V.)

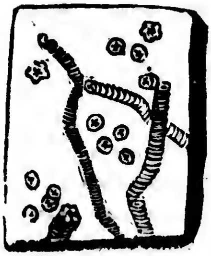

Fig. 83.

Owing to this fragmentary condition of our Canadian examples generally, and to the great rarity of perfect or determinable forms, it is unnecessary in an essay like the present (and would indeed be useless where we are obliged to restrict the number of our engravings) to attempt descriptions of genera and species. The crinoids of our Lower Silurian strata will be found described in great detail by Mr. Billings, in the fourth Decade of "Canadian Organic Remains."* Of the species met with in our other formations, no complete record has yet been published.

2. *Blastoida.*—The forms placed in this Order have been separated of late years from the Crinoids proper. They present an oval or globular body, (the calyx) composed of several series of plates, and having at the summit five "ambulacral areas" or rays, in the shape of a star, furrowed down the centre of each ray, and striated across. These are thought to have supported delicate tentacles, but no arms have been discovered. The body was fixed to the sea-bottom by a short, jointed stem. The order contains but few genera. The genus

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* In further illustration of the inutility of entering into descriptions of these forms in the present place, it may be observed that, of several species described and figured by Mr. Billings, only single specimens are known. We have therefore thought it advisable to restrict, for the greater part, our limited number of engravings to representations of characteristic or commonly-occurring corals, brachiopods, lamellibranchiates, gasteropods, cephalopods, and trilobites.

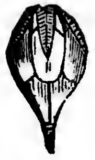

Fig. 84.

Pentremites (fig. 84) is the principal. It is chiefly characteristic of the Devonian and Carboniferous formations. A closely related form—separated generically under the name of Blastoidocrinus*—has been described by Mr. Billings from the Chazy limestone of the Trenton Group, a member of the Lower Silurian series, (Canadian Organic Remains: Decade IV.)

Fig. 85.

3. *Cystidea.*—The representatives of this Order are more or less closely allied to the crinoids. The cystideans possessed a globular or oval body attached to the sea-bottom by a short stem. The body was covered by polygonal plates, which in some genera were arranged in definite order, and in others, irregularly. Arms were either rudimentary or altogether wanting. The body openings were three in number, comprising (according to the more general view) an oral, anal, and ovarian aperture. The latter (or according to some palæontologists, the oral orifice) was surrounded by five or more triangular plates, forming a kind of pyramid. In addition to these openings, most genera exhibit a series of pores, either distributed irregularly over the body-plates or collected into lozenge-shaped areas termed "pectinated rhombs," see Fig. 85 (= *Glyptocystites Logani*, Billings).

The cystideans were limited entirely to the Lr. Silurian period. Not a trace of this Order is found in the rocks of any succeeding epoch. Various species, but mostly in a very fragmentary state, occur in our Canadian strata. These are illustrated and described by Mr. Billings in Decade III. of *Canadian Organic Remains*. The following is an analysis of the leading forms, extracted from a review, by the writer of this Essay, in the Fourth Volume of the *Canadian Journal* (*New Series*.

"With regard to the recognised species of Canadian cystideæ, Mr. Billings describes nineteen new forms, belonging to his genera, Pleurocystites, Glypto-

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* *Pentremites* exhibits three series of plates (exclusive of the Ambulacroid series): Basals Radials, and Inter-radials, the latter resting upon the radials in alternate position. The radials are comparatively large, the inter-radials small, so that the ambulacroids extend into the former. In *Blastoidocrinus* the reverse of this takes place. The inter-radials are large, and the ambulacroids do not extend below them.

cystites, Comarocystites, Amygdalocystites, Malocystites, Palæocystites, and Ateleocystites. The genus Pleurocystites is a very remarkable one. It is chiefly characterised by the dissimilar structure of the two sides of the body; a series of comparatively large plates covering the dorsal side, whilst the ventral side consists of an open space protected by an integument covered with numerous small plates. The genus, with us, appears to range from the Chazy to the Hudson River group; and geographically from Canada to Wales and Bohemia (Caradoc group and Barrande's *étage D.*) Six species are enumerated: *P. squamosus* (plates plane or slightly concave; pectinated rhombs, with obtuse angle above); *P. robustus?* (plates concave); *P. filitextus* (pectinated rhombs with acute angle above; plates on ventral side fewer and larger than in *P. squamosus*); *P. elegans; P. exornatus;* and *P. Anticostiensis* (plates probably smooth). *P. elegans* and *P. ornatus* may perhaps prove eventually to be mere varieties of *P. filitextus.* The genus Glyptocystites is characterised chiefly by its cylindrical body, enclosed in four series of plates (= 4 basal + 5 + 5 + 5) some with re-entering angles; and by the presence of *ten or more* pectinated rhombs, a strikingly peculiar character. It ranges from the Chazy to the Trenton group, and comprises the following species: *G. multiporus* (arms 4+ 1, extending down the sides of the body); *G. Logani* (plates with stellar ridges, arms not developed: Trenton): *G. gracilis; G. Forbesi* (plates large and strong, with numerous ridges and striæ: Chazy). Of the genus Comarocystites only one species, *C. punctatus*, has been recognised. It occurs in the Trenton group, and may be readily distinguished by its deeply-concave plates. The basal plates are three in number, succeeded by from eight to eleven irregular rows; the mouth is provided with a valvular apparatus, and there are *free arms.* The genus Amygdalocystites possesses the same plate-formula as Comarocystites, and the mouth is also furnished with a valvular apparatus; but, in addition to other distinguishing characters, the arms are recumbent, and composed of a double in place of a single series of joints. Three species are enumerated. One of these, however, may belong to a distinct genus, and the other two may perhaps be united. They comprise: *A. florealis*, *A. tenuistriatus* (?), and *A. radiatus.* In both Comarocystites and Amygdalocystites the plates are without pores, at least on the unworn external surface. The genus Malocystites has likewise an indefinite number of non-poriferous plates.* The arms are recumbent, and the mouth is nearly at the apex of the cup. Two species are described: *M. Murchisoni*, with eight long and winding arms, and *M. Barrandi*, with two short arms. In the genus named Palæocystites, the plates are numerous and also poriferous, or rather crypto-poriferous, as the pores do not extend directly to the outer surface, but communicate with the interior through the sutures, on the edges of which they open. Nothing is known respecting the arms, orifices, and stem. Three species are enumerated: *P. tenuiradiatus*,† *P. Dawsoni*, and *P. Chapmani*,

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* As subsequently shown, however, by Mr. Billings, the pores in Comarocystites appear to open out on the sides of the plates at the sutures, as in the genus Palæocystites. May not this be the case, also, with regard to Cryptocrinus (Von Buch), and the other so-called non-poriferous types?

† This is the *Actinocrinus tenuiradiatus* of Hall. The other species appertaining to the different genera enumerated in the text, belong entirely to Mr. Billings.

but their specific characters are necessarily somewhat obscure. Finally, in the genus Ateleocystites, a single species, *A. Huxleyi*, is mentioned. The calyx in this form appears to have, as in Pleurocystites, a dorsal side made up of comparatively few plates, with numerous small plates on the ventral side. In other respects, however, the genus is a very peculiar one, and perhaps referable to a distinct group."

4. *Thyroida.*—This Order is represented by a single genus, *Agelacrinites:* a peculiar type, connecting the cystideans with the star-fishes. It presents a somewhat flat, circular form with a five-rayed star at the upper part, each ray being composed of two series of interlocking plates, whilst the intermediate spaces are covered by numerous scale-like imbricating plates, arranged more or less irregularly. The rays in some species are long and curved, and in others straight and short. Between two of these rays there is a circular opening, covered by five or ten triangular plates in the form of a "pyramid," as in the cystideans. The genus ranges from the Lower Silurian to the Carboniferous formations. Figure 86 represents *Agelacrinites Billingsii* of the Trenton limestone (Lower Silurian). Other species from the same formation, *A. Dicksoni* and *A.* (*Edrioaster*) *Bigsbyi*, have long curved rays. (Decade III. "Canadian Organic Remains." See also for a more complete description of A. Billingsii, a paper by the writer in the *Canadian Journal*, Vol. V., p. 350, and in the *Annals of Natural History*, August, 1860.)

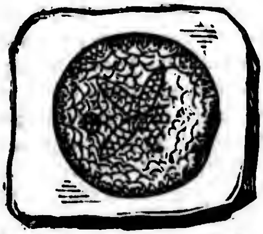

Fig. 86.

5. *Asterida.*—This Order includes the greater number of the so-called star-fishes. The body is covered by a thick skin, strengthened by plates and tubercles of carbonate of lime. There is no stem, and the mouth is always on the underside of the body, in the centre of the arms or rays. These are five or more in number. The visceral cavity or stomach extends into them. Species occur in all formations from the Lower Silurian upwards, but the Order appears to be more numerous in existing seas than in the waters of any former epoch. In the Third Decade of Canadian Organic Remains, Mr. Billings describes several species from the Lower Silurian rocks. These are placed under the following genera, but specimens, it should be observed, are of rare occurrence, and the characters of those obtained are more or less obscure.

Palasterina.—Five rays, with intermediate connecting area.
P. stellata, more or less regularly pentagonal.
P. rugosa, dorsal plates in part stelliform (ventral aspect unknown.)

Petraster.—Connecting area very slightly developed. Large marginal plates. *P. rigidus*, (characters imperfectly known.)

Stenaster.—No connecting area. Rays without spines or overlapping plates. *S. Salteri*, rays comparatively broad.
S. pulchellus, rays long and narrow.

Tæniaster.—No connecting area. Rays narrow, covered in part with spines, and with their outer, or adambulacral, plates partly overlapping. *T. spinosus; T. cylindricus.* (The latter of these is apparently the larger and more robust species of the two, but otherwise the characters are much alike).

In addition to these forms, small and more or less imperfect specimens of Asterida, probably referable to Hall's genus Palæaster, are occasionally obtained from the Niagara limestone of the Upper Silurian Series.

6. *Ophiurida.*—The star-fishes of this Order differ from the Asterida proper, in having their arms or rays quite distinct from the central visceral-cavity. With the exception of a doubtful fragment from the eastern Post-Tertiary deposits (see *Part V.*), no examples have as yet been noticed in Canadian rocks.

7. *Euryalida.*—In this Order, the arms and stomach are also distinct, but the body is only partially covered by calcareous plates. No fossil representatives.*

8. *Echinida.*—This is an important Order, but fossil representatives are all but unknown below the Mesozoic rocks, and none (with the exception of a modern form in the Post-Tertiaries of Beauport, see Part V.) are of Canadian occurrence. The echinids, of which the modern "sea-egg" or "sea-urchin" may be taken as a type, have no arms. The body is hemispherical, oval, cordiform, &c., and covered by a calcareous test or shell, composed of polygonal plates joined at their edges. Some of these plates, in radiating areas termed "ambulacra," are perforated for the passage of retractile respiratory tubes. The test, moreover, is covered by moveable calcareous spines (which fall off after the death of the animal); and it has always two openings, one of which, the mouth, is invariably situated on the under side of the body. In existing seas these forms are exceedingly abundant, and they appear to have been equally numerous in the seas of the Cainozoic and Mesozoic ages (see Table of Formations, page 93, above).

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* The *Protaster* of E. Forbes is now referred to the Ophiurida.

In the Palæozoic deposits, on the other hand, only three or four genera have been met with, and examples of these are rare. As already remarked, our Canadian rocks of this age have not yet offered any representatives of the Order.

9. *Holothurida.*—This Order comprises various more or less soft-bodied marine animals, of which the Holothuria or "sea-cucumber" may be taken as the type. Fossil representatives are of exceedingly doubtful occurrence. None belong to Canadian rocks.

Molluscous Animals.—The forms of the sub-kingdom MOLLUSCA may be arranged under the following groups and classes:—*A. Coralliform Mollusca:* 1, BRYOZOA. *B. Acephalous* (*or headless*) *Mollusca:* 2, TUNICATA, (no fossil representatives); 3, BRACHIOPODA; 4, LAMELLIBRANCHIATA. *C. Encephalous Mollusca*: 5, PTEROPODA; 6, HETEROPODA; 7, GASTEROPODA; 8, CEPHALOPODA.

BRYOZOA.—The bryozoons (so named from the general moss-like aspect of their united cells) are minute animals of marine habitat. They form cell-colonies after the manner of most coral animals, but present a higher organization than these latter. They possess a distinct oral and anal cavity, and assimilate in many other respects to the molluscous type. The compound cell-structure in some forms takes the shape of leaf-like expansions, and in others is either dendritic, plumose, rounded, or irregular. It is also either free, or attached by growth to shells and other sub-marine bodies.

Modern bryozoons abound in all seas. Fossil forms of this class are also exceedingly numerous, ranging throughout the entire series of fossiliferous rocks. Their separation from corals is, in many instances, however, a task of much perplexity; and, as those found in our Canadian strata are of little importance as test-forms, we confine our illustrations to a single example, ***Fenestella elegans***, (Fig. 87), from the Niagara Group of the Upper Silurian Series. Representatives of the class, it may be observed, occur as low down as the Calciferous-Sand-Rock (see PART V.); and Professor Dawson, on the other hand, has found a number of species identical with existing forms, in the Post-tertiary deposits of Eastern Canada. These are described in the fourth volume of the ***Canadian Naturalist***.

Fig. 87.

The *Graptolites*, already described as a section of the POLYPIFERA or CORALS, (see page 105, above) are referred by some palæontologists to the present class.

BRACHIOPODA.—The brachiopods are marine, headless mollusks, provided with a bivalve shell. The valves of this shell are always of unequal size; and one is situated on the dorsal, and the other on the ventral side of the animal. The ventral valve is almost invariably the larger of the two, and without reference to the anatomy of the mollusk would be naturally taken for the dorsal valve. The valves, though unequal in size, are "equilateral"—*i. e.*, a vertical line drawn straight through the middle of each valve, divides the shell into two exactly equal parts. This serves to distinguish at a glance a brachiopod shell from the shells of other bivalves: or at least from the great majority of these, as some few, the *Pectens* for example, have nearly equilateral shells. A depression or "sinus" frequently occurs down the centre of one valve, and a corresponding projection or "mesial fold" down the centre of the other. The sinus is almost invariably on the ventral, and the fold on the dorsal valve. The pointed upper extremity of the valve, is technically known as the "beak." In some forms the valves are close together; but in others, a closed space (often striated across) occurs between the two. This is called the "area." See Fig. 88 and accompanying explanation. In the centre of the area, or under the beak of the ventral valve, there is frequently (as in the *spirifers*, &c.,) a triangular or circular orifice, the "foramen." This opening, in the species which possessed it, served for the passage of the pedicel by which the animal was attached to the sea-bottom. The foramen is situated, at other times, upon, or near to, the ventral beak, as in *spirigera*, &c. In many species again, it appears to have become closed by age; and in others, it is altogether absent. The line of junction between the upper part of the valves is termed the hinge-line. It is straight in some genera, (*Orthis*, *Strophomena*, *Spirifer*, for example,) and arched or curved in others, (*Athyris*, *Rhynconella*, *Pentamerus*, *Terebratula*, etc.)

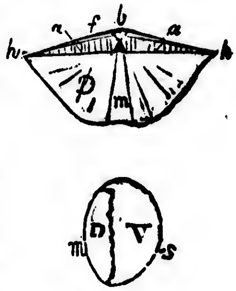

Fig. 88.*

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* *D*=dorsal valve. *V*=ventral valve. *a*, area; *b*, beak of ventral valve; *f*, foramen; *h*-*h*, the hinge line; *m*, position of mesial fold; *s*, position of mesial sinus.

In many brachiopods, the shell is traversed by minute pores or tubular prolongations. When this is the case, the shell is said to be "punctate;" and when the pores are absent, it is termed "impunctate."

The brachiopods possess, as their chief characteristic, a pair of long fleshy "arms," covered with delicate cilia, and either entirely confined in a coil within the shell, or capable of protrusion to a certain extent. In some genera, the inside of the dorsal valve carries peculiar spiral processes, or a shelly loop or other calcareous framework, for the support of these arms. A support of this kind is however wanting in many genera, or is otherwise merely rudimentary. The brachiopods differ essentially from the lammellibranchiate bivalves in the non-possession of distinct branchiæ or breathing gills. In existing seas the brachiopods are comparatively rare, the number of known species not exceeding fifty; whilst the fossil species discovered up to the present time, amount to over thirteen or fourteen hundred. They constitute moreover, at least ninety per cent. of the bivalve shells met with in the lower fossiliferous rocks.

The following are the more important genera of Canadian occurence: *Lingula, Orthis, Strophomena, Leptæna, Spirifer, Athyris, Spirigera, Atrypa, Rhynconella, Pentamerus, and Stricklandia.*

Lingula :—Shell: horny, thin, oblong, and nearly equivalve. Black and shining in our examples, and consisting largely (as first shewn by Prof. Sterry Hunt), of phosphate of lime. No internal calcareous appendages. This genus ranges from the Lower Silurian epoch into the present or existing period. Numerous species occur in our Silurian formations. *L. quadrata*, fig. 89, from the Trenton Limestone, Utica Slate, and Hudson River Group (Lower Silurian,) may be cited as a common example.

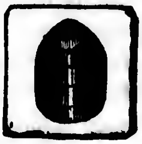

Fig. 89.

Orthis :—Shell calcareous. Bi-convex or plano-convex; with straight hinge-line, and punctate surface. No internal supports, properly so-called. This genus ranged throughout the Palæozoic age, but was most abundant during the Silurian and Devonian periods. The species have usually a more or less circular outline, with the surface of the shell marked by fine or course radiating lines. Canadian examples are exceedingly numerous; more especially those belonging to *O. testudinaria*, fig. 90, of the Trenton and higher divisions of the Lower Silurian series. Fig. 91 represents *O. pecti-*


Fig. 90.

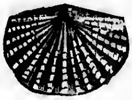
Fig. 91.

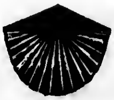
Fig. 92.


Fig. 93.


Fig. 94.

nella; fig. 92, *O. tricenaria,* and fig. 93, *O. lynx,* all of common occurrence in the Trenton Group. *O. elegantula* of the Niagara Group (Upper Silurian) is closely related to *O. testudinaria,* and has the general form of fig. 90. *O. Vanuxemi,* fig. 94, is a Devonian species. The Lower Silurian form, *O. lynx,* fig. 93, has the general aspect of a spirifer, but its mesial fold and sinus are marked by several plications, a character not exhibited by any of our Canadian Spirifers. It was formerly called *Delthyris lynx.*

Strophomena:—Shell, concavo-convex; hinge-line, straight; no internal supports. This genus ranges from the Silurian to the Carboniferous formation. Canadian examples are very abundant.


Fig. 95.

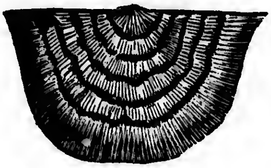
Fig. 96.

Fig. 95 represents *S. alternata,* a species of exceedingly common occurrence in the Trenton and Hudson River Groups (Lower Silurian.) *S. filitexta* is a closely related form. Fig. 96 exhibits another well-known species, *S. rhomboidalis* (=*Strophomena* and *Leptæna depressa,*) from the Niagara Group and other Upper Silurian strata, and also from the Devonian rocks of Western Canada.

In these latter rocks a few species of *Chonetes* and *Productus*, (genera allied to *Strophomena*,) also occur.

Leptæna:—This genus (or rather sub-genus,) merely differs from *Strophomena* by the character and elongation of its muscular impressions. *L. sericea*, Fig. 97, of the Trenton and Hudson River Groups, is a species of common occurrence.


Fig. 97.

Spirifer:—Shell with internal calcareous processes in the form of two spiral coils pointing outwards. Hinge-line straight, long; area well developed, with triangular foramen. The genus ranges from the Silurian to the Triassic (or Jurassic) epoch, but is chiefly characteristic of Upper Silurian, Devonian, and Carboniferous rocks. Fig. 98 represents *S. Niagarensis* of the Upper Silurian, and Fig. 99, *S. mucronatus* of the Devonian series. Both are of common occurrence. The hinge-line of the latter is sometimes shorter (as compared with the height of the shell,) than is shewn in the figure. In our Western Devonian rocks, several other species occur: as *S. duodenarius*, with eight or nine rounded ribs on each side of the mesial fold; *S. raricostatus*, with two or three coarse plications on each side of the fold; *S. gregaria*, a small species, &c. These are figured and described by Mr. Billings in the *Canadian Journal*, vol. VI. Another common species of the Upper Silurian series, is *S. radiatus*. This differs chiefly from *S. Niagarensis* by its finer and more numerous plications. A third Niagara species *S. sulcatus*, has about eight plications on each side of the mesial fold, crossed by the rough and strongly-pronounced edges of the layers of growth.

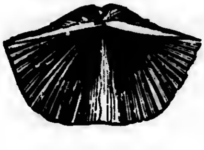
Fig. 98.

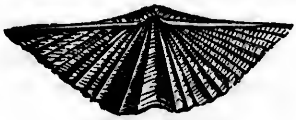
Fig. 99.

Athyris:—The shell in this genus has internal spires as in *Spirifer*, but the hinge-line is curved, and the area is absent or rudimentary. Species range from the Silurian to the Triassic formations. Several occur in our Devonian rocks. One of the most common of these,

Fig. 100

A. clara, (Billings,) is represented in fig. 100. *A. Maia* is a somewhat similar species, but with a more developed or longer mesial fold and sinus, and with a slight space or false area between the beaks. These and other Devonian species are described in detail by Mr. Billings, in the *Canadian Journal,* Vol. V.

Spirigera :—This genus or sub-genus differs from *Athyris* in having a perforation or foramen in the beak of the ventral valve. *S. concentrica* of the Devonian rocks is shewn in fig. 101. The genus *Retzia* is nearly allied to *Spirigera,* but the shells are smaller and strongly ribbed.

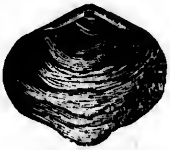

Fig. 101.

Atrypa :—A good deal of uncertainty still prevails with regard to the proper limitation of this genus. In outward form it agrees with Rhynconella, see below, but appears to possess internal calcareous spires, the points of which extend into the hollow of the smaller or dorsal valve. Fig. 102 represents an exceedingly common species, *A. reticularis,* of the Upper Silurian and Devonian strata, but chiefly characteristic of the latter.

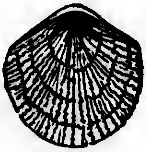

Fig. 102.

Rhynconella :—Shell, in general, strongly bi-convex. Hinge-line, curved; no area. No internal spires, but in the living species the arms are coiled spirally, the spires pointing downwards and inwards. The genus ranges from the Lower Silurian into the existing epoch. Fig. 103 represents a small form, *R. plena,* very common in the Chazy

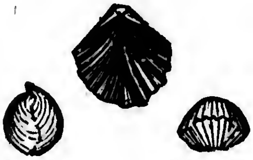

Fig. 103.

Fig. 104.

Fig. 105.

limestone of the Trenton Group, (Lower Silurian); and fig. 104, *R. increbescens*, a closely related species occurring abundantly throughout the Trenton limestone. In this latter species, the plications on the shell are crossed by well-marked imbricating lines of growth. Numerous examples of this genus occur also in our Upper Silurian and Devonian strata. A modern species, found in the Post-Tertiary deposits of Eastern Canada, *R. psittacea*, is figured in the woodcut 105.


Fig. 106.

Fig. 106 is a representation of the old *Rhynconella hemiplicata* of the Trenton Group, now referred by Mr. Billings to his new genus *Camerella*. It is characterized by a few broad plications on the lower part of the shell.

Pentamerus:—In this genus, the shell is prominently bi-convex, with arched hinge-line and large incurved beak. Internally it is divided by septa into several chambers. The genus ranges from the Silurian to the Carboniferous formations. *P. oblongus*, of the Niagara Group, is represented in fig. 107, the sketch 107 *a* shewing a ventral view of the internal cast. *P. aratus*, of the Devonian rocks, is figured in 108. This latter form is closely related to the well-known typical species *P. galeatus*.


Fig. 107.


Fig. 107 *a*.

Stricklandia:—This genus has been recently established by Mr. Billings. It includes certain more or less oval forms with nearly equal valves, formerly referred to *Pentamerus*. *S.elongata*, a Devonian species, is shewn in fig. 109. Other species occur in these and in the Upper Silurian rocks.

Fig. 108.

Fig. 109.

Our Canadian formations do not appear, as yet, to have offered any examples of the well-known genera, *Crania, Calceola*, and *Terebratula.*

LAMELLIBRANCHIATA (or CONCHIFERA.)—Lamellibranchiate mollusks are marine or fresh-water animals of the acephalous type. They are provided in the adult condition with laminated gills or branchiæ for breathing purposes, (as seen, for example, in the so-called "beard" of the oyster,) and they secrete a bi-valve external shell. The two valves in most genera (those of the *Ostreidæ* and some *Aviculidæ* are the only exceptions) are of equal size, but always more or less inequilateral. (See under the Brachiopods above). These mollusks are exceedingly abundant in the fossil state, though less numerous than the brachiopods in the older rock formations. The known species obtained from the seas, lakes, and rivers, of existing nature, somewhat exceed three thousand, whilst nearly double that number of fossil species have been recognized. These latter, however, belong it must be remembered, not to one period, but to many successive epochs; although on the other hand, it is manifest that we see in them merely an incomplete record of the lamellibranchiate fauna of the Past.

In their classification, the lamellibranchiate mollusks fall into two leading sections and four groups, as follows :

- (1) ASIPHONIDA
  - (1 *a*) *Pleuroconcha.*
  - (1 *b*) *Orthoconcha.*
- (2) SIPHONIDA
  - (2 *a*) *Integro-Pallialia.*
  - (2 *b*) *Sinu-Pallialia.*

The animals of the first section are without the peculiar respiratory tubes possessed by the SIPHONIDA. These latter, for example, have a pair of short or long siphonal tubes, which assist in the process of respiration, and which admit in the *Sinu-pallialia* of extension beyond the shell.

The *Pleuroconcha*, (group 1), of which the oyster may be taken as a type, rest in their natural position with one valve *below*, and the other *above*, and thus approximate to the Brachiopods. They have in general but one large muscular impression in the centre of the inside of each valve. This forms a shallow pit, occupied by the muscle which keeps the valves closed. The common fossil known as *Ambonychia radiata* (fig. 110) may be cited, though doubtfully, for its true affinities are still obscure, as an example of this division. It is exceedingly abundant in the Hudson River Group of the Lower Silurian series.


Fig. 110.

The forms of the second group, or *Orthoconcha*, (as restricted above*,) are also without siphonal tubes, but their valves are *right* and *left*, instead of *upper* and *under*, as regards the normal position of the animal, and the muscular impressions are two in each valve. The fossil species known as *Modiolopsis modiolaris* fig. 111, so common in our Hudson River Group, belongs in all probability to this division. The genus *Cyrtodonta* of Billings, (with its sub-genus *Vanuxemia*), may also be referred to the *Orthoconcha* of this Section. Fig. 112 represents the *Cyrtodonta Huronensis* (var. *subcarinata*) of the lower part of the Trenton Group. Another and more remarkable species of this genus—widely known as the *Megalomus Canadensis*, of Hall—occurs in great numbers in the Onondaga Salt Group, (Upper Silurian), of Canada West, and more especially in the neighbourhood of Galt. It is found chiefly in the form of internal casts, as shewn in the figures 113 and 113 *a*.


Fig. 111.

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* The term *Orthoconcha*, it should be observed, is applied by some palæontologists to our groups, 1 *b*, 2 *a*, and 2 *b*, collectively—the forms of the two first of these being united under the subordinate group of *Integro-Pallialia*.


Fig. 112.


Fig. 113.

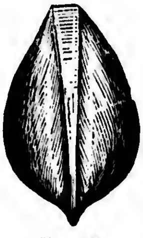
Fig. 113. *a*.

The *lamellibranchs* of the third group, *Integro-Pallialia*, have the upright (or right and left) position of the *orthoconcha* of Section I., but, unlike these latter, they possess a pair of short respiratory tubes. The muscular impressions, two in each valve, are connected, as in the forms of the last group, by an uninterrupted shallow groove or "pallial impression,"—*i.e.*, a continuous line without any bend or sinus in it. The existing fresh-water genus *Cyclas*, species of which occur in our Post-Tertiary deposits, and especially in those of Western Canada, may be cited as an example of the present group. (See PART V.)

Finally, the *mollusks* of the fourth group, *Sinu-Pallialia*, possess a pair of long siphonal-tubes, capable of extension beyond the shell; and their two muscular impressions are united by a more or less deeply sinuated pallial line. Many of these lamellibranchs burrow in the sand of the shores on which they live, between the tide-marks, with their respiratory tubes extending to the surface; and fossil examples occupying this upright position, and thus shewing the animals to have been fossilized in their original burrows, are met with in certain strata. As examples of the group, we may refer to *Mya truncata*, fig. 114, and to *Saxicava rugosa*, fig. 115, both of which are of exceedingly common occurrence in the Post-Tertiary deposits of Eastern Canada.

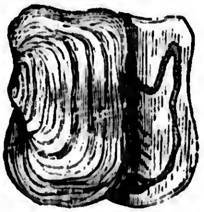
Fig. 114.


Fig. 115.

Pteropoda:—The living pteropods are swimming or floating mollusks, frequenting the open sea. Some few are naked, but the greater number secrete a delicate external shell (univalve), and all possess a pair of fins or wing-like appendages for natatory purposes. In the pteropods with shells, the head is more or less indistinct. The *Conularia* is the only form of Canadian occurence, referrible, and that doubtfully, to this class. Fig. 116 represents *C. Trentonensis* of the Trenton Group. The shell in this genus is more or less conical and four-angled, furrowed longitudinally, and marked transversely by numerous straight or zig-zag lines. These latter often resemble rows of minute punctures. The genus extends from the Lower Silurian division into the Lias formation of the Mesozoic rocks.

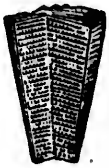
Fig. 116.

Heteropoda.—The representatives of this class are regarded by many naturalists as forming simply an Order (*Nucleobranchiata*) of the class Gasteropoda. They constitute however a truly aberrant group, having affinities with the Pteropods on the one hand, and with both Gasteropods and Cephalopods on the other. Existing forms, like the pteropods, are of pelagic habit, swimming, by means of a fin-like appendage, in the open seas. The swimming organ is a modification of the gasteropod foot: see below. Some are without a shell, whilst others secrete one of a fragile and delicate texture, sometimes provided, as in many gasteropods, with a lid or "operculum," by which the opening of the shell is closed when the animal withdraws itself within it. The fossil genera *Maclurea*, *Bellerophon*, and *Cyrtolites*, from certain characters which their shells appear to

Fig. 117.


Fig. 118.


Fig. 119.

possess in common with those of the modern genus *Atalanta*, are usually referred to this class; but much uncertainty still prevails with regard to the true affinities of these fossil types. The comparative solidity of the shell is opposed to their alliance with the *Atalantidæ*. Mr. Salter of the English Geological Survey, suggests, however, that *Maclurea* may have been a Heteropod with heavy shell, inhabiting the sea-bottom. Fig. 117, represents *Maclurea Logani* of the lower part of the Trenton Group; *a* is an inside view of the curious operculum often found detached. Fig. 118 is an example of *Bellerophon expansus*, and fig. 119 of *Cyrtolites ornatus*, of the Trenton and Hudson River Groups (Lower Silurian series.) By some palæontologists,* the genera *Bellerophon* and *Cyrtolites* are considered identical.

Gasteropoda.—The gasteropods have a distinct head; and all the typical species possess a fleshy expansion or foot on which they creep, and from which the class derives its name. The greater number secrete an external and univalve shell, but some few, as the common slug, are "naked" or possess merely a rudimentary shell; and in the *chitons* the shell is composed of several pieces. Some gasteropods, as the common snail, are terrestrial. Others, as the *limnea*, *paludina*, and *planorbis*, species of which are so common in our lakes and streams, inhabit fresh-water; but the greater number inhabit the sea. The class may be subdivided naturally into two leading groups: *Branchifera* or water-breathers, and *Pulmonifera* or air-breathers.

The *Branchifera*, furnished with gills or branchiæ for breathing the air contained in water, are all fluviatile or marine types. They fall into two sections: *Siphonostomata* and *Holostomata*. In the former, the opening or so-called "mouth" of the shell is more or less deeply notched at one or both extremities, or is otherwise lengthened into a kind of slit tube or "canal." The species are marine, and all are carnivorous. Comparatively few occur in the lower fossiliferous rocks, the place of the carnivorous gasteropods having been apparently supplied in great part, in the early geological epochs, by numerous predatory cephalopods. An example of this section is

Fig. 120.

shewn in fig. 120, representing a species of *Buccinum* (closely allied to the existing *B. undatum*, if not identical with that species,) from the Post-Tertiary deposits of Eastern Canada.

In the *Holostomata*, the aperture of the shell has an uninterrupted and more or less circular margin. The species are almost entirely vegetable-feeders. Representatives occur in all the fossiliferous rocks, and are numerous in existing Nature. The annexed figures represent several of our more characteristic Canadian examples. Figure 121 is the *Ophileta* (formerly *Maclurea*) *compacta* of the Calciferous-sand group (Lower Silurian.) Fig. 122 represents *Murchisonia gracilis*, (*a*, shewing internal cast); and fig. 123 exhibits a cast of *Murchisonia sub-fusiformis* of the Trenton and Hudson River Groups. *Pleurotomaria* (or *Trochonema*) *umbilicatula*, a common Trenton fossil, is shewn in fig. 124; and a cast of *Euomphalus rotundus* (?), a Devonian form, in figure 125.

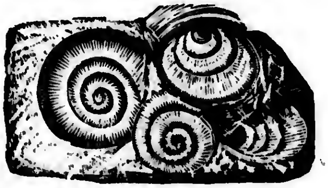

Fig. 121.

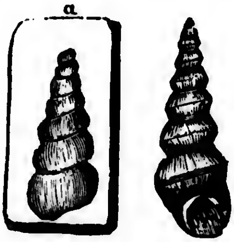

Fig. 122.

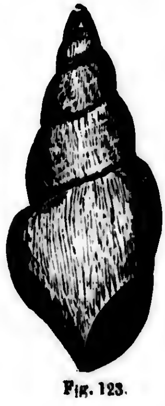

Fig. 123.

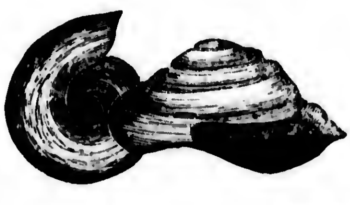

Fig. 124.

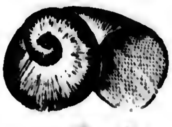

Fig. 125.

The *Pulmonifera*, in place of branchiæ, possess a simple form of lung-structure by which they breathe air directly from the atmosphere. Some, as the snails, are terrestrial; others inhabit ponds, streams, and fresh-water lakes. All are vegetable-feeders; and the shell, in those forms which secrete one, is more or less light and thin. Our only fossilized examples, comprising existing species of *Helix, Limnea, Planorbis,* &c., occur in the higher Drift or Post-Tertiary deposits of Western Canada. These will be referred to, more particularly, in PART V.

CEPHALOPODA.—The Cephalopods are the most highly organised representatives of the molluscous type. They possess a distinct head, furnished with large eyes and with a central mouth. The latter contains a pair of horny jaws or "beaks," (somewhat resembling, although in reversed position, the beaks of a parrot), and is surrounded by eight or ten arms, or by a greater number of tentacles, serving partly for locomotion, but chiefly for prehensile purposes. It is from the possession of these arms or tentacles, viewed as organs of locomotion, that the class derives its name of *Cephalopoda* or "head-footed." Its species are entirely marine. The Nautilus, the Argonaut or "Paper Nautilus," and the Sepia or Cuttle-fish, may be cited as characteristic living types.

The Cephalopods fall into two orders or leading groups, viz.: (1.) *Tetrabranchiata* or *Tentaculifera;* and (2.) *Dibranchiata* or *Acetabulifera.* The tetrabranchiate or tentaculiferous cephalopods possess four branchiæ or organs of respiration, numerous simple or unarmed tentacles, and a many-chambered shell. The dibranchiate or acetabuliferous cephalopods have only two branchiæ, and eight or ten arms; but the latter are provided on the inside with special organs of prehension in the form of *acetabula* or "suckers." These forms also possess a so-called "ink-bag," or internal sack, containing a dark fluid secretion which the animal can eject into the surrounding water when pursued or otherwise alarmed. A single genus, the Argonaut, inhabits a one-chambered shell. All the other genera are "naked," or without external shells, as seen in the Cuttle-fish. These dibranchiate cephalopods exhibit the higher organization, and approximate in some respects to the class of Fishes. Our Canadian rocks offer, however, no fossil representatives of this group, so abundant in existing Nature, and also to some extent so characteristic of the Mesozoic periods of the Earth's history. The tetrabranchiate cephalopods, on the other hand, are almost extinct. The Nautilus is the only remaining type; and of this, no more than two or three living species are known; whilst from rocks of various ages, upwards of 150 fossil species have been collected.

The shell in the tetrabranchiate group is divided into a number of compartments or chambers, by concave, sinuous, angulated, or highly-lobed partitions, called "septa"—the animal inhabiting the outer chamber—and it is traversed, throughout its entire length, by a tube or "siphuncle" of variable form and position. In the Nautilus, according to Professor Owen, this siphuncle opens into the cavity which contains the heart; and its use, although still doubtful, is thought to be to keep up the vitality of the shell in parts distant from the creature's body. It passes through the various chambers without affording any communication between these, so that the old idea respecting the use of the tube, and according to which the animal was thought by its means to be able to fill the chamber with water, or to eject this, in order to sink or rise at will, is now altogether exploded. Under ordinary conditions the nautilus appears to creep on the sea-bed, head downwards, at moderate depths, and to feed on holothuriæ, star-fishes, crustacea, &c. The accompanying diagrams, fig. 126, exhibit the marginal outline of the more general kinds of septa presented by the shells of this group. A simple septum of the *orthoceratites* and *nautilus* is represented by *a*; an angulated septum of the *goniatites* by *b*; a lobed and denticulated septum of the *ceratites* by *c*; and a foliated septum of the *ammonites*, *baculites*, *hamites*, &c., by *d*.

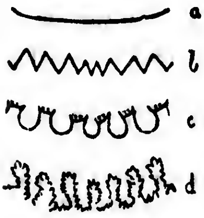

Fig. 126.

In accordance chiefly with these characters, the Tetrabranchiata, or chambered cephalopods, may be classed as follows:

Family I., Nautilidæ.—Septa with entire or slightly sinuous margins. Siphuncle, variable.

Sub-Family 1, *Gomphoceratidæ*.—Aperture of shell partly closed, or much contracted.

Sub-Family 2, *Orthoceratidæ*, or *Nautilidæ proper*.—Aperture more or less open.

Family II., AMMONITIDÆ.—Septa prominently lobed. Siphuncle "external," or along the apparent back of the shell.

Sub-Family 1, *Goniatidæ.*—Septa angulated, *i. e.*, with angular lobes.

Sub-Family 2, *Ceratidæ.*—Septa lobed and denticulated.

Sub-Family 3, *Ammonitidæ proper.*—Septa foliated.

The Ceratidæ and Ammonitidæ proper are entirely restricted to rocks of Mesozoic age, and are consequently unknown among Canadian fossils. (See the Table of Formations given at page 93 of this work, and also those of Canadian occurrence on the succeeding page). The sub-families of the Gomphoceratidæ, Orthoceratidæ, and Goniatidæ present Canadian examples; but those belonging to the first and last of these sub-families, are few in number and of comparatively rare occurrence; and even the Orthoceratidæ, though rich in examples, are confined, with us, to a small number of genera. It is not necessary, therefore, in describing these forms, to adhere to any close system of classification, more especially as the fragmentary or otherwise imperfect condition in which the fossil cephalopods of the lower rocks so generally occur, forbids in many instances the strict application of definite structural characters. This understood, our Canadian genera may be conveniently described in the following order: *Orthoceras* (including *Gonioceras*, &c., as explained below), *Cyrtoceras, Phragmoceras* (belonging to the first sub-family, but placed here, for convenience, as allied by form to cyrtoceras), *Lituites, Nautilus,* and *Goniatites.* Other genera, enumerated by palæontologists, and occurring with us, are distributed under one or more of these types.[*]

Orthoceras.—In this genus the shell is straight and conical, tapering more or less gradually from the body chamber to its other

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[*] Many of the genera hitherto established for the Tetrabranchiate Cephalopods can only be regarded as provisional. Characters until recently considered of generic value (and on which distinct genera have been founded by Pictet, D'Orbigny, Hall, and other palæontologists of authority), are now shewn to be more or less inconstant, and consequently of uncertain application. The siphuncle in its form and position, as regards at least the types with simple septa, appears more especially to be a character of this kind; but it may be questioned whether the mere shape of the shell, although a readily observable character in most instances, and hence a convenient one, is actually of any greater value. It would seem, for example, that relations quite as close must have obtained between an orthoceras with ordinary siphuncle and a slightly curved cyrtoceras—as between the former and an orthoceras (or endoceras) with a laterally-situated siphuncle of large size and more or less aberrant structure.

extremity. The septa are simply concave, or slightly sinuous, and at comparatively short distances apart. If we imagine the shell of a nautilus unrolled and straightened out, we have the typical orthoceras shell. The siphuncle is variable, both in shape and position. Three convenient, if not strictly natural, sub-genera, *Orthoceras proper*, *Ormoceras*, and *Endoceras*, may be founded on its characters. The genus ranges from the Lower Silurian into the Triassic formation. In many of its examples, the shell, if perfect, would shew a length of several feet.

The first sub-genus, *Orthoceras proper*, has a siphuncle in the form of a narrow tube, central or sub-central in position. *O. lamellosum* (fig. 127) and *O. bilineatum* (fig. 128), both from Lower Silurian Strata, are Canadian examples of common occurrence.

Fig. 127.

Fig. 128.

The second sub-genus, *Ormoceras*, comprises the various orthoceratites (as the species of the genus Orthoceras are collectively termed) with moniliform or "beaded" siphuncle, as shewn in *Ormoceras tenuifilum* (fig. 129) from the Trenton limestone and lower beds. This sub-genus includes the Huronia and Actinoceras of authors, and also the peculiar flattened species named *Gonioceras anceps* by Hall. This latter form is an Orthoceras with beaded siphuncle and slightly sinuous septa, and with a shell so compressed as to offer almost trenchant edges. Fig. 130 represents a fragmentary specimen. The species is very common in the Chazy and Black river limestones at the lower part of the Trenton group. In weathered specimens, both of this and other species of *Ormoceras*, the outer portion of the shell is often obliterated, when the beaded siphuncle with its attached septa, has a certain resemblance to the vertebral column of a fish. Weathered specimens of this kind are

Fig. 129.
A worn fragment shewing siphuncle and septa.

Fig. 130.

usually described by quarrymen and farmers as fish remains; but no vestiges of a true fish, or other vetebrated type, have as yet been discovered in our Silurian strata.

In the third sub-genus, for which, without regard to the supposition originally involved in the term, Prof. Hall's name of *Endoceras* may be retained, we may place the orthoceratites with very large and laterally-situated or more or less marginal siphuncle. *Endoceras proteiforme*, of Hall, (fig. 131), is a familiar Canadian example. The siphuncle, in this species, often contains a long cone of calcareous matter, made up of successive layers. This secretion probably served to counterbalance the increasing buoyancy of the shell, as the air-chambers during the growth of the latter became more and more numerous. The shells of smaller orthoceratites are also sometimes found, with other accidental bodies, in the interior of these large siphuncles. Examples of *Endoceras proteiforme*, five or six inches in diameter, and in fragments of over eighteen inches or two feet in length, have been obtained from the Trenton limestone of Nottawasaga township, near Collingwood, C. W.; also from Belleville; and from the Hudson River beds of the River Humber, near Toronto, as well as from other parts of the Province. One of the largest specimens, yet collected, was obtained by the writer from the shores of Georgian Bay, (Lake Huron,) and is now in the Museum of the Toronto University.

Fig. 131.

NOTE:—We have retained for the orthoceratites described above, the specific names by which they are familiarly known in Canada, after the determinations ofProf. Hall in his "Palæontology of New York." But *Orthoceras lamellosum* is probably identical with the European species, *O. regulare;* whilst *O. tenuifilum* may perhaps be referred to *O. cochleatum* (Schlotheim); *O. bilineatum* to *O. calamiteum* (Munster); and *Endoceras proteiforme* to Schlotheim's *O. vaginatum. Gonioceras anceps,* on the other hand, is quite distinct from the *Orthoceras anceps* of De Koninck, and also from the earlier and doubtful *O. anceps* of Count Munster. An extended discussion of synonymes, or minute comparison of specific details, would be quite out of place, however, in an Essay of the present character.

Cyrtoceras:—This genus includes the *curved* orthoceratites with normal shell-aperture. The septa are simply concave, or slightly sinuated, and the siphuncle variable. Its forms, as at present known, may be arranged under two sub-genera, representing the first and third amongst the straight or true orthoceratites. The genus ranges from the Lower Silurian into the Carboniferous formation.

The first sub-genus, *Cyrtoceras proper,* has a gradually tapering and more or less slightly curved shell, with small siphuncle: the latter occupying a central or sub-central position, or lying along the larger curve of the shell. Fig. 132 is a sketch of *C. annulatum* from the lower part of the Trenton group.

In the second sub-genus, characterised by a large siphuncle as in the endoceratites, we may place the *Piloceras* of Salter. This form presents short, thick, and slightly curved shells with large siphuncle. The latter often contains a cone of calcareous matter, as in *Endoceras proteiforme.* The type, as yet, is comparatively rare, but a species has been discovered in the Calciferous Sand Rock of the Mingan Islands, by Sir William Logan and Mr. Richardson. This is described by Mr. Billings in the *Canadian Naturalist,* Vol. V., p. 171. In making *Piloceras,* however, merely a sub-genus of *Cyrtoceras,* as explained above, we follow our own views.

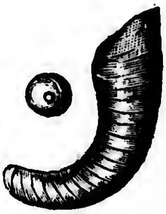

Fig. 132.

Phragmoceras:—This genus, in form, is closely allied to *Cyrtoceras,* and is also confined to Palæozoic rocks. The shell is curved, and the septa simple or slightly sinuated; but the aperture of the shell is more or less strongly contracted. The siphuncle is variable, although in most species hitherto referred to Phragmoceras, it lies along the shorter curve of the shell. In the Bohemian *P. perversum* of Barrande, and in the *P. præmaturum* of Billings, it occupies, nevertheless, the convex side. Fig. 133 represents a fragment of the latter species (after Billings), from the Black River Limestone of La Cloche Island, Lake Huron.

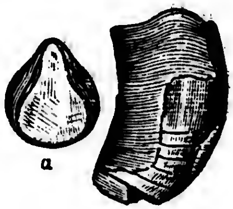

Fig. 133.
a. Represents the aperture.

Fig. 134.

To this genus, Hall's *Oncoceras constrictum* (fig. 134) should also be referred. This species is exceedingly common in the lower part of the Trenton group; but when in imperfectly preserved specimens, it cannot be distinguished from a cyrtoceras. The siphuncle is near the outside or larger curve of the shell.

Lituites:—The shell in this genus, is involute or "rolled up" (like that of the nautilus) for a certain distance, and is then projected in a straight line. The septa are simply concave, and the siphuncle of small size and mostly central. Species have not been found as yet above the Silurian rocks. In fragmentary specimens, however, it is often impossible to determine the genus—the straight part of the shell resembling that of an orthoceras with narrow siphuncle, and the involute portion being identical with the shell of a nautilus. Fig. 135 represents the *Lituites undatus* of Hall. Examples having a general resemblance to this, but (as first pointed out by the writer) with external siphuncle, occur in our Lower Silurian beds, at Lorette near Quebec, and elsewhere.

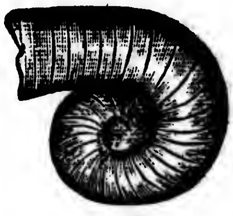

Fig. 135.

Nautilus.—This genus is one of peculiar palæontological interest, as the only living type of the great group of tetrabranchiate cephalopods, or those inhabiting a many-chambered shell. It passes (although with diminished, and, of course, with changing species) from the Silurian epoch into the existing age—its fossil representatives traversing the rocks of all intervening periods. The shell is involute, the septa simple, and the siphuncle mostly central in position. Our Canadian examples are scarce, and have not yet been thoroughly determined.

Goniatites.—This genus first appears in Devonian strata, and becomes extinct in the Triassic deposits. It belongs, as already stated in our introductory remarks, to the family of the Ammonitidæ, and is essentially characterized by its angulated septa (see fig. 126, above). The shell is involute in form, like that of the nautilus, and the siphuncle external and of small size. Several species occur in the Devonian rocks of Western Canada, but the relations of these have not yet been fully worked out.

As already explained on a preceding page, the second or Dibranchiate Order of Cephalopods—comprising the Argonaut, the Octopus or "Poulpe" of the French, the Loligo, (more familiarly known as the Calamary or Squid), the Sepia or Cuttle-Fish, the extinct Belemnite, and other kindred genera—are without representatives in rocks of Canadian occurrence.

Articulated Animals.—The forms of the sub-kingdon *Articulata* (see above, p. 98), are arranged in the following classes:—ANNELIDA, CIRRHOPODA, CRUSTACEA, ARACHNIDA, MYRIAPODA, and INSECTA; but of these, the annelids, cirrhopods, and crustaceans are alone represented by fossil examples in Canadian rocks.

ANNELIDA.—The annelids comprise various worm-like forms, and are usually grouped in three Orders:—*Abranchiata, Dorsibranchiata,* and *Cephalobranchiata.* The abranchiate annelids are without any visible or external branchiæ. They include the common earth-worms and other forms unrepresented in the fossil state. The dorsibranchiate annelids are marine worms with tufts of branchiæ in the form of delicate filaments at regular distances along the sides of the body. They offer a few fossil species, but have not been recognized in Canadian rocks. Finally, the cephalobranchiate annelids, also marine types, possess thread-like branchiæ around the mouth or head. Some of these forms secrete a calcareous tube or shell for the protection of the worm-like body. These constitute the genera *Serpula* and *Spirorbis:* the former having an irregular wavy tube, whilst in the latter the tube is spirally rolled up. These tubes are mostly attached to the backs of shells or other sub-marine bodies. A fine species of serpula, *D. splendens,* seven or eight inches in length, and a quarter of an inch across the opening, has been described by Mr. Billings from the Chazy limestone of the Lower Silurian Series (*Canadian Nat.*, vol. iv., page 470). Other genera of cephalobranchiate annelids form a protecting tube or sheath of fragments of shells or grains of sand (*Terrebella, Sabella*); but our rocks have not yet offered any examples of these.

Cirrhopoda.—The cirrhopods form a small group of marine animals, sedentary in their adult condition, and more resembling mollusks at first sight than members of the articulated series. They secrete an external many-valved shell, and possess a number of delicate plume-like cirrhi, or so-called "arms," capable of protrusion beyond the shell, and of thus creating currents in the water, by which food is brought within the creature's reach. There are two more or less distinct types: *pedunculated* and *sessile* cirrhopods. In the former, to which the well-known barnacles belong, the animal is attached, head downwards, to ships' bottoms, pieces of floating timber, &c., by a kind of semi-corneous stem; whilst in the latter, typified by the *balanus* or "sea acorn," the shell is fixed directly by its base to rocks and other sub-marine bodies, or to such as lie between the tide-marks.* Fig. 136 represents a group of several *balani*, to shew the general form of the shell. Fragments of one or two species occur in our Post-Tertiary or comparatively modern deposits, at Beauport and elsewhere in Eastern Canada (see Part V.); but no cirrhopods are met with in our lower rocks. The *balanidæ*, indeed, appear to date only from the Tertiary age, although the *anatifidæ* or pedunculated forms exhibit representatives as low down as the Jurassic series, and perhaps in still older deposits.

Fig. 136.

Crustacea.—This important class, abundant at the present time in genera and species, is sub-divided into a considerable number of Orders; but, of these, two only, embracing the *Cyproids* and the *Trilobites*, present examples of common occurrence in Canadian rocks. The higher and more typical forms of the crustaceans—the *Decapods*—comprising the various lobsters, crabs, and other allied species—offer no representatives below the Carboniferous formations.

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* The balani, though usually fixed to stationary bodies, are sometimes, like their cousins the barnacles, fated to a more or less migratory life. We carried off surreptitiously from a public dinner table, a short time ago, the beak or projecting part of the head-covering of a large lobster, to the extremity of which a full grown balanus was attached. The specimen may be seen, by the curious in such matters, in the Museum of the Toronto University.

Cyproids, or *Bivalve Entomostracans.*—The crustaceans of this order are more or less minute forms, partly inhabitants of the sea, or of brine solutions, and partly of fresh water. The existing marine types belong mostly to the genus *Cythera* or *Cytherina*: the others to the genus *Cypris*. In each, the form is closely alike; and in fossil species the one is scarcely to be distinguished from the other, except by its associated fossils. In living forms, the minute animal is seen to possess a delicate bivalve shell, with curious tufted feet and antennæ, which it projects beyond the shell when swimming. These little crustaceans occur in rocks of all ages, and much resemble, in the fossil state, small scattered grains or seeds (fig. 137). The shell is frequently brown and lustrous, and usually oval or semi-circular in shape. Canadian genera (Organic Remains, Decade IV.,) have been referred to *Beyrichia*, *Leperdita*, &c., but their characters are quite microscopic and more or less indistinct.

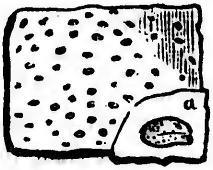

Fig. 137.
a. = Magnified Specimen.

Trilobites.—This order is entirely extinct. Its representatives—evidently marine types—are confined to the lower and middle portion of the Palæozoic series; or range, in other words, from the earliest fossiliferous rocks into the base of the great Carboniferous formation. Above the deposits of the latter geological horizon, not a trace of a trilobite has been discovered. The nearest existing type to this extinct group, appears to be the *Limulus*, or "King-crab"—a form which must be familiar to all who have visited the New England coast.

The shelly covering of the back, with a portion of that which protected the under side of the head, are the only parts of these crustaceans which have been preserved to us. The back (see fig. 138) consists of three principal parts: the *Buckler* or *Head-shield*, *H*; the *Body* or *Thorax*, *T*; and the *Pygidium* or *Caudal-shield*, *P*. The shell, moreover, in most instances, is strongly tri-lobed by two longitudinal furrows, as shewn in the figure. From this character the order derives its name.

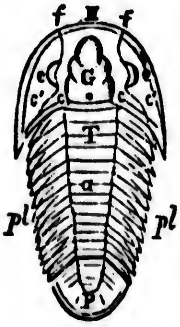

Fig. 138.

In the centre of the head-shield there is usually a distinctly raised portion (=G in fig. 138) called the *glabella*. It is bounded laterally bythe two longitudinal furrows mentioned above; and is either smooth, or variously lobed, furrowed, or granulated. In some genera it expands anteriorly, or towards the upper part; and in others it becomes contracted in this direction. The head-shield in most genera exhibits also on each side of the glabella a sutural line—called, technically, the *facial* suture—as shewn at *f f* in Fig. 138. The direction of the facial suture differs somewhat in different genera, as explained in our descriptions of these, below. In some few (as in Trinucleus) again, it is either absent, or concealed by being situated along the edge of the shield. The eyes (*e e*) when present, occur on each side of the head-shield, in the line of the facial suture, as shewn in the figure. They are compound, as in existing crustaceans, insects, &c.; and the component facets in certain genera (*Dalmannites*, *Phacops*) are thrown up in strong relief, forming the so-called *reticulated eye*. In other trilobites the reticulation is less distinct.[*] The sides of the head-shield or "cheeks," (c′ c′), often separate along the facial suture, and are found detached. The shell is continued over the head-shield; and under the glabella, where the mouth was situated, a so-called *hypostoma* or *labrum* is occasionally found. This, which is also and more commonly met with in a detached state, is generally of an oval form; but in the genus *Asaphus* (see below) it is hollowed out into a fork, or is somewhat of a horse-shoe shape. The hinder or lower extremities of the head-shield are rounded in some species, whilst in others they terminate in long or short horns.

The body or thorax of the trilobite is composed of a series of separate rings or segments, varying in number in different genera. Each segment is sub-divided into three parts by the two longitudinal furrows already alluded to. The middle part, or that between the furrows, is generally known as the *axis*, whilst the outside portions are called sides or *pleuræ*. These latter have their ends rounded in some species, and pointed, or even prolonged into spines, in others. In some, also, there is a raised band on each pleura, and, in others, a groove or furrow. Detached segments, or the three-curved impressions of these, shewing their trilobed character, are frequently seen in our Utica Slate and other fossiliferous rocks. The greater or less degree of mobility with which the thoracic segments were endowed,

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[*] In the genus *Harpes*, according to Barrande, the eye is pseudo-compound, consisting of simple stomata in merely approximate union. See an article by the writer, on the classification-characters, &c., of the Trilobites, in the *Canadian Journal*, Vol. I., pp. 271-286.

permitted the trilobites to bring the under parts of the caudal and head-shields together, both for the protection of the soft or undefended parts of the body, and also, in all probability, to enable the creature to sink with greater rapidity into deeper water during moments of danger or alarm. Specimens in this "rolled up" condition are of very common occurrence (see fig. 143 *a*, and 144).

The shell covering of the *pygidium* or "tail" (*P* in fig. 138), consists of a single or entire piece: or rather, perhaps, of various consolidated segments. It is very generally met with detached from the other portions of the body. Its outline is either rounded, pointed, or digitated; and it sometimes terminates in a long spine, or exhibits several spinous processes. In some genera it is very small, whilst in others it equals the head-shield in size.

The more important genera and species of Trilobites, occurring in Canadian rocks, are enumerated below:

Trinucleus.—Head-shield surrounded by a perforated border; glabella, globose and strongly pronounced; eyes, wanting. Six body-rings. Caudal-shield of moderate size. *T. concentricus* (fig. 139), of the Trenton and Hudson River Groups, is our only species; but examples of this (in a more or less fragmentary state) are common. When perfect, the corners of the head-shield terminate in horns, and a spine projects backwards from the base of the glabella. Average length between one and two inches.

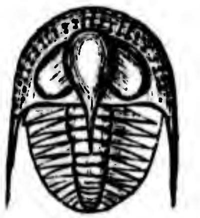

Fig. 139.

Asaphus.—Head, thorax, and pygidium, of about equal size. Glabella smooth or slightly furrowed, and not much raised. Eyes tolerably near together. Hypostoma forked. Body-rings, eight in number. Our two most common species comprise *A. platycephalus*, formerly called *Isoteles gigas* (fig. 140), with rounded head angles and nearly smooth pygidium, chiefly from the Trenton Group; and *A. Canadensis* (Fig. 141), with head-angles terminating in points, and with furrowed pygidium, from the Utica Slate deposits. Fragments of this latter form, and sometimes entire specimens, occur in great abundance at Collingwood and at Whitby (see *Canadian Journal*' Vol. III., p. 230). The forked hypostoma is shewn at *a* in the above figures. Another species, *A. megistos*, with smooth pygidium and horned head-shield, is also common in the Trenton Limestone of Cobourg, C.W. The genus *asaphus*, both on this Continent and in

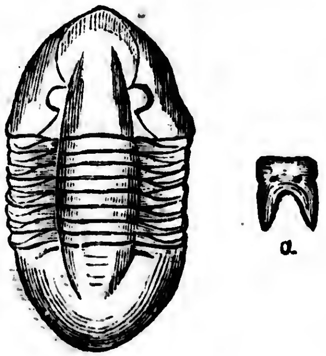

Fig. 140.

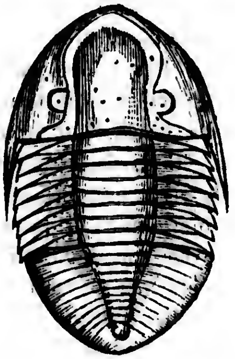

Fig. 141.

Europe, does not pass out of the Lower Silurian series. Examples vary in length from less than an inch to over eighteen or twenty inches.

Ogygia:—This genus resembles *Asaphus* in its general aspect, number of body-rings, &c., but possesses an *oval* in place of a *forked* hypostoma. It is often impossible to decide, consequently, as to which genus fragmentary examples should be referred. Under *Ogygia*, the *Dikelocephalus* of Dale Owen, and the *Bathyurus* of Billings, should probably be placed. Several species of these, although in a more or less imperfect condition, have been found in the Quebec group (see Part V.) of Point Levi, and also, as regards *Bathyurus*, in the corresponding Calciferous Sand Rock of the Mingan Islands, as well as in the Chazy Limestone of Grenville, &c. The body-rings in the latter type are perhaps nine in number, but few specimens, in which they are complete, have as yet been met with. Fig. 142 represents a fragmentary example of *B. Angelini*, after a figure by Mr. Billings, from the Chazy limestone. A portion of the head-shield of *B. Saffordi*, copied also from Billings, is shewn at *a*. In *Dikelocephalus*, the pygidium has often a deeply serrated or spinose margin; but it may be

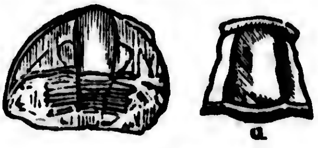

Fig. 142.

questioned whether all the separated caudal-shields referred to that type, really belong to it.* The species are restricted, as far as present observation goes, to the lowest fossiliferous zone.

Illænus:—In this well-characterized genus, the shell-covering is more or less smooth and comparatively free from furrows. Head, thorax, and pygidium are in most specimens nearly equal in size. Glabella broad, but feebly raised or otherwise defined. Eyes far apart. Body-rings generally ten (rarely eight or nine) in number. Pygidium almost or quite smooth, with even, rounded outline. The genus belongs to both the Lower and Middle Silurian deposits, but is chiefly found in the middle and higher parts of the lower series. Fig. 143 represents one of our most common species, from the Trenton and Hudson River groups. It is usually referred to *Illænus crassicauda*. A "rolled-up" example is shewn at *a*.

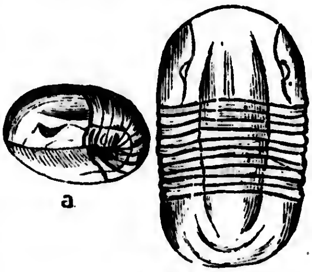

Fig. 143.

Phacops:—Glabella largely developed, expanded anteriorly, and often granulated but not lobed. Facial-suture cutting the sides of the head-shield. Eyes strongly reticulated. Head-angles and pleuræ with rounded ends. Body-rings eleven in number. Pygidium with rounded or entire outline. Range of genus, Lower Silurian to Devonian. *Phacops bufo* (fig. 144) from the Devonian beds of Western Canada, is one of our most characteristic and and best known species.

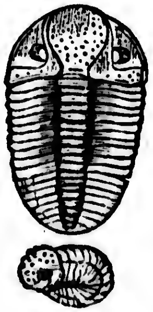

Fig. 144.

Dalmannites:—Like *Phacops*, but with lobed glabella, head-angles extended into horns, and pointed or spinose pleuræ. Pygidium also with more or less spinose margin, or otherwise terminating in a point or spine. Fig. 145 represents *Dalmannites limulurus* from the Niagara group. The caudal spine, in many specimens, is broken off.

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*The caudal-shield referred to *Dikelocephalus magnificus* (*Can. Nat.*, Vol. V., p. 307) appears to have equal if not greater claims to be placed under *Ceraurus*.

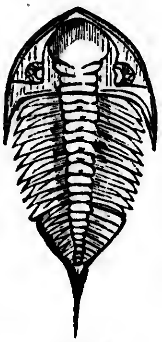

Fig. 145.

The reader will find descriptions of various fragmentary species in papers by Mr. Billings in the fourth and fifth volumes of the *Canadian Naturalist.* He is referred also to that publication for figures of less known or uncertain species of *Illænus* and other forms of this order.

Ceraurus.—This genus is the *Cheirurus* of European authors. It is more or less closely allied to Dalmannites, but the eyes exhibit only a delicate reticulation, and the pleuræ have a raised band on the surface, in place of a groove as in the latter type. The glabella is large, and furrowed at the sides. The facial suture cuts the side of the head-shield. The angles of the head terminate in points or horns. The pleuræ are also pointed; and the caudal shield has a spinose or serrated outline, or otherwise terminates in one or several horns. Body-rings eleven in number. The genus ranges from Lower Silurian into Devonian beds. A common species from the Trenton Group, *Ceraurus pleurexanthemus,* is shewn in fig. 146. Impressions of the glabella, and of the two-horned pygidium, are especially abundant.

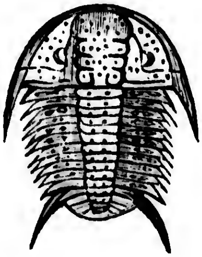

Fig. 146.

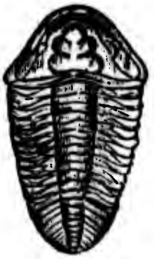

Fig. 147.

Calymene.—The glabella of this genus is prominently developed, lobed, and contracted anteriorly. The head-angles are rounded, and the facial suture cuts these. The body-rings are thirteen in number: pleuræ rounded. Pygidium with entire outline. Our most common species is the widely distributed *C. Blumenbachii* (fig. 147). This species ranges from the Trenton Group into the Devonian deposits. It is very frequently found in a "rolled up" condition.

Fig. 148.

Homalonotus.—This genus has the same number of body-rings as *Calymene*, and the general shape, direction of the facial suture, &c., is also the same. The glabella, however, although contracted anteriorly, is without lobes, and the two longitudinally furrows, which impart a three-lobed character to the trilobites generally, are here but feebly developed. A common species of the Niagara Group, *H. delphinocephalus* is represented in Fig. 148.

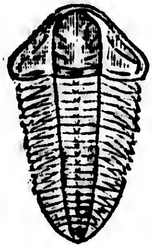

Fig. 149.

Triarthrus.—This genus is also somewhat allied to *Calymene*, but the body-rings are fourteen, or from fourteen to sixteen, in number, and the head-shield and pleuræ, in some species, terminate in points. The glabella is nearly straight at the sides, not much raised, and marked on each side by three short furrows. *T. Beckii*, (fig. 149) of our Utica Schist formation, is the best known species. Impressions of the glabella of this form occur abundantly in the shale beds near Collingwood, and also in the neighbourhood of Whitby, C. W. In *T. Beckii*, each segment of the thorax bears in the centre a short spine. In another species, made known by Mr. Billings under the name of *T. spinosus*, a long spine descends from the neck furrow of the glabella, and another from the eighth body-segment. A third species, *T. glaber* (Billings), is destitute of spines. The two latter forms occur in the Utica Slate of Lake St. John, north of Quebec.

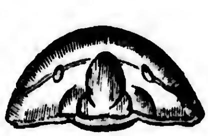

Fig. 150.

Conocephalites.—In this genus, the gabella, though convex, is very short, and the body-rings are fourteen or fifteen in number. Its species are characteristic of the lowest fossiliferous deposits, and are mostly of very small size. The head-shield of *C. Zenkeri*, after Billings, is figured in wood-cut 150 (*Can. Nat.*, vol. v., p. 205). It occurs in the Quebec Group of Point Levi.

Paradoxides.—Head-shield terminating posteriorly in horns; glabella well developed; body-rings over fifteen in number; pleuræ pointed, the second or third pair often longer than the others; caudal-shield, very small. This genus is also characteristic of the lowest zones of fossiliferous strata. Some more or less obscure species, first found in Vermont, have lately been discovered in the Quebec Group of Anse au Loup, on the north shore of the Straits of Belle Isle.

Vertebrated Animals.—Remains of vertebrated forms are of rare occurrence in Canadian rocks. Our Silurian strata are entirely destitute of any signs of these remains, and traces only have as yet been discovered in our Devonian beds. These consist of fish scales and impressions (North Cayuga; St. Marys; Malden; Kettle Point; Bear Creek). In the higher Drift accumulations, the bones and teeth of the Mastodon and Mammoth, the latter an extinct species of elephant (*Elephas primigenius*), are occasionally found; and in these and more recent deposits, the remains of existing forms, such as those of the capelin (*Mallotus villosus*), the lump-sucker (*Cyclostomus lumpus*), the northern seal (*Phoca Grœnlandica*), the Canadian beaver, Wapiti, &c., have also been discovered. No marine forms, however, have been found in these deposits west of Kingston, as explained more fully, in our remarks on the Drift and succeeding period, in the next division of our subject.

PART V.

CANADIAN ROCK-FORMATIONS: THEIR SUBDIVISIONS, FOSSILS, ECONOMIC MATERIALS, AND TOPOGRAPHICAL DISTRIBUTION.

Introductory Notice.—The lowest rocks of the geological series, hitherto recognised, consist of a vast thickness of crystalline and semi-crystalline strata, or beds in a more or less altered or metamorphic condition, entirely destitute of organic remains, and hence classed together under the common term of *Azoic Rocks*. They are regarded as sedimentary deposits, collected in the earlier seas which extended over the greater portion of the earth during that period of its history which preceded the creation of organic types In Canada, as will be seen below, these Azoic rocks are enormously developed.

Above the deposits of the Azoic Age, various sandstones, limestones, slates and other strata, in which organic remains first appear, are recognized as forming the second geological series, and are known collectively as *Palæozoic Rocks.* The term "Palæozoic," signifying "ancient life," is bestowed on these strata in allusion to the marked difference which prevails between their organic types, viewed as a whole, and those belonging to existing Nature. Among the more remarkable extinct forms of the Palæozoic Age, Graptolites, Cystideans, numerous Brachiopods, Orthoceratites, Trilobites, and some peculiar fishes, hold a prominent place. Reptilian types are rare, and of comparatively low organization; and Mammalia appear to have been entirely absent. In Canada, the lower members of the Palæozoic strata are largely developed, but the higher divisions of the series are of only partial occurrence, or are altogether wanting.

The strata of a succeeding series, still ascending in the geological scale, are known as *Mesozoic* or *Secondary Fossiliferous Rocks.* Their organic remains are quite distinct from those which occur in the underlying formations. Ammonites and Belemnites, with highly organized reptilian types, including the Ichthyosaurus, Plesiosaurus, Pterodactyl, Iguanodon, &c., are among their more characteristic and extinct forms. Fishes with equally-lobed tail-fins, and others with scale-coverings similar to those of the great majority of fishes which inhabit our present waters, first appear in the deposits of this Secondary Fossiliferous Age. Mammalian types are all but unknown, and those hitherto discovered, are of low organization. In Canada, the Mesozoic rocks are without representatives.

The *Cainozoic* or *Tertiary Fossiliferous Strata* succeed the Mesozoic. In these, the organic remains closely approximate to the forms of the present epoch. Amongst the mollusca, brachiopods become scarce, and cephalopods with chambered shells have greatly diminished. Those with foliated septa (as ammonites, baculites, &c.) have entirely disappeared, together with the huge and abnormal reptiles of the Mesozoic Age. Mammalian types, on the other hand, are fully represented—examples of all existing orders, with the exception of that in which Man is alone included, being met with in these deposits. In Canada, however, the Cainozoic formations do not occur.

Finally, a still higher series of deposits, partly merging into the Cainozoic, where these occur, and in part consisting of the products of existing causes, may be classed together under the term of Post-

Tertiary deposits. These, which include the great Drift formation, and sundry accumulations of more recent origin, are largely developed in Canada.

SKETCH-SECTION OF CANADIAN ROCK-FORMATIONS.

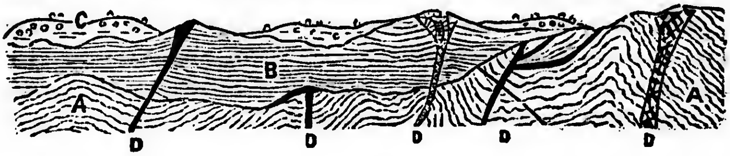

Fig. 151.

A=Azoic Strata (Laurentian and Huronian.)
B=Palæozoic Strata (Chiefly Silurian and Devonian.)
C=Post-Tertiary deposits (Drift and Modern accumulations.)
D=Eruptive rocks (Traps, Trachytes, Syenite, Granite.)

Our rock-formations, therefore, as shown in the accompanying diagram, comprise representatives of the Azoic, Palæozoic, and Post-Tertiary series, a wide break occurring between the two latter,—together with trap dykes and other masses of eruptive origin. The subdivisions and leading characters of these will now be considered. We commence with the older formations, and proceed upwards to those of modern date.*

AZOIC ROCKS OF CANADA.

Huronian.
Laurentian.

The Canadian rock-formations of Azoic age, are referred to two series: the *Laurentian*, below; and the *Huronian* above. This subdivision, not yet fully recognized by American geologists, was first proposed by Sir William Logan; and the terms "Laurentian" and "Huronian" are of his bestowal. The former is now adopted in Europe for gneissoid strata of the same ancient date. The Lauren-

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* In the present place, these rock-formations will be considered separately, and in a more or less detailed manner as regards structural characters, economics, characteristic fossils (when exhibited), localities of instructive exposures, and other allied points of inquiry; and afterwards, in a connected sketch, their mutual relations will be shown, together with the special geological areas which occur within the Province. The general reader will scarcely gain a clear idea of the Geology of Canada, until after the perusal of this latter section. The present details are necessary, however, as an introduction to this.

tian series, which forms the lower and more largely developed portion of the Azoic group, is chiefly characterised by its highly crystalline condition, and (as regards Canada) by the great beds of iron ore which it contains. The Huronian series includes many conglomerates and partially-metamorphosed slates amongst its strata, and is traversed by numerous quartz veins holding copper pyrites and other copper ores. Iron ore is also associated with this series, but not abundantly in Canada. The semi-crystalline condition of its rocks (as compared with the highly crystalline gneissoid strata of the Laurentian series) and the marked prevalence of slaty conglomerates, constitute its more distinctive characters.

Laurentian Series.—These strata, the oldest series of deposits recognised on the American continent, are regarded as sedimentary accumulations, originally collected together by the action of water, and converted subsequently into a crystalline condition by the agency of metamorphic forces. (See under the head of "Metamorphic Rocks" in *Part III*). Their absolute thickness cannot be ascertained, but it must be very great, embracing many thousands of feet; and their exposed area in Canada, as estimated by Sir William Logan, covers a surface of about 200,000 square miles. It will be convenient to consider these Laurentian rocks under the following heads:—(1) Mineral characters; (2) Structure; (3) Associated intrusive rocks; (4) Economic materials; and (5) Topographical distribution.

Mineral characters of the Laurentian strata;—The stratified rocks of Laurentian age consist essentially of vast beds of micaceous and hornblendic gneiss; interstratified with subordinate beds of quartz-rock' mica-slate, hornblende-rock, crystalline limestone and dolomite, and oxidized iron ores; and associated with thick beds of feldspar rock or anorthosite. In addition to these, a few quartzose conglomerates (shewing the metamorphic character of these deposits), thin layers of serpentine, beds and layers of a talcose character (Renselaerite, or pyrallolite: see PART II.), and others composed in large part of Wollastonite, are interstratified with the limestones, or with the gneissoid beds, of particular localities. These different kinds of metamorphic rocks have been described already in PART III.; but a few additional remarks on some of their more special characters are necessary here. Viewing our Canadian formations, of this age, in their broader features, we may subdivide them conveniently, and to some extent naturally, into three groups, viz:—(*a*) Gneissoid strata; (*b*) Limestones, Quartzites, and Iron bands; and (*c*), Anorthosites or feldspar rocks.

(*a*) *Gneissoid Strata:*—These make up the larger mass of our Laurentian rocks. Ordinary gneiss, as explained in PART III., consists of quartz, potash-feldspar, and mica; whilst in syenitic gneiss, the mica is replaced by hornblende. These varieties occur both alone and mixed with one another, throughout our Laurentian districts. The feldspar is generally red or white, the quartz colourless and vitreous, and the mica and hornblende of some dark tint—black, brown, or green. The two latter minerals occasionally die out, when a binary mixture of quartz and feldspar results. In certain beds of coarse structure, the stratification lines become obscure; but usually, and even in hand specimens, gneiss exhibits a striped or banded aspect, by which it is distinguished from ordinary granite. The potash-feldspar or orthoclase (see PART II.) is sometimes replaced or accompanied by soda-feldspar or albite, but the instances of this are not common. The predominating colour of these gneissoid strata, is reddish or dark grey, the latter resulting from stripes of dark mica combined with narrow zones of white quartz and white or pale red feldspar. When much hornblende is present, the rock may assume a black or dark greenish colour, or present a flecked surface of red and black: exhibiting in the former case, a transition into hornblende-rock. A red gneiss with green layers of epidote, forming a stone well adapted for ornamental purposes, occurs at Carlton Place near Kingston, and at some other localities. The black or dark-green hornblende-rock associated with the gneissoid and limestone strata, frequently contains crystals of red garnet (Barrie township, &c.); and the latter mineral sometimes occurs in the gneiss or quartzites in considerable abundance (Grenville, River Rouge, &c.) It is usually found, however, in the vicinity of the limestone bands, occasionally forming true garnet-rock.

(*b*) *Limestones, Quartzites, and Iron Ores:*—The limestone beds associated with the gneissoid and other Laurentian rocks are often of a fine granular or saccharoidal texture; at other times coarse granular, and occasionally almost compact. The colour is usually white or grey, but for short distances the rock is sometimes of a pale reddish, or greenish tint. It is frequently zoned with specks and scales of mica, serpentine, or graphite, and contains also various accidental minerals, of which the more abundant or interesting comprise: Iron pyrites; apatite or phosphate of lime; sulphate of baryta; tremolite, diopside, and other varieties of hornblende and augite; garnet; tourmaline; condrodite; spinel; corundum, molybdenite, &c. Descriptions of these minerals are given in the second Part of this Essay. A talcose mineral (Renselaerite or Pyrallolite), probably an altered augite, (see PART II.) occurs also in interstratified beds with the limestones of some localities (Ramsay, Grenville, Rawdon); and in Grenville and Burgess, yellowish and greenish-grey serpentine occurs under similar conditions. Phosphate of lime likewise, occasionally forms irregular bands amongst the strata: as, more especially, in North Elmsley, South Burgess, and Ross; and at Calumet Falls.

Some of the limestone beds are of great thickness. According to Sir William Logan, who has devoted much time to an elaborate examination of the crystalline limestones of the Ottawa region in particular, certain beds exhibit a thickness of 1500 feet. In the district alluded to, four beds, presenting an aggregate thickness of over 3500 feet, have been traced out and mapped. For full information respecting the structural and other characters of these, the reader is referred to the Revised Report on the Geology of Canada, by Sir William Logan and the other officers of our Geological Survey.* The more important localities in which workable beds of crystalline limestone occur, will be found under the head of "Economic Materials." below. The crystalline dolomites, composed of carbonate of lime and carbonate of magnesia, closely resemble the crystalline limestones, and occur under the same conditions, the two being frequently interstratified. A fine saccharoidal variety is found on Lake Mazinaw in the County of Frontenac, and a more compact kind occurs in the townships of Madoc, McNab, Loughborough, Sheffield, Grenville, &c. Many of these dolomites, it is remarked by Sir William Logan, become of a yellowish brown colour by weathering.

The quartzites and quartzose conglomerates, mentioned above, may be referred to in connection with the limestones, as they are generally found in their immediate vicinity or otherwise interstratified with them. Some beds of quartzite present a thickness of several hundred feet. This rock, composed of quartz more or less pure, exhibits a vitreous or sub-vitreous aspect, and is either colourless or of a pale reddish, brownish, or greenish tint. The quartzose conglomerates are com-

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* To this valuable and truly national work, it may be mentioned here, the present Essay is mainly intended to serve as an introduction: illustrating and explaining the various technicalities and details, a knowledge of which, on the part of the reader, is necessarily presupposed in the Report in question.

paratively rare, but some occur in the townships of Rawdon and Bastard, associated with crystalline limestone. They are usually somewhat micaceous, and the imbedded pebbles consist of quartz, feldspar, (often decomposed), sandstone, and sometimes of limestone. The quartzites of Bay St. Paul, and those of Rawdon, contain garnets in great abundance, and pass into garnet rock.

The beds of iron ore, also placed in this subdivision from their general association with the crystalline limestones and dolomites, belong partly and chiefly to Magnetic iron oxide, and partly to Specular iron ore—minerals of which full descriptions are given in Part II. of this Essay. These ores occur in vast beds interstratified with the limestones and other Laurentian strata. In thickness they vary from a yard or two, to upwards of two hundred feet. Their more important localities are mentioned below.

(c) *Anorthosites*:—The term anorthosite was first employed by Prof. Sterry Hunt of the Geological survey, to designate the more purely feldspathic rocks of the Laurentian series. These rocks consist of a mixture of lime and soda feldspars—minerals forming several species (Labradorite, Albite, Anorthite, &c., see Part II), all of which belong to the Triclinic or Anorthic system of crystallization (Part I.) The anorthosites make up in themselves a vast thickness of the Laurentian rocks, and cover surface areas of large extent. They appear, according to Prof. Hunt, to occupy a higher position than the orthoclase gneiss-rocks, although occasionally interstratified with subordinate beds of these, and also, though more rarely, with strata of quartz-rock. Their structure is coarsely crystalline, or otherwise more or less compact; and their marks of stratification are frequently obscure. They often contain laminar masses of hypersthene of a brown (or green) submetallic tint; and when this mineral becomes somewhat abundant, the variety termed "hypersthene rock" originates (see Part III.) Ilmenite or titaniferous iron ore (described in Part II) is also sometimes present. An immense bed, 300 feet long and about 90 feet wide, occurs in a feldspathic rock of this series, near Bay St. Paul, below Quebec. These rocks are chiefly of a greyish blue colour, but some are white, and others exhibit a yellowish, greenish, or reddish tint. All become opaque white by weathering. Many contain cleavable masses of lime feldspar or Labradorite (Part II.), or appear to be almost wholly made up of that mineral. In these, a fine green and blue opalescence or play of colour is sometimes observable: as in the anorthosite of the township of Abercrombie in the county of Terrebonne, in those of Morin and Mille-Isles, and in some of the boulders met with in the Ottawa district.

2. *Structure of Laurentian rocks*:—These rocks, as a general rule, occur in inclined beds—the dip varying from eight or ten to over seventy degrees. The direction of the dip is extremely variable, as the strata are not only inclined, but are folded more or less into a series of anticlinals and synclinals. In some beds, both of gneiss and limestone, the subordinate layers are much contorted, as shown in the annexed figure, sketched on Crow Lake, north of Marmora; and the same peculiarity is seen in many other localities. Between the Laurentian strata and the Silurian beds which rest upon them in Eastern and the greater part of Western Canada (the Huronian being absent), there is always a want of conformability. Along the line of junction of the two formations, between the eastern extremity of Lake Ontario and the east coast of Georgian Bay, the Laurentian strata appear to dip very generally towards the north, that is, between N.W. and N.E., or away from the Silurian beds—as shown in the accompanying section, taken on Lake St. John in the township of Rama, C. W. The dotted line in this section shows the ordinary level of the lake. The Laurentian strata have a general northerly dip also, near the junction line of the two formations in the township of Elzevir, and at other points visited by the writer; but this does not apply everywhere, as on Loughborough and Crow Lakes the dip is SE. or nearly so; neither does it continue apparently for any great distance to the north, the dip rapidly changing with the foldings of the strata. The Sketch-section on a previous page (fig. 151), in which an attempt is made to convey an idea of the foldings of the Laurentian strata generally, will render this sufficiently clear.

Fig. 152.

Fig. 153.

3. *Intrusive Rocks*:—Considering the immense extent of country occupied by the Laurentian rocks, intrusive masses of contempora-

neous geological age, appear to be exceedingly rare. Many of the granitoid and quartzose veins seen amongst the gneissoid strata, are considered, by those who have had the best opportunities to study them, as veins of segregation rather than true eruptive matters. The most important example of undoubted eruptive origin, is the great mass of syenite described by Sir William Logan as occupying an area of about thirty-six square miles in the townships of Grenville, Chatham, and Wentworth, near the left bank of the Ottawa. This consists of red or white potash-feldspar, with black hornblende, and a small amount of quartz; but here and there it contains a certain amount of mica also, forming the variety generally known as syenitic granite. This eruptive mass cuts a series of greenstone dykes belonging to a still earlier eruption; and is in itself traversed by another series of porphyritic dykes of a necessarily more recent origin. The greenstone dykes, according to Sir William Logan, exhibit a well-marked columnar structure, and vary in width from a few feet to a hundred yards. These three eruptive formations are also intersected by a fourth series of dykes, supposed to be of Palæozoic age. (See Report for 1853. Also the Revised Report on the Geology of Canada). As the more northern and uncleared districts within the vast area of our Laurentian region become opened up or more thoroughly explored, other eruptive masses of an analogous character will, in all probability, be brought to light.

4. *Economic Materials:*—In addition to good building stones of gneiss, &c., obtainable generally throughout the region occupied by our Laurentian rocks, the following are the more important economic materials discovered in these strata up to the present time: * (*a*) *Iron Ores;* (*b*) *Lead Ore;* (*c*) *Sulphide of Molybdenum;* (*d*) *Graphite;* (*e*) *Mica;* (*f*) *Ornamental Feldspars;* (*g*) *Marbles;* (*h*) *Sulphate of Baryta;* (*i*) *Millstones.*

(*a*) *Iron Ores.*—These comprise Magnetic Oxide of Iron; Specular Iron ore (or Red oxide of Iron); and Titaniferous Iron Ore. The magnetic ore occurs principally at the following localities:—(1) Belmont Township (the Marmora mine): several beds, lying between crystalline limestone and gneiss, and mixed with layers of serpentine, talcose slate, &c. Total thickness of the ore beds, over 400 feet.—2, Madoc Township: Bed of ore of excellent quality, 25 feet thick, in

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* These various substances will be found described in full, as regards mineral characters, composition, &c., in PART II. of this Essay.

gneiss.—3, South Crosby Township, Newborough mine: Bed in gneiss, on Mud Lake, 200 feet in thickness.—4, South Sherbrooke Township: Bed of 12 feet in gneiss.—5, Hull Township on the Ottawa: Dome-shaped bed in gneiss; thickness, about 90 feet.—6 Grenville Township, C. E.: Bed of 10 or 12 feet in thickness.—7, Grandison Township, C. E., 20 feet bed. The average amount of iron in these beds, varies from 60 to 70 per cent. Specular iron ore (averaging about 55 per cent. of metal) occurs in a 30 feet bed, in the township of McNabb, near the Lac des Chats. Also in "Iron Island" on Lake Nipissing. Titaniferous Iron (Ilmenite), as already mentioned, forms a bed of 90 feet in thickness, in Feldspar-rock (anorthosite) at Bay St. Paul on the Lower St. Lawrence.

(*b*). *Lead Ore:*—This consists of galena or sulphide of lead. Mixed with a gangue of calc spar and heavy spar it forms a series of narrow veins in the townships of Lansdowne, Ramsay, and Bedford, C. W. These veins, which vary in thickness from six inches to a foot, belong, probably, to a somewhat more recent period of formation than the Laurentian epoch; but as they occur among the Laurentian rocks, they are properly mentioned in connexion with these strata. The lead ore is very slightly argentiferous, and apparently in no great quantity in the veins. It occurs also, under similar conditions, in the township of Dummer, Peterborough Co., C. W.

(*c*). *Sulphide of Molybdenum:*—This mineral (see PART II.) is not at present of much value. It forms the source of various molybdenum compounds, some of which are employed in chemical investigations, and occasionally in porcelain painting. It occurs, in small quantities, in the Laurentian rocks of several localities, as mentioned under the description of the mineral in a preceding part of this Essay; but in workable quantities it has only been found, as yet, at the mouth of the Quetachoo River on the north shore of the Gulf of St. Lawrence. ("Descriptive Catalogue of the Economic Minerals of Canada in the Exhibition of 1862"—issued by the Geological Survey.)

(*d*). *Graphite:*—Found in workable quantities in the Augmentation of Grenville, on the Ottawa, (see PART II.) Also in the townships of Burgess and Lochaber. The quality is scarcely sufficient to render the substance available as a material for pencils, but the graphite of these localities is well adapted for refractory crucibles, and also as a burnishing material for stoves and grates.

(*e*). *Mica:*—This mineral occurs in pieces sufficiently large for stove-doors, &c., in the townships of North and South Burgess, C. W. Also in Grenville and the "Augmentation" of that township in C. E.

(*f*). *Ornamental Feldspars* :—These comprise, the Labradorite of Abercrombie township, C. E.; the Peristerite (an iridescent variety of Albite) found in the townships of Bathurst and Burleigh, C. W.; and the Perthite (an iridescent Orthoclase,) of the township of Burgess. See PART II. The two latter varieties were first made known (as occurring in these localities) by Dr. James Wilson of Perth.

(*g*). *Marbles*:—The principal marbles of Laurentian age occur at the following localities: Arnprior, MacNabb township (grey, striped); Grenville township (white with yellowish specks of serpentine, or yellowish-white); Augmentation of Grenville (white with pale green spots of serpentine); Elzevir township, C. W., (white but of somewhat coarse grain); Barrie township, at Lake Mazinaw, &c., (a crystalline dolomite, pure white, and of saccharoidal texture).

(*h*). *Sulphate of Baryta* :—This substance, used as a paint material or substitute for white lead (see PART II.), is found in considerable quantities, in connexion with Laurentian rocks, in the townships of Lansdowne, Burgess, Bathurst, and Dummer, in Canada West, where it occurs in the form of veins which often contain galena. It is found still more abundantly on Lake Superior, but in rocks of another age.

(*i*). *Millstones* :—The intrusive mass of syenite in the township of Grenville, C. E., (described under the head of "Eruptive Rocks" above) is associated with some remarkable veins of *chert* (a variety of quartz) from which good millstones have been manufactured. These veins are regarded by Sir William Logan as veins of segregation; and it is considered probable that the siliceous matter of which they consist may have been derived from the decomposition of the feldspar in the adjoining mass of syenite. The feldspar is said to be converted into kaolin for a considerable distance on each side of the chert.

5. *Area of the Laurentian Rocks* :—As shewn by the shaded surface in the accompanying map, (figure 154), the Laurentian strata may be regarded as constituting from the coast of Labrador, the whole of the north shore of the Saint Lawrence to within a short distance of Quebec (Cape Tourmente)—a few isolated and narrow strips of Lower Silurian strata (made known by the Geological Survey) alone intervening between these rocks and the waters of the Gulf or river. These outlying patches occur on the north shore of the Straits of

Belle Isle, at the mouth of the Mingan River, near the Seven Islands, and at the Murray Bay River, and the Gouffre. From Cape Tourmente, the Laurentian strata run inland, at a distance of from ten to thirty miles from the river but roughly parallel with its course, and cross the Ottawa near the Lac des Chats. From this point, the strata extend both southwards and to the northwest. The southern portion crosses the Saint Lawrence about the Thousand Isles, and occupies a large area in the State of New York between Lake Ontario and Lake Champlain, including the wild district of the Adirondack Mountains. The narrow belt of crystalline rock connecting this southern Laurentian area with the main or northern region of these strata, probably exerted at the close of the Drift period, as discussed on a succeeding page, a remarkable influence on the physical condition of the country to the west. The other portion of the Laurentian outcrop, west of the Lac des Chats, traverses the back townships of the counties of Frontenac, Addington, Hastings, Peterborough, Victoria, and Simcoe, and strikes Georgian Bay near the mouth of the River Severn. From thence, the Laurentian rocks form the eastern and north-eastern shores of the Bay up to a point nearly opposite the east end of the Manitoulin Islands, or some five or six miles west of the most western mouth of French River, where they are overlaid by Huronian deposits. They reappear upon the east and north shore of Lake Superior, and extend far into the great North-West—reaching in all probability to the shores of the Arctic Ocean. The vast area thus occupied by the Laurentian rocks, includes many thousands of square miles; and that part of it which lies within the limits of Canada properly so-called, greatly exceeds in extent the other portions of the Province.

Fig. 154.

6. *Agricultural Capabilities :*—As a general rule, liable only to par-

tial or local exceptions, the Laurentian area is not favorably circumstanced for agricultural occupation. Soils of depth and fertility can only be expected to occur under the following conditions:—first, where feldspar rocks or anorthosites prevail, most of these yielding calcareous soils by decomposition; secondly, where the belts of crystalline limestone crop out and form the surface of the country; and thirdly, where the rocks are covered to a sufficient depth by Drift clays and sands. These latter deposits, however, are usually filled in these districts with large and numerous boulders, and rarely extend over areas of any considerable size. Patches of a certain extent occur here and there, but they are too generally separated by huge and bare masses of gneissoid rock, familiarly known to the settlers as "elephants' backs." Such, at least, is the general condition of the country in the back townships of the western counties mentioned above. Northwards, and in Eastern Canada, the severe climatic relations which there prevail, must be added to these disadvantages. In those parts of the province, however, which are occupied by other rock-formations, numerous uncleared tracts of unrivalled fertility are still left to repay the settler's toil.

Huronian Series:—The rocks of this group, the next in ascending order above the Laurentian series of strata, may be described under the following heads:—1, Mineral characters; 2, Associated intrusive rocks; 3, Economic materials; and 4, Topographical distribution.*

1. *Mineral Characters of the Huronian Strata:*—These rocks consist principally of thick beds of quartzite, passing into quartzose and jasper conglomerates; green slate rocks passing into slate conglomerates; bands of compact or sub-crystalline limestone; and interstratified masses or beds of greenstone. The entire thickness of the series, where fully displayed, is probably not far short of 20,000 feet. The quartzites are chiefly white or greenish in colour, but exhibit in some places grey, brownish, and also red tints. Some are vitreous in texture; others, more or less arenaceous. In the conglomerates, the included pebbles, which are sometimes quite small, consist of different varieties of quartz—colourless, opaque-white, brown, black, dark-red,

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* It is but just to state, that most of the facts given under these heads, are drawn from the publications of the Geological Survey of Canada. The writer, however, has visited the north shore of Lake Huron where the rocks of this series are chiefly displayed; and he has thus examined many of the strata and greenstone masses *in situ*, and has procured, personally, a considerable collection of specimens from that locality. He is consequently better able than a mere compiler would be, to classify and separate from subordinate details the more salient points belonging to the study of this geological group. These observations will apply also to other cases in which he is more especially indebted to the labours of the Survey.

&c.,—the latter constituting the variety known as jasper. The slates and slate conglomerates appear to owe their general green colour to the presence of chlorite and epidote, or perhaps more commonly to the former alone. In some, different shades of green (or of green, black, and red) run in parallel lines, imparting to the rock a beautiful ribanded aspect. Well-marked slaty cleavage, however, is apparently very rare: if ever present. In the conglomerates, the enclosed pebbles, or rounded fragments, for some are eight or ten inches across, consist of pieces of gneiss, syenite, quartz, &c., evidently derived in many instances from the adjacent Laurentian rocks. Some of these slates and slate conglomerates form vast stratified masses of between two and three thousand feet in thickness. The limestone beds of the Huronian series are of comparatively subordinate importance. They are chiefly of a light or dark grey colour, though in places they offer a white, greenish or brownish tint. In structure, they are more or less compact, or but slightly crystalline; the latter condition is, however, rare. Some exhibit a brecciated appearance, and all seem to contain a good deal of siliceous matter. Thin beds of chert (a flinty variety of quartz) occur indeed interstratified with them, in some places. In addition to their want of crystalline texture, these limestones differ from those of the Laurentian series in not containing any crystallized minerals—apatite, garnets, tourmaline, homblende, &c.,—a fact pointed out by Professor Sterry Hunt. The masses of greenstone interstratified with the slates and other beds of this series, are of somewhat doubtful origin. They may consist, as suggested by Prof. Hunt, of altered sedimentary deposits; or they may be stratified beds made up of materials derived from neighbouring dykes and eruptive greenstone masses; or, otherwise, they may consist of overflows of igneous rock during the building up of the associated strata; or of lateral dykes, so to say, forced at some after period between the lines of bedding. As regards structure, &c., they exhibit several varieties. Some are large-grained, consisting of feldspar (usually of a greenish-white color) and dark green or black hornblende. Other varieties are fine-grained, and of a uniform green colour except when they become amygdaloidal or contain cavities filled with calc spar, magnesite, quartz, &c. Certain fine-grained varieties also become schistose and quite sectile, from the presence of a large quantity of chlorite. These finer greenstones are likewise porphyritic in places, or hold imperfect crystals of feldspar; and those of coarser grain, by the addition of a little quartz, pass occasionally into syenitic gneiss or syenite—according as to whether the rock be regarded as of sedimentary or eruptive origin.

2. *Associated Intrusive Rocks, Mineral Veins, &c:*—The intrusive rocks which break through the Huronian series, and belong apparently to the same geological period, consist of numerous dykes of dark greenstone, varying in breadth from less than a foot to two hundred feet or more; and of some large masses and veins of red granite, frequently of an epidotic character. An exposure of the latter occurs in force on the north shore of Lake Huron, associated with Laurentian strata, but is regarded by Sir William Logan as most probably of Huronian age from its agreement in mineral characters with similar veins which traverse the deposits of that period at neighbouring localities. Some of the greenstone dykes are older, and others newer, than the granite masses. The vein-fissures filled with copper pyrites, &c., which are so abundant amongst these Huronian strata, are of still later formation, since they cut many of the greenstones and granites, and often break the continuity of these and the surrounding beds, causing upthrows or downthrows of greater or less extent. An enormous fault caused by a dislocation of this character, has been traced out by Mr. Murray in the valley of the Thessalon and adjoining district. In one place, a downthrow of nine thousand feet is attributed to this fault. (See the Report for 1858. Also *Canadian Journal*, vol. V, p. 463.) Finally, it may be observed that several large anticlinals extend across the Huronian strata of this region generally. The axis or summit of one of these, crosses the workings of the Bruce Mines.

3. *Economic Materials:*—The more important substances of this class obtained from the Huronian rocks, comprise: copper ores; quartzose sandstones suitable for glass making purposes; hones of good quality; and (as ornamental stones) the jasper conglomerates mentioned above. The copper ores belong chiefly to copper pyrites, purple copper pyrites or erubescite (the "horse flesh ore" of the miners), and copper glance: minerals which have been fully described in PART II. These occur on the north shore of Lake Huron in veins or lodes, varying in thickness from about two to ten feet. The gangue or veinstone consists essentially of quartz, and the average yield of metal is said to be from six to eight per cent: amounting, however, in the dressed ore to about eighteen or twenty per cent. The principal workings are at the Bruce Mines (Cuthbertson location), Wellington Mines (Keating location), and at the Copper Bay Mines; but ore has been found also at the Wallace Mine near the mouth of White

Fish River, at Echo Lake, Root River, Garden River, Mississagui River, Spanish River, and other localities of that region. The ore (according to Mr. Murray's observations) appears to be far more abundant in the greenstones than in the quartzites. Lodes of some richness in the greenstone, when passing into the latter frequently become quite poor. Ottertail Lake, an expansion of the Thessalon River, is named by the Geological Survey as a locality from which good hones may be obtained. They are cut from the green or greyish siliceous slates, found towards the base of the series. From some of the soft chloritic slates, also, the Indians have long obtained sufficiently compact and sectile masses to be worked into pipe-bowls and other objects.

4. *Topographical Distribution :*—The Huronian rocks are unknown throughout the greater portion of Western Canada, and in the East they appear to be entirely wanting. The Laurentian rocks of these districts, either form the surface of the ground, with or without a covering of Drift, or are otherwise overlaid unconformably by Silurian strata—the Huronian being absent. The principal Huronian area extends along the north coast of Lake Huron from a few miles west of French River, where this enters the lake, up to the the neighbourhood of Root River opposite the northern part of Sugar Island, or to within a short distance of the Sault Ste. Marie. A narrow strip of the shore-line, however, from about ten miles north of the entranc to Lake George to a point west of Little Lake George, consists apparently of newer strata. The extension northward of this Huronian belt has not yet been definitely made out, but it does not appear to exceed ten or fifteen miles, and in places is less than this. Huronian rocks are exposed also at several points on Lake Superior: as in Batchehwahnung Bay; at the mouth of the Doré, and around the lower part of Michipicoten River; in strips along the coast farther west; and more extensively around the lower part of the Kaministiquia River, and elsewhere, on the coast of Thunder Bay. In many parts of this region, the Huronian rocks are followed unconformably by a somewhat similar series of altered strata, associated with dykes and interstratified masses of trap, and containing also, copper ores, native copper, and other metallic matters. Until recently, these strata were considered to be of Huronian age; but they are now looked upon as altered Silurian deposits, belonging in part to the Potsdam group, and partly to the Calciferous or Quebec Series. They will be described, consequently, under those divisions.

PALÆOZOIC ROCKS OF CANADA.

The formations of Palæozoic age, recognized in Canada, comprise, in ascending order: (1) A complete series of deposits belonging to the *Silurian Epoch;* (2) A succeeding series, referrible to the earlier part of the *Devonian Epoch;* and (3) A partial development of Carboniferous strata—these latter, however, being only found in Gaspé, at the extreme east of the Province.

SILURIAN STRATA:—The Silurian strata are usually subdivided into two series—the *Lower* and the *Upper* Silurians, respectively; but in Canada, the officers of the Geological Survey have recently adopted a third or additional group—the *Middle* Silurians. This latter group includes the lower portion of the Upper Silurian series as originally constituted.*

Lower Silurian Series:—This series comprises, in ascending order, the following subdivisions:—1, The Potsdam Group; 2, the Calciferous Group; 3, The Chazy Formation; 4, The Trenton Group; 5, The Utica Slate Formation; and 6, The Hudson River Formation.

Note:—The Calciferous and Chazy strata, as regards their occurrence in the neighbourhood of Quebec and throughout the Eastern Townships, are united by Sir William Logan under the term of the Quebec Group. It would also, perhaps, be more in conformity with Nature to unite the three latter divisions, as given above, and to arrange the whole as in the annexed Table. The term "Ontario Group" might be adopted for the proposed union of these higher formations.

Ontario Group.	Hudson River Formation. Utica Formation. Trenton Formation. Bird's Eye and Black River Formation.		
Quebec Group.	Chazy or Sillery Formation. Calciferous or Levis Formation.	—	The higher beds of the Upper Copper-bearing strata of L. Superior (?)
Potsdam Group.	Beauharnois Formation. Kaministiquia Formation. (?)	—	The bottom beds of the Upper Copper-bearing strata of L. Superior (?)

The Potsdam Group:—This subdivision, until a comparatively recent period, was known as the *Potsdam Sandstone.* Its stratified

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* The term "Upper Silurian," it should be observed, is employed in the preceding Parts of this Essay in its original signification i.e., as including the so-called "Middle Silurians" of the later system of division

deposits may be arranged under the heads of: deep-sea strata; shallow-sea or shore-line deposits; and altered rocks. Of the deep-sea strata of the Potsdam epoch, merely uncertain indications have at present been obtained. Sir William Logan has suggested that some dark slates which are found to occupy a lower geological position than the Quebec beds of Point Levis,* may very possibly represent some of the deep-sea deposits of that period; whilst it is certain that the ordinary sandstones, of the epoch, were shore-line or coast deposits. This is proved by the presence of ripple marks, and tracks of crustacea or other animals, as well as by the general nature of the sediments of which these sandstones consist. The slates, however, may be of contemporaneous formation with the sandstones: a point at present unsettled. Another series of slate rocks and slaty conglomerates, somewhat resembling those of the Huronian series, associated with beds of chert (a flint-like variety of quartz, sometimes coloured black from the presence of anthracitic matter), grey dolomites, (weathering red), interstratified trap beds, and some argillaceous sandstones, occur in Thunder Bay, and especially near the Grand Falls of the Kaministiquia River, and probably belong to the Potsdam period. They overlie the Huronian rocks in unconformable stratification with these, and hence belong to a succeeding geological epoch. If of Potsdam age, the question again arises as to whether they represent a distinct series, older than the sandstone beds of the east, or whether they are to be considered of the same period of deposition. If older, they might be arranged as in the above table, under the name of the Kaministiquia formation. They are more or less altered by metamorphic action, and contain native copper, iron pyrites, and other metallic matters.

As the sandstones or shore-line deposits of the Potsdam Group form the most characteristic and widely-spread rocks of the period, as exhibited at least in Canada, it is necessary to refer to them in somewhat greater detail. In the table given above, they are designated as the Beauharnois Formation, from their especial development in the county of that name. They consist essentially of beds of sandstone of various colours, but chiefly white, green, red, brown, or yellowish; and of conglomerates of different degrees of coarse-

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* In the pronunciation of this word the final letter is mute. Hence the word is often written Lévi.

ness. Many of the sandstones are fine-grained and of a purely silicious character, and some exhibit bands or stripes of different colours. With these beds, a few layers of dolomite or of more or less impure limestone are occasionally interstratified. Fossils, with the exception of fucoids, are of rare occurrence. In addition to the problematical *Scolithus* (see PART IV., page 97),* the most common is a species of lingula (*L. acuminata*, fig. 155), a genus which thus occurs in the very lowest of our fossiliferous rocks, and which, passing upwards through the entire series of geological formations, is still found in the seas of the existing age. Some remarkable fossil tracks occur also in our Potsdam beds. These belong to two distinct types or genera. The oldest, in point of discovery, were first made known by the late Mr. Abraham, of Montreal, in 1847. They were observed on the surface of a sandstone bed on the St. Louis River, in the County of Beauharnois, and were considered to be the tracks of a tortoise or some related chelonian. The examination of other examples, however, led to the inference that they were really made by a much lower animal, an extinct crustacean, probably more or less akin to the modern *limulus*. The generic name of ***Protichnites*** has been bestowed on these tracks by Professor Owen. They present several varieties, but exhibit essentially a narrow and often interrupted central groove with a parallel series of pit-marks on each side, as shewn in fig. 156. The groove is supposed to have been made by the caudal shield or tail-spine of the animal, and the pit-marks by the creature's claws. Tracks of ***Protichnites*** occur at other localities in Beauharnois, and likewise in Vaudreuil, &c., in Eastern Canada.

Fig. 155.—*Lingula acuminata* (Conrad).

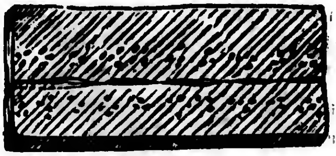

Fig. 156.—*Protichnites alternans* (Owen).

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*The *Scolithus* cavities figured on this page appear to differ from the common Canadian forms in being longer and more regularly cylindrical. The Canadian type is named *S. Canadensis* by Mr. Billings. (See Revised Report on the Geology of Canada.) p. 101.

They have also been found near the Town of Perth in the Township of Drummond, Canada West, where they are accompanied by the second kind of track impressions alluded to above. These latter exhibit narrow bands about five or six inches in width, with "beaded" edges, and usually a central beaded line crossed by a transverse series of curved or straight ridges: the whole presenting, as stated by Sir William Logan, a general resemblance to a rope-ladder. An idea of this appearance may be gleaned from fig. 157.

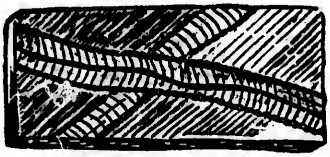

Fig. 157—*Climactichnites Wilsoni* (Logan).

On account of their ladder-like aspect, Sir William Logan has designated these tracks under the generic name of *Climactichnites.* Fig. 157 represents *C. Wilsoni* (Logan), so named from the discoverer of these latter impressions, Dr. Wilson of Perth, to whose explorations Canadian geology is also largely indebted in various other respects.

The more important economic materials of the Potsdam Group comprise building stones of good quality, as those from Lyn and Nepean employed in the construction of the Parliament Buildings at Ottawa; sandstones for glass-making purposes, being almost free from oxide of iron (Beauharnois, Vaudreuil),; and sands and sandstones for lining the sides and floors of iron furnaces. The friable sandstone of the Township of Pittsburg (just east of Kingston), and other beds on the St. Maurice in Eastern Canada, are largely used for the latter purpose. To these materials must be added the native copper, native silver, silver glance, amethyst quartz, and sulphate of baryta, contained in the veins which traverse the bottom rocks of the upper copper-bearing series of Lake Superior on the coast and islands of Thunder Bay, as at Prince's Location west of Fort William,* &c.—always supposing the altered rocks in question to be really a portion of the Potsdam Group.

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* When the earlier portions of this essay were printed, the upper copper-bearing rocks of Lake Superior had not been definitely separated from the underlying and greatly resembling Huronian series. This should be borne in mind with regard to the descriptions of certain minerals in Part II.

The sandstones and conglomerates of this group are developed chiefly in the Counties of Beauharnois, Vaudreuil, Two Mountains, and Berthier in Eastern Canada; and in those of Grenville, Leeds, Lanark, Renfrew, and Carleton in Canada West. A narrow belt occurs also to the west of the gneissoid ridge that crosses the St. Lawrence at the Thousand Isles. This belt runs through the Townships of Pittsburg, Storrington, and Loughborough, and dies out a little to the west of Knowlton Lake. At these various localities the Potsdam beds lie in unconformable position on the upturned edges or between the foldings of the Laurentian rocks. Strata belonging to the Potsdam Group have likewise been traced out, by the officers of the Geological Survey, on the north shore of the Straits of Belle Isle; and the formation is also thought, on good evidence, to occur between the Mingan Islands and the adjacent coast. The thickness of the formation appears to vary from about forty feet or less, in some localities, to six or even seven hundred feet, in others. Interesting exposures occur more particularly at the following places:—Loughborough, Eel, and Knowlton Lakes; north shore of the St. Lawrence, a mile or two below Brockville; north shore and islands of Charleston Lake (Townships of Lansdown and Escott, in Leeds County); vicinity of Beverly in the Township of Bastard; Otty Lake, in Drummond Township, and surrounding district; Townships of Nepean and Gloucester, in Carleton County; Lake St. Louis; Lake of Two Mountains; Point St. Anne and Point du Grand Detour, in Vaudreuil; Lachute, on the Rivière du Nord; River St. Maurice (various parts, near the Cachée, &c.); and Hemmingford Mountain in the Township of that name, on the border line of the Province.* The name of this group is derived from Potsdam, near Ogdensburg, in the State of New York. This name was applied to it by the New York geologists, long before the Geological Survey of Canada was commenced.

The Calciferous Group:—This division was formerly known as the Calciferous Sand Rock formation, a name bestowed upon it by the New York Survey. The latter term, however, is to some extent a misnomer, since the prevailing or more characteristic strata (in the

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* Many interesting details and measurements in reference to these and other localities, will be found in the Revised Report on the Geology of Canada, issued by Sir William Logan and his colleagues.

unaltered districts) are chiefly dolomitic limestones; although many contain, it is true, a considerable amount of sandy or silicious matter. A specimen from Rigaud gave to Prof. Hunt an amount of insoluble matter equal to 36·90 per cent.; and samples from near Prescott, and from the Beauharnois Canal (the latter containing casts of *Ophileta compacta*) yielded to the writer amounts varying from 27·12 to over 40 per cent. Other specimens from near Brockville and elsewhere, left, however, an insoluble residuum of less than 8 per cent.

The rocks of this group may be conveniently discussed under three heads, viz.:—Normal Deposits; Displaced and Altered strata of Eastern Canada; and Altered strata of Lake Superior.

Normal deposits of the Calciferous Group:—In Canada these consist principally of dark-grey dolomitic or magnesian limestones, many containing, as stated above, a certain amount of arenaceous matter. They are also interstratified very frequently with beds of grey, white, or brownish sandstone, varying in thickness from a few inches to four or five feet. The calcareous beds in many districts yield but a poor description of lime, and hence the term "bastard limestones," often applied to them by settlers and others. Small cavities lined or filled with calc spar, or more rarely with quartz, heavy spar, or gypsum, occur in some of the beds; and these and other beds occasionally exhibit in places a coarse concretionary structure. Fossils are of rare occurrence. The most common, perhaps, is the *Ophileta compacta*, fig. 158. Scolithus casts (figured on an earlier page) appear also in certain strata. In Western Canada, these normal Calciferous rocks are apparently unknown west of the gneissoid belt that crosses the St. Lawrence at the Thousand Isles. They may occur, however, in a thin band along the inner or south-western edge of the outcrop of the Potsdam series in the Townships of Pittsburg and Loughborough, although no certain indications of their presence have as yet been found. On the eastern side of the gneissoid belt, they are somewhat extensively developed—as shown by the area marked 4 in the map a few pages further on (fig. 249)—although more or less obscured by thick

Fig. 158.—*Ophileta compacta* (Salter)

beds of Drift. Exposures occur in the Counties of Leeds, Grenville, Lanark, Renfrew, Carleton, &c., of this district. An important vein of lead ore (galena) occurs in this Formation in the Township of Ramsay, Lanark County. In Eastern Canada, these beds occupy also a considerable area, and occur in the Counties of Beauharnois, Vaudreuil, Two Mountains, Chambly, L'Assomption, &c. They have been discovered likewise, of late years, in the Mingan Islands and on the adjacent coast, a locality in which they have proved more fossiliferous than in other and more western sites.

Displaced and altered Calciferous Rocks:—The displaced strata and altered beds of this age in Eastern Canada, are known more especially as the *Quebec group*. Under this term, however, the succeeding Chazy beds (in an equally altered condition, and which cannot in this district be well separated from the Calciferous deposits) are also included. These strata, until a comparatively recent period, were thought to occupy a somewhat higher place in the Silurian series, or to lie at about the horizon of the Hudson River Formation, near the top of the Lower Silurians. The fossil evidence traced out by the skill and perseverance of Mr. Billings, Palæontologist to the Geological Survey of Canada, first shewed their true position. They consist of a series of grey, black, red, and green shales, in places over a thousand feet in thickness, with interstratified beds of dark and other coloured dolomites, limestones, and sandstones, holding graptolites, brachiopods, trilobites, and other fossils. In this condition, these beds occur more especially in the Island of Orleans, near Quebec, and in the district around Point Levis opposite the city. As they extend southwards from the St. Lawrence, both into the Eastern townships and into central Gaspé, and the intervening district, they become greatly

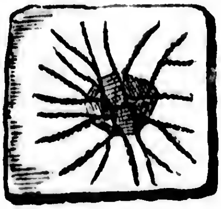

Fig. 159.
Graptolithus Logani (Hall).

Fig. 160.
a. *Phyllograptus typus* (Hall).
b. *Obolella pretiosa* (Billings).
c. *Lingula Quebecensis* (Billings).

altered by metamorphic agencies. The fossils are obliterated; and the shales and other strata are changed into gneissoid, talcose, chloritic, and epidotic schists; and also into fissile slates, serpentines, crystalline marbles, and other analogous rocks. Some of these hold large amounts of copper ore, chromic iron, magnetic and red iron ores, galena, &c.; and the sands and alluvial sediments, derived from their disintegration, contain native gold. (See the descriptions of these minerals in PART II). The unaltered or fossiliferous strata of this series present also an abnormal character, in being forced by a great dislocation and uplift into a position apparently higher than that occupied by the Trenton and other strata of really newer formation. This dislocation or great fault appears to be one of a connected series extending along the whole line of the Appalachian Mountains from Alabama to Eastern Canada. The immediate fracture along the line of which the Quebec Formation has been lifted up, is traced from the vicinity of Lake Champlain to a point just above Quebec, and from thence through the north part of the Island of Orleans, and along the Gulf of the St. Lawrence into the coast of Gaspé. The strata to the south and east of this dislocation are much disturbed, and inclined at high angles, even where they remain (as on the edge of the disturbed region) free from metamorphic or chemical alteration. Many of the rocks, both altered and unaltered, of this region, contain irregular fissures partially filled or lined with a peculiar anthracitic substance usually regarded as an altered bitumen. It is black, more or less lustrous, and usually very brittle. Sometimes (as also in more recent strata) it fills cavities in fossil corals and shells. It occurs more especially around Quebec, in the Island of Orleans, at Point Lévis, and in the townships of Acton, Grantham, St. Flavien, &c. It is occasionally taken for coal; but although chemically of the nature of certain varieties of this substance, it differs from it geologically, and essentially, by never occuring in true or workable beds, but only

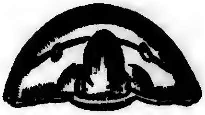

Fig. 161.
Conocephalites Zenkeri (Billings).

Fig. 162.
Bathyurus Saffordi (Billings).

in irregular masses and narrow veins of no utility. Its ash does not exhibit any traces of vegetable structure, as seen in the ashes of all ordinary coals.

The following are the more important economic substances of the Quebec Group.* *a*) *Copper Ores:*—These comprise chiefly the yellow or common Pyrites, Purple Pyrites, and Copper Glance, occasionally mixed with small portions of native copper and native silver. The ores occur in large irregular or lenticular masses, or in beds, and yield from eight to about eighteen per cent. of metal. Workable quantities are known to exist in the townships of Acton, Upton, Wickham, Durham, St. Flavien, Leeds, Cleveland, Melbourne, Sutton, Chester, Ham, and Garthby; and indications of copper occur in many other localities of this metamorphic region. *b*) *Gold:*—Indications of gold have been met with near the Chaudière Rapids, and in a quartz vein in the township of Leeds. The gold of the alluvial districts will be referred to in connexion with the economic substances of the Drift Formation, as it occurs in the deposits of this latter age. *c*) *Chromic Iron Ore:*—(In beds in serpentine: townships of Ham, Bolton, and Melbourne. Mount Albert: Schickshock Mountains of Gaspé). *d*) *Hœmatitic* and *Magnetic Iron Ores:*—(in beds: townships of Brome and Sutton). *e*) *Galena;*—(Sutton, Chaudière Valley). *f*) *Carbonate of Magnesia*, *Soapstone*, and *Potstone:*—(Sutton, Bolton). *g*) *Marble;*—(Parish of St. Armand (white, black, &c). St. Joseph (red, with white veins). *h*) *Serpentine* and *Serpentine-Marble:*—(Mount Albert, Gaspé; St. Joseph, Beauce Co.; townships of Orford, Melbourne, &c). *i*) *Roofing Slates:*—(Melbourne, Cleveland, Orford, Tring, Kingsey. Walton's quarry, near Richmond (Melbourne township), is in active operation. The cost of the slates delivered and loaded on the cars at Richmond, is four dollars per 100 square feet for those of large size (24in. x 12), and two and a quarter dollars for the smaller size (11in. x 6). *j*) *Whetstones:*—(Stanstead, Hatley, Bolton, Kingsey).

Calciferous Strata of Lake Superior:—These strata form the higher beds of the upper copper-bearing series of the lake region,—the lower beds of this series, as explained above, being now generally referred to the Potsdam Group. They consist of quartzose sand-

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* The reader will find various details of much interest on the copper mines, slate quarries, &c., of the Eastern Townships and other localities of the Quebec Formation, in the Descriptive Catalogue of the Economic Minerals of Canada in the London International Exhibition of 1862, by Sir W. E. Logan.

stones, red and greenish sandstone conglomerates, various limestones and shales, and interstratified masses of compact and amygdaloidal trap. These beds are also intersected by numerous trap or greenstone dykes; and a vast mass of trap, in places of a basaltic character, generally caps the entire formation. The total thickness of the group is estimated by Sir W. Logan as not far short of 10,000 feet. The cavities in the bedded amygdaloidal traps are filled with agates, amethyst-quartz, calc spar, various zeolites, green earth, epidote, specular iron ore, native copper, &c. Some of the intrusive dykes are porphyritic, and a few consist of syenite. (See PART III). The greenstone dykes present everywhere a transverse columnar structure and are frequently of great width. As they usually resist the disintegrating action of the water and the atmosphere better than the main body of the rocks which they traverse, they often stand out in relief and form buttress-like masses extending into the lake, so as to produce many natural harbors and breakwaters. The rocks of this series are also traversed by a considerable number of mineral veins, belonging, according to the officers of the Survey, to two distinct systems, some being parallel with the range of the strata, whilst others run in a converse direction to this. The veinstones consist usually of calc spar, heavy spar, or quartz; but sometimes of chert or agate, or of the above substances mixed with various zeolites, fluor spar, copper, copper-glance, the common and purple copper pyrites, galena, and blende, in addition to much iron pyrites. The more important metallic sites comprise Prince's Location (native silver and silver glance); Harrison's Location, St. Ignace Island (native copper with native silver); Mamainse (native copper and copper ores); and Michipicotin Island. At the latter locality, native copper (in places slightly argentiferous) occurs not in a vein, but in nodules distributed through a bed of amygdaloidal trap. The other economic minerals of these rocks, include the sulphate of baryta (heavy spar) of Thunder Bay; the amethyst quartz of the same locality; and the agates of Michipicoten and St. Ignace.

Exposures of these higher beds of the upper copper-bearing series, occur principally on the south-east side of Thunder [illegible] where they form an escarpment of white sandstone (the bottom [illegible] of the higher group) about 200 feet high; also between Thunder Bay and Black Bay; at Granite Islet, Point Porphyry, Edward Island, the mouth of the Neepigon River, the Battle Islands, St. Ignace, Michipicoten, Cape Gargantua, Batchehwahnung Bay, and Mamainse. (Various interesting details respecting these and other less prominent localities of the rocks in question, will be found in the Revised Report on the Geology of Canada by Sir William Logan and his colleagues.)

The Chazy Formation:—This series of strata derives its name from the town of Chazy, in Clinton county, N. Y. It forms a transition series between the underlying Calciferous beds and the overlying deposits of the Trenton Group. In Canada, it consists principally of grey, brownish-black, and other coloured limestones, with shales and calcareous sandstones, the latter chiefly at the base of the formation. The limestones are sometimes dolomitic, and sometimes bituminous; and they exhibit in places a concretionary structure. Many are highly fossiliferous. Some of the more common fossils comprise *Leperditia Canadensis* (a bivalve entamostracan, fig. 163), and *Rhynconella plena* (a brachiopod, fig. 164). Also, the coral *Stenopora fibrosa* (fig. 165*a*), which ranges into the higher rocks; a peculiar form of uncertain character, *Bolboporites Americanus* (fig. 165 *b*); and *Lingula Lyellii* (fig. 165 *c*). This latter fossil at Allumettes Rapids on the Ottawa, is accompanied by numerous dark nodules consisting chiefly of phosphate of lime, and supposed to be

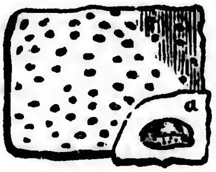

Fig. 163.—*Leperditia Canadensis* (Jones).

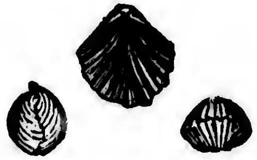

Fig. 164.—*Rhynconella plena* (Hall).

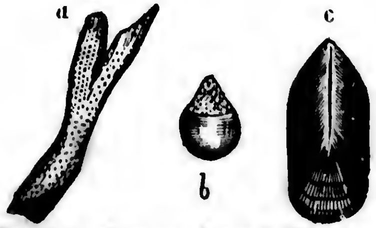

Fig. 165.—*a. Stenopora fibrosa* (Goldfuss).
b. Bolboporites Americanus (Billings).
c. Lingula Lyellii (Billings).

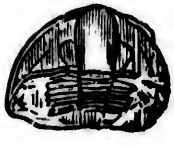

Fig. 166.—*Bathyurus Angelini* (Billings).

coprolites. *Bathyurus Angelini* (fig. 166) is a trilobite belonging to this formation. It has been found in the townships of Huntley, Ramsay, Grenville, &c.

The principal economic materials of the Chazy beds (exclusive of those from the altered rocks of the Eastern Townships as described under the Quebec Group, above: some of these rocks being probably of Chazy age) comprise—a dolomitic limestone from the township of Nepean in Carleton county, yielding the well-known "Hull cement;" grey, and grey-and-red fine-grained limestones, capable of employment as marble, from Caughnawaga, Montreal, the Lake of Two Mountains, St. Dominique, and St Lin, in Canada East; a thin-bedded limestone, filled with *rhynconella plena*, and largely quarried for tombstones and table-tops, from L'Orignal on the Ottawa; an excellent sandstone for building purposes, from near Pembroke, in Renfrew county, on a higher part of the Ottawa River; and good limestones for the same purpose, from Montreal, Caughnawaga, Hawkesbury, and other localities.

The sandstones of the Sault Ste. Marie and surrounding district, (formerly regarded as belonging to the Potsdam Group), are now thought to be of Chazy age; but otherwise the Chazy formation has not been definitely recognized west of Kingston, although it may perhaps be slightly developed between the Potsdam sandstone and the limestones of the Black River formation in the townships of Storrington and Loughborough. In the area east of Kingston, between the Ottawa and the St. Lawrence, it occurs somewhat extensively. Exposures are seen in the townships of Nepean, March, Ramsay, Huntley, Hawkesbury, &c., of that region. It occurs also largely on the other side of the Ottawa, in the townships of Chatham, Grenville, Longueuil (Prescott county), and especially around the city of Montreal. It is found likewise in places farther east, between that point and the River Chicot; and again in the Mingan Islands.

The Trenton Group:—This group derives its name from Trenton in New York. The lower beds of the group have been separated from the higher beds, and referred to two distinct formations, called, respectively, the Bird's Eye and the Black River Limestones; but in Canada, a separation of this kind cannot be definitely carried out. As certain fossils, however, are restricted *locally* to the bottom beds of the group, or are more especially characteristic of these, the terms Bird's Eye and Black River Limestone, or the latter alone, is occasionally employed in reference to the beds in question: thus partially recognising two sub-formations, the Bird's Eye and Black River (united) below, and the Trenton proper, above. The strata of the entire group average from 600 to 700 feet, and consist almost wholly of limestones, usually of a grey or black colour and more or less bituminous. Here and there a bed of sandstone, rarely exceeding two or three feet in thickness, and a thin seam of calcareous clay, may occur amongst the series; but limestone rocks essentially characterize the formation. Some of these are thick, and others thin-bedded, the latter passing into limestone shales. Fossils are exceedingly abundant in most of these beds. Those more especially characteristic of the lower sub-division, comprise:—*Tetradium fibratum* (fig. 167), *Columnaria alveolata* (fig. 168), *Stromatopora rugosa*

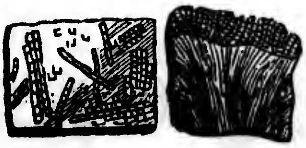

Fig. 167.—*Tetradium fibratum* (Safford).

Fig. 168.—*Oolumnaria alveolata* (Goldfuss).

Fig. 169.—*Stromatopora rugosa* (Hall).

Fig. 170.—*Maclurea Logani* (Hall).

(fig. 169), *Maclurea Logani* (fig. 170), *Ormoceras* (Orthoceras) *tenuifilum* (fig. 171), *Ormoceras* (Gonioceras) *anceps* (fig. 172), and other orthoceratites with beaded siphuncle (see *ante*, PART IV.) Also species of *Lituites*, *Cyrtoceras*, and *Phragmoceras* (figs. 173, 174, and 175).

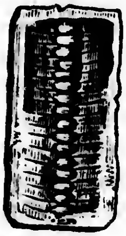
Fig. 171.—*Ormoceras tenuifilum* (Hall).


Fig. 172.—*Ormoceras anceps* (Hall).


Fig. 173.—*Lituites undatus* (Hall).


Fig. 174.—*Cyrtoceras annulatum.*

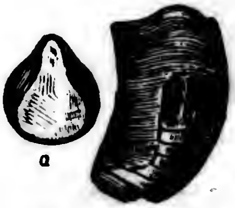

Fig. 175. — *Phragmoceras præmaturum* (Billings).


Fig. 176.—*Oncoceras constrictum* (Hall).

The more characteristic or otherwise interesting fossils of the Upper or Trenton subdivision, properly so-called, are exhibited in the following figures. The zoological positions and affinities of these have already been indicated in PART IV.


Fig. 177.—*Stenopora fibrosa** (Goldfuss).


Fig. 178. — *Petraia cornicula* (Hall).

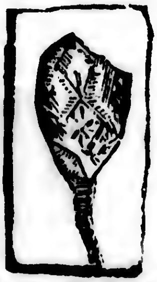
Fig. 179.—*Glyptocystites Logani* (Billings).

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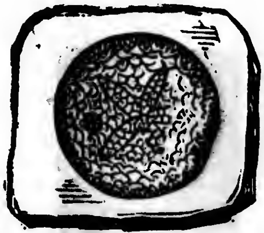
* The circular varieties of this coral are sometimes known as *S. petropolitana.*



E. J. C. DEL. ELLIS SC

Fig. 180.—*Agelacrinites Billingsii* (Chapman).

Fig. 181.—*Lingula quadrata* (Hall).

Fig. 182.—*Orthis testudinaria* (Dalman).

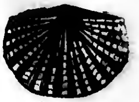


Fig. 183.—*O. pectinella* (Conrad).

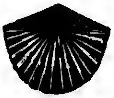


Fig. 184.—*O. tricenaria* (Conrad).

Fig. 185.—*O. lynx* (Eichwald).

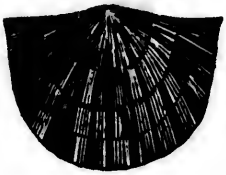


Fig. 186.—*Strophomena alternata* (Conrad).

Fig. 187.—*Rhynconella increbescens* (Hall).

Fig. 188.—*Camerella hemiplicata* (Billings).

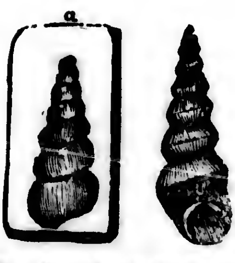


Fig. 189.—*Murchisonia gracilis* (Hall).

Fig. 190.—*M. subfusiformis* (Hall).

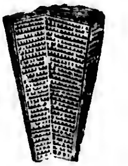


Fig. 191.—*Conularia Trentonensis* (Hall).

Fig. 192.—*Orthoceras lamellosum* (Hall).

Fig. 193.—*O. bilineatum* (Hall).

Fig. 195.—*Trinucleus concentricus* (Eaton).

Fig. 194.—*Endoceras proteiforme* (Hall).

Fig. 196.—*Asaphus platycephalus*† (Stokes).

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† *Asaphus megistos*, from Cobourg, is a closely related species, but with the posterior ngles of the head-shield prolonged into horns. See *ante*, **PART IV.**

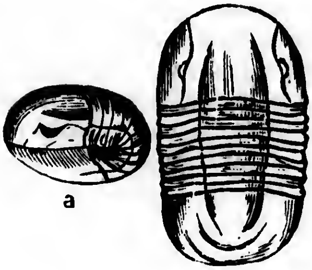


Fig. 196 *a.—Illænus crassicauda* (Hall).

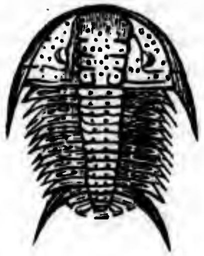
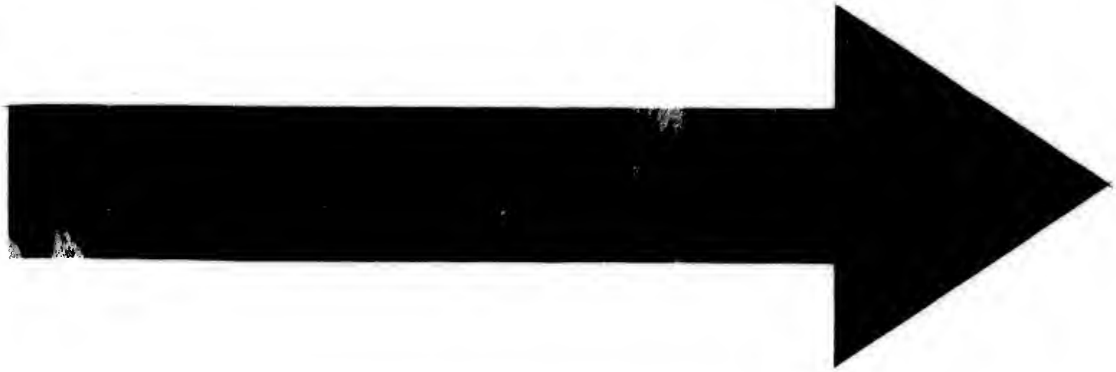
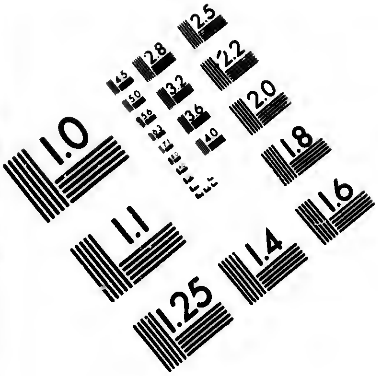


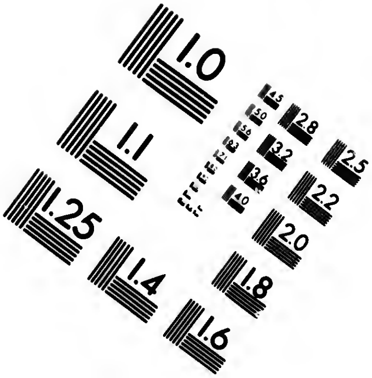
Fig. 1[illegible] [illegible]*raurus pleurexanthemus* (Green).

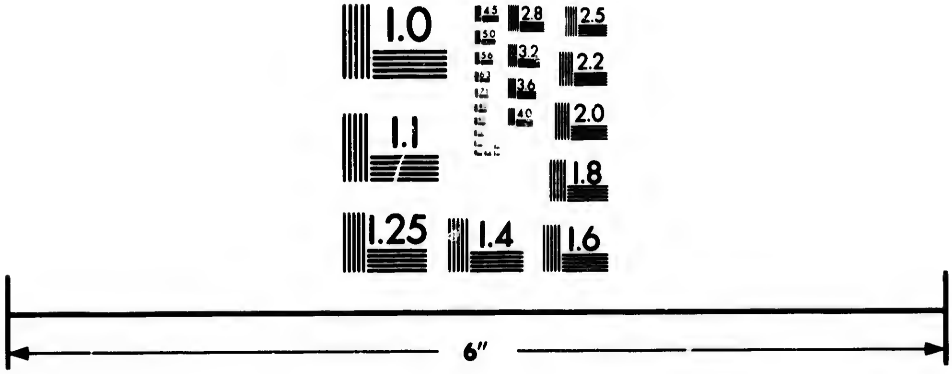
Some of the limestones of the Trenton Group are sufficiently fine-grained to take a good polish, and hence to be employed as marble. To these belong, more especially, a dark or chocolate-brown variety from the River Mississippi in the township of Pakenham (Lanark Co.), and grey varieties from the township of Gloucester (Carleton Co.), and from Montreal. Good building stones are quarried in La Chevrotière (the so-called Deschambault stone, of which the principal buildings in Quebec are constructed), at Montreal, Point Claire, Mille Roches in Cornwall township, Kingston, Ox Point near Belleville, Cobourg, Lake Couchiching north of Lake Simcoe, and various other localities. The Lake Couchiching stone is highly silicious, and consequently difficult to dress, although exceedingly durable. Excellent lime is also obtained from most of the limestones of this group. A thin light-coloured bed belonging to the lower part of the series, and which may be traced with slight interruption from Marmora to Lake St. John in the township of Rama, yields also a lithographic stone of useful quality. Near the mouth of the Coldwater River on Georgian Bay, likewise, a thin greenish sandstone, quite at the base of the series, has been long used by the Indians for the manufacture of pipe-bowls, &c. It is easily worked at first, being comparatively soft until after exposure for some time to the atmosphere.

The limestones of the Trenton Group are extensively developed in both Western and Eastern Canada. In the former (see the Map, fig. 249, in which this group is denoted by the number 6), they occur largely in the counties of Prescott, Russell, Carleton, Renfrew, Lanark, &c., between the Ottawa and the St. Lawrence, and espe-





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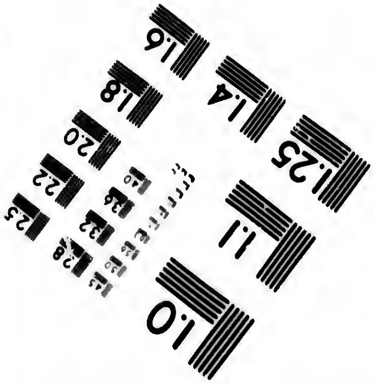

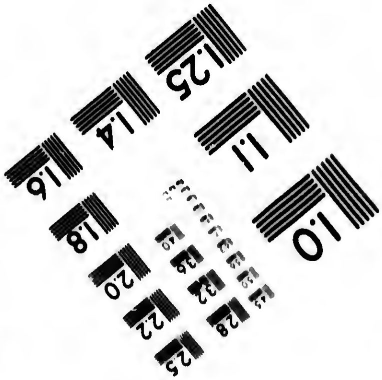


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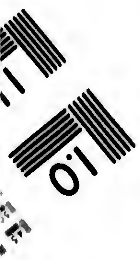
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cially around Ottawa City; but they occupy a still more extensive area on the west side of the Laurentian belt, already so frequently alluded to as separating the Silurian deposits of the basin between the two rivers, from the same deposits of the region west of Kingston. In this latter district, they form the north shore of Lake Ontario to the neighbourhood of Cobourg, and stretch northwards into the townships of Loughborough, Portland, Camden, Hungerford, Madoc, Marmora, and Dummer; and northwestward along the southern outcrop of the Laurentian rocks up to near the mouth of the River Severn on Georgian Bay,—a line of small lakes occurring for a great part of this distance between the highly-tilted gneissoid strata and the nearly horizontal Black River and Trenton beds. From a little west of Cobourg, the other or more westerly limit of the Trenton outcrop runs also to the north-west, and comes out on Georgian Bay a short distance west of Collingwood. The whole of Lake Simcoe, with Balsam, Rice, and other smaller lakes, lies thus within the Trenton area; but the country is much covered by drift deposits, so that exposures of rock are not of very frequent occurrence except along the northern limit of the formation as given above, and at these points, the Black River or lower subdivision is chiefly exposed. The upper or Trenton beds, on the other hand, come out chiefly on Lake Ontario. Still farther to the west, the formation runs across the northern portions of Manitoulin Islands, and is also seen in Lacloche, Mississague, the Snake, and other smaller islands, along the north shore of Lake Huron. It occurs finally on the north part of St. Joseph Island at the entrance of St. Mary's River. The underlying sandstone of this island, as well as the sandstone beds of Sault Ste. Marie, formerly referred to the Potsdam series, are now looked upon as representatives, in this region, of the Chazy formation.

In Eastern Canada, exposures of the Trenton Group occur more particularly at and around the village of Caughnawaga, on the south bank of the St. Lawrence; at Point Claire; around Montreal; on Isle Jésus, Isle Bizard, &c.; at St. Lin, and in the environs of that village; at St. Rocque and other places on the Achigan, as well as on the rivers Naquarean, Bayonne, and Chaloupe, and here and there between these points and the River St. Maurice; at various places in the seigniories of Portneuf, Deschambault, and La Chevrotière; at Pointe aux Trembles on the St. Lawrence; Quebec and its vicinity; around the Montmorenci Falls; on the River Ste. Anne; at Cape

Tourmente and Cape Aux Rets; on the Gouffre river; in the seignory of Les Eboulemens; at Murray Bay; and at Lake St. John on the Saguenay. These localities of the Trenton Group in Eastern Canada, with others of less importance, are described very fully in Sir William Logan's Revised Report on the geology of the Province.

The Utica Formation :—This subdivision (named after the City of Utica in the State of New York) is generally known as the Utica Slate Formation. It comprises a series of dark-brown bituminous shales, interstratified here and there with a few beds of dark limestone. The shales weather light-grey, and yield by decomposition a soil of much fertility. In Western Canada, the entire thickness of the formation is under one hundred feet; but in parts of Canada East, it is at least three times that amount. Considerable difficulty, however, is experienced in separating the Utica beds from the overlying deposits of the Hudson River Group, and sometimes, also, from the underlying Trenton strata—certain fossils ranging throughout the three groups, and beds of passage occurring likewise between these. Anthracitic matter, as in many other of our rock formations, is occasionally found in thin coatings on the surface of the shale beds. In some districts, as in the townships of Collingwood and Whitby, C. W., these shales are sufficiently bituminous to yield profitable amounts of mineral oil and gas for illuminating purposes. The Collingwood shales have afforded about twenty gallons of oil to the ton; but the distilleries of that place have now ceased working, chiefly in consequence of the large and cheap supply of mineral oil furnished to commerce by the "oil-wells" of the West.

The following figures exhibit the more characteristic fossils of the Utica formation.

Fig. 198.—*Graptolithus pristis* (Hisinger).

Fig. 199.—*Lingula obtusa* (Hall.)

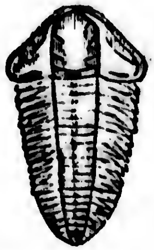

Fig. 200.—*Triarthrus Beckii* (Green).

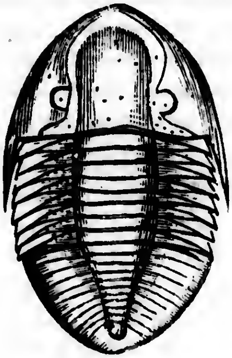

Fig. 201.—*Asaphus Canadensis* (Chapman).

In addition to the above forms, several species of brachiopods, which occur also in both the Trenton and Hudson River Groups, are also frequently met with. The most abundant of these comprise: *Orthis testudinaria* (fig. 182), *Strophomena alternata* (fig. 186), *Rhynconella increbescens* (fig. 187), and *Leptæna sericea* (fig. 204).

In Western Canada, the Utica formation (No. 7 on the map, fig. 249) occupies a small area in the immediate vicinity of Ottawa city, another in the township of Cumberland, and a third in Clarence and Plantagenet (Counties of Russell and Prescott); but it is far more extensively developed in the geological region on the western side of the gneissoid belt which crosses the St. Lawrence at the Thousand Isles. In this region, it forms the shore of Lake Ontario from a little west of Cobourg to the township of Pickering, and sweeps from these points to the north-west, coming out at Georgian Bay in the townships of Nottawasaga and Collingwood. Within the intervening space, however, it is entirely obscured by a thick capping of Drift deposits. It appears also in a narrow band in the Manitoulin Islands, more especially in the neighbourhood of Cape Smyth; and is obscurely seen on St. Joseph's Island. The best exposures in Western Canada, occur near Ottawa City; on and adjacent to the shore of Lake Ontario, in the township of Whitby; in Nottawasaga Bay under the "Blue Mountains," a few miles west of Collingwood Harbour; and at Cape Smyth and some of the neighbouring bays and small islands of the Manitoulin group.

The formation in Eastern Canada, presents in many localities a considerable developement. Exposures occur at Montreal, and in the vicinity of that city, where the shales are much penetrated by trap dykes; also on the Richelieu River, and in the adjoining district; here and there on the north shore of the St. Lawrence, between Montreal and Quebec, as on the St. Maurice and Achigon rivers; largely in the vicinity of Quebec itself, and more especially about Beauport and the Falls of Montmorenci, and along the north shore of the Island of Orleans; again near Cape Tourmente; and at Lake St. John on the Saguenay.

The Hudson River Formation.—The strata of this sub-division in Western Canada, consist essentially of arenaceous shales. These are chiefly of a bluish or greenish-grey colour, but become brown by weathering. They are occasionally interstratified with layers of ordinary sandstone, and with a few beds of limestone—their extreme thickness being about 700 feet. In Eastern Canada, the formation consists also in chief part of shales of a similar character, mixed with subordinate beds of bituminous shale, conglomerate, and limestone. Its thickness in the vicinity of Quebec is estimated at about 2000 feet; but in Western Canada, it does not exceed 700 or 750 feet in thickness. Many of its fossils are identical with those of the Trenton and Utica groups; but certain forms are peculiar to it; and others (such as *ambonychia radiata*, *modiolopsis modiolaris*, *&c.*) although occasionally occurring in the Trenton group, are more particularly characteristic of the present formation. The accompanying figures represent some of the most important of these fossilized remains.

Fig. 202.—*Graptolithus bicornis* (Hall.)

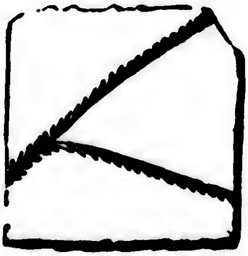

Fig. 203.—*G. ramosus* (Hall.)

Fig. 204.—*Leptæna sericea* (Sowerby.)

Fig. 205.—*Ambonychia radiata* (Hall.)

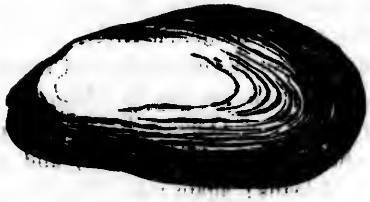

Fig. 206.—*Modiolopsis modiolaris* (Conrad).

Fig. 207.—*Cyrtolites ornatus* (Conrad)

Fig. 208.—*Orthoceras crebriseptum* (Hall).

Fig. 209.—*Calymene Blumenbachii* (Brogniart).

In addition to the above, the following species (figured under the Trenton Group, on a preceding page) are also of common occurrence:—*Stenopora fibrosa* (fig. 177); *Petraia cornicula* (fig. 178); *Orthis testudinaria* (fig. 182); *Strophomena alternata* (fig. 186); *Rhynconella increbescens* (fig. 187); *Orthoceras bilineatum* (fig. 193); *O. lateralis* (fig. 192); *Trinucleus concentricus* (fig. 195); *Asaphus platycephalus* (fig. 196); *and Illænus crassicauda* (fig. 196 *a*).

In western Canada, the Hudson River formation occurs as an outlier in the vicinity of Ottawa City, associated with the bituminous shales of the Utica series. Its chief development in this section of the Province, however, is between the more western extremity of Lake Ontario, and the Western shores of Georgian Bay. It forms the shore-line of Lake Ontario from the River Rouge in the Township of Pickering (Ontario Co.), to the River Credit in Toronto township (Peel Co.); and sweeps from these points to the north and north-west, coming out on Georgian Bay in the townships of Collingwood, St. Vincent, Keppel, and Albemarle. Lonely Island and the other islands between Cabot's Head and the Manitoulins are also composed of Hudson River strata; and the formation runs through the Manitoulin group, and across Drummond Island—reappearing in Sulphur Island, and on the north shore of St. Joseph's Island, from whence it passes into Michigan. Instructive exposures, from which many fossils may be collected, occur more particularly on the banks of the Don, Humber, Mimico, Etobikoke, and Credit, along the southern outcrop of the formation. Also at Point Boucher in Nottawasaga Bay; Point Rich, Point William, Cape Crocker, and Point Montresor, further west along the coast. On Lonely and Rabbit islands, at Cape Smyth, and various points along the north shore of the great Manitoulin; and on the northern headlands of Cockburn Island.

In Eastern Canada, the formation is exposed more particularly on the banks of the Richelieu, about Chambly, and on the Rivière des Hurons and the Yamaska, these rivers probably running, according to Sir William Logan, on three parallel anticlinals. Also on the south shore of the St. Lawrence, between St. Nicholas and the Rivière du Chêne; around Quebec, and largely at the Montmorenci Falls; and on the north side of the Island of Orleans. It has been discovered also on Snake Island, Lake St. John; and likewise on the coast of Gaspé, between Cape Rosier and the River Marsouin, and more especially about the Magdalen River. Finally, the Hudson River Formation occurs in force along the north coast of the Island of Anticosti, where it is principally composed, however, of argillaceous limestone. The remarkable fossil bodies named *Beatricea* by Mr. Billings, were discovered at this locality, and also at Lake St. John, some years ago, by Mr. Richardson of the Geological Survey. These fossils resemble petrified fragments of the trunks and limbs of large trees. Their true nature is still doubtful, but they are generally regarded as belonging to an extinct genus of corals.

The Hudson River formation is not rich in economic materials, but it yields in places some tolerably good flagging stones. At the "Blue Mountain," in Collingwood township, whetstones of fair quality are also obtained from this formation; and certain strata near Quebec furnish a good hydraulic cement. A very strong cement has likewise been manufactured from a dark dolomitic bed of this age, occurring on the Magdalen River, in Gaspé.

Middle Silurian Series. The rocks of this series, as explained on a preceding page, originally formed part of the Upper Silurian division. They have been separated from the latter, by the officers of the Canadian Geological Survey, in consequence of certain peculiarities connected with their occurence in the Island of Anticosti. In this island, situated at the entrance of the St. Lawrence Gulf, the rocks in question contain fossils belonging to both the Lower and Upper Silurians (as occurring elsewhere), and thus appear to offer a transitional series, or middle term, between these two divisions.* They compose the "Anticosti group" of Sir W. E. Logan, with the overlying Guelph deposits; and present, in ascending order, the following formations:—(1.) The Medina and Clinton Formation; (2.) The Niagara Formation; and (3.) The Guelph Formation. These, as regards Western Canada, might fairly be grouped together, under the term of the *Niagara Group.*

Medina and Clinton Formation.—In the State of New York, the rocks of this subdivision constitute two more or less distinct sets of strata; but in Canada, the upper or Clinton series merges on the one hand into the underlying Medina beds, and, on the other, into the succeeding Niagara series. Its deposits consequently are partitioned off between these two formations, the term "Clinton" being, however, retained to designate the higher strata of the first or lowermost of these. Thus defined, the Medina and Clinton subdivision consists in Canada of red and green arenaceous shales, succeeded by a coarse and somewhat loosely consolidated sandstone of a red colour, with overlying soft red marls and shaly beds, striped and spotted with green, and capped by a bed of grey sandstone (known as the "grey band,") of from ten to twenty feet in thickness. These strata, about 614 feet in thickness at the western extremity of Lake Ontario, constitute the Medina series proper. The succeeding Clinton beds comprise a series of green, greyish, and red shales—the latter, highly ferruginous—with some interstratified limestones and dolomites. At the mouth of the Niagara River, the Clinton division, as thus defined, is merely a few feet thick; but it increases in thickness towards the north-west, and attains to about 180 feet on the shores of Georgian Bay, by Cabot's Head.

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* The same holds good however, to some extent, in other localities.

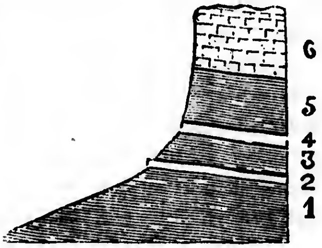

Fig. 210.

In the annexed section, 1 indicates the higher portion of the Medina beds; 2, the grey band, which forms the upper limit of this series; 3, the Clinton strata; and 4, 5, and 6, the succeeding calcareous beds of the Niagara formation. In the Medina deposits, fossils are exceedingly rare. They appear with us to be limited to fucoids, and to a single species of lingula of a triangular or cuniform outline (*L. cuneato.*) The most characteristic fucoid is the *Arthrophycus Harlani,* (fig. 211), a form which occurs also, and more abundantly, in the Clinton beds. These latter contain, in addition, various corals, brachiopods, trilobites, &c.; many of which, however, belong likewise either to the succeeding Niagara formation, or to some of the Hudson River or Trenton beds' of the Lower Silurian series. Some of the most abundant comprise: *Stenopora fibrosa,* (fig. 117,) *Heliopora fragilis,* (fig. 212,) *Favosites Gothlandica,* (fig. 214,) *Strophomena rhomboidalis,* (fig. 232,) *Orthis lynx,* (fig. 135,) *O. elegantula,* (fig. 218,) *Spirifer radiatus,* (fig. 220,) *Atrypa reticularis,* (fig. 240,) and *Calymene Blumenbachii,* (fig. 209.)

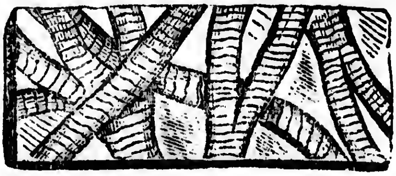

Fig. 211.—*Arthrophycus Harlani* (Hall.)

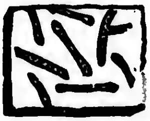

Fig. 212.—*Heliopora fragilis* (Hall.)

This formation (Nos, 9 and 10, the latter denoting the upper or Clinton beds, in the sketch map, figure 249) constitutes the greater portion of the south shore of Lake Ontario, and sweeps round the western extremity of the lake, by Hamilton, &c., to within a short distance of Oakville. From these points, it runs in a general northerly and north-westerly direction through East and West Flamborough, Nelson, Caledon, &c., up to the western extremity of Georgian Bay, where its higher strata form the lower and middle portion of the promontory of Cabot's Head. From Queenston, where it enters Canada, along the whole of this distance, the formation is capped by an escarpment or cliff-face of the succeeding Niagara strata; whilst the "grey band" at the top of the Medina subdivision proper, stands out in many places as a distinct terrace below the sloping bank formed by the out-cropping but debris-covered edges of the Clinton beds. Further to the west, the formation is seen in the Manitoulin Islands. Some of the more instructive exposures occur at Queenston, and in the gorge of the Niagara river; at the Welland Canal in Thorold; at St. Catherines; near Jordan in Louth township; on Stoney Creek, in Saltfleet; at Hamilton; Wellington Square; Dundas and its neighborhood; Waterdown in East Flamborough; Georgetown; Esquesing; on the River Credit in the township of Caledon; on several creeks in Nottawasaga; at Owen Sound and on the Sydenham River; and at Cape Commodore and along part of the adjacent coast up to Cabot's Head.

In Eastern Canada, the Medina and Clinton formation has not been definitely recognised; but Sir William Logan states that an escarpment of red shales overlying the Hudson River series, on the south shore of the St. Lawrence, between the rivers Nicolet and Gentilly, together with another restricted patch of a similar character, in that district, may very probably be referred to the Medina division.

The only important economic materials belonging to the formation, are derived from the Grey Band at the top of the Medina beds, and from a dark dolomitic limestone of the Clinton subdivision. The former yields an excellent building stone, and also grindstones of good quality, (Hamilton, Dundas, Waterdown, Georgetown, &c.,); whilst from the latter, about Thorold and St. Catherines more especially, a strong water-lime (known as Thorold cement) is largely manufactured.

The Niagara Formation:—The group of strata thus named, includes, in Canada, the upper portion of the Clinton subdivision as recognized by the geologists of the New York Survey, together with

Fig. 213.—*Pentamerus oblongus* and *Internal cast.*

the Niagara beds proper. Thus defined, the formation consists at its lower part of about twenty feet of dark-grey limestone (in part dolomitic, and in which the well-known *Pentamerus oblongus*, fig. 213, first appears), followed by a considerable thickness of dark, more or less bituminous, thin-bedded limestones or calcareous shales, which in their turn are overlaid by dark, thick-bedded limestones, also of a bituminous character. These relations are shewn in the section, fig. 210: beds 4, 5, and 6. At the Falls of Niagara, the calcareous shales make up a thickness of about 80 feet, and the thick-bedded strata which succeed, and over which the cataract breaks, exhibit about the same amount; but in adjoining localities it attains a thickness of 165 feet. Thin bands of gypsum occur in both the shales and limestones; and the latter contain, in various places, small cavities and fissures filled with crystals of calc spar, pearl spar or dolomite, gypsum, blende, galena, &c. They often enclose, also, peculiar casts of somewhat doubtful origin. The general form of these is shewn in figure 214. Casts of this kind occur not only in the present formation, but likewise occasionally in the Trenton limestones, and in the strata of the Onondaga and various other groups. They are generally known as *crystallites* or *epsomites*, and have probably been formed by the infiltration of carbonate of lime into spaces previously occupied by crystalline masses of sulphate of magnesia or soda, or of some other soluble mineral. Many of the Niagara beds are exceedingly rich in fossils. Some of the more characteristic of these (in addition to the *Pentamerus oblongus* depicted above) are shewn in the following figures:—

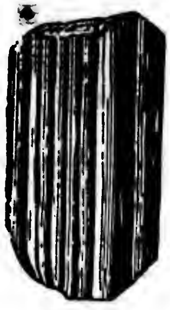

Fig. 214.

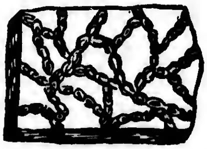

Fig. 215.—*Favosites Gothlandica* (Goldfuss).

Fig. 216.—*Halysites catenulatus* (Linnæus).

Fig. 217.—*Fenestella elegans* (Hall)..

Fig. 218.—*Orthis elegantula* (Dalman).

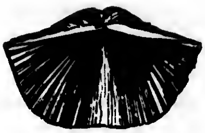

Fig. 219.—*Spirifer Niagarensis* (Conrad).

Fig. 220.—*S. radiatus* (Sowerby).

Fig. 221.—*Dalmannites limulurus* (Green).

Fig. 222.—*Homalonotus delphinocephalus* (Green).

In addition to the above forms, *Strophomena rhomboidalis* (fig. 232), *Atrypa reticularis* (fig. 240), *Calymene Blumenbachii* (fig. 209), with various other species, are likewise more or less abundant. Some of the beds of this formation consist in great part also, of broken stems and other fragmentary remains of crinoids.

The Niagara formation (No. 11 in the sketch map, fig. 249) is well displayed around the great Falls and along the gorge of the Niagara River. The abrupt cliff-face or escarpment, which runs with slight interruption from that locality, to Cabot's Head on Georgian Bay, through portions of the Counties of Lincoln, Wentworth, Halton, Peel, Simcoe, and Grey, is made up principally of this series of strata. The formation constitutes also, Fitzroy Island, the "Flower Pots," &c., together with the southern portion of the Manitoulin Islands—from whence, turning to the south west, it extends along the western shore of Lake Michigan. Good exposures occur more particularly at the

Falls, and along the Niagara River between these and Queenston; also on the Welland Canal near Thorold; in the vicinities of Hamilton, Ancaster, Dundas, and Rockwood; at Belfontaine on the River Credit in the Township of Caledon; at various points in Mono, Mulmur, Nottawasaga, Artemisia, and Euphrasia Townships, where it forms high cliffs, more especially at the Nottawa and Beaver Rivers; Owen Sound and neighbourhood; Cape Paulet on Georgian Bay, and along the coast to Cape Chin; and likewise at Cabot's Head. At this latter locality, the lower part of the cliff, to a height of about 180 feet, consists of the Clinton subdivision—the Niagara beds resting upon this up to the summit of the promontory.

The annexed figure exhibits the Niagara and underlying strata as occurring in the gorge of the Niagara River between the Falls (*F*) and Queenston (*Q*). The dip of the beds, however, is unavoidably somewhat exaggerated.

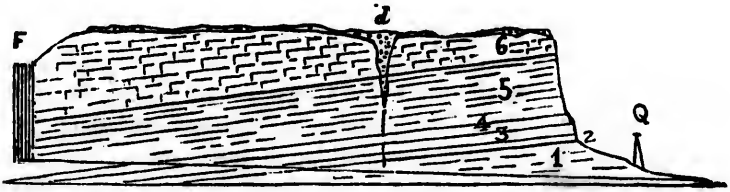

Fig. 223.—Section of the Niagara, Clinton, and Medina strata in the gorge of the Niagara River, between the Falls and Queenston.

1 — Red marls and shales (Medina).
2 — "Grey Band" (Medina).
3— Greenish shales (Clinton).
4 — Layer of Pentamerus limestone (Old Clinton; now referred to the Niagara Group).
5 — Calcareous shales (Niagara).
6 — Niagara limestone.
d, Drift and Post-Tertiary accumulations.

In the accompanying sketch, fig. 224, a section of the rocks across the Falls is shewn, with Goat Island (*G*) in the centre. No. 5, as in the preceding sketch, indicates the Niagara shales; No. 6, the thick bedded limestone; and *d* the Drift and Post-tertiary deposits. *A* denotes the American side, and *C* the Canadian shore. The Post-tertiary accumulations will be alluded to more fully in our description of

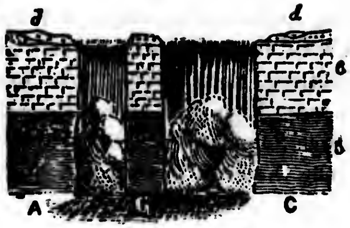

Fig. 224.

the Drift and succeeding deposits; but it may be observed that the more recent of these accumulations contain shells of the *unio, cyclas, melania,* and other fresh-water types now inhabiting the river, and evidently indicate, as first pointed out by Sir Charles Lyell and Professor James Hall of Albany, an ancient and at one time continuous deposit spread over the original river-bed. Accumulations of a similar character occur, however, in various parts of the Western Province, and were produced by our lake waters when these were united into one vast fresh-water sea, as explained in a subsequent part of this Essay.*

The limestones of the Niagara Formation yield excellent building materials, and quarries have been opened in these beds at Rockwood, Owen Sound, and other places.

In Eastern Canada, the Niagara strata, or rocks of the same geological horizon, are thought to occur in Gaspé, on the Chatte, Rimouski, and other rivers, and on Lake Metapedia; but much uncertainty still prevails with regard to the true position of these beds. They form the lower portion of the strata provisionally known as the "Gaspé limestones." In the Island of Anticosti in the Gulf of the St. Lawrence, however, there is a great display of limestone rocks undoubtedly of Middle Silurian age: the equivalents consequently of the Medina and Clinton, combined with the Niagara Formation. Along the more northern shore of the island, there runs a belt of Hudson River strata, as explained in our remarks under that formation; and this is succeeded by the limestones in question. These, with a few interstratified shales, occupy all the rest of the island, and make up, according to Mr. Richardson of the Geological Survey, a thickness of nearly 1,400 feet. The numerous fossils which they contain, have on the whole an essentially Upper Silurian character, but certain forms amongst them appear to establish a connecting link or passage between the Lower and Upper subdivisions of the Silurian series as

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* See a paper by the writer, on the ancient extension of our lake area, &c., in the *Philosophical Magazine* for July, 1861, and in the *Canadian Journal*, Vol. VI., p. 221. Also an article by Robert Bell, of the Canadian Geological Survey, in the *Canadian Naturalist* Vol. VI.

originally recognised: hence the separation of the so-called Middle Silurian series—these Anticosti beds being taken as the type of the latter subdivision. The expediency of the separation, however, is somewhat questionable.

Finally, with regard to the Niagara Formation, it may be observed that limestone strata of apparently the same age, but resting on Huronian rocks, have been discovered at Lake Temiscamang, north of the great Laurentian water-shed which separates the northern geological area of Canada from the western and eastern areas of the south. See the general sketch of the distribution of our rock formations, a few pages further on.

The Guelph Formation:—The rocks of this formation, unlike the Niagara and other Canadian strata, have not been traced beyond the limits of the Province. The "Leclaire limestone" of Iowa, which at one time was thought to belong to the same geological horizon, is now referred by Professor Hall to the Niagara subdivision. The Guelph Formation, as known in Canada, follows the more western limit of the Niagara area, and occurs especially in the vicinities of Galt and Guelph. According to Sir William Logan, it appears to form a lenticular-shaped mass, gradually thinning out both westward in Lake Huron, and in the neighbourhood of Ancaster, in the east. Its greatest thickness is estimated at about 160 feet. Its strata consist essentially of white or light-coloured dolomites mostly of a peculiar semi-crystalline or granular texture. These yield excellent building materials.

Many of the enclosed fossils are identical with those of the Niagara beds, as *Favosites Gothlandica* (fig. 215), *Halysites catenulatus* (fig. 216), &c., but others appear to be confined to this formation.

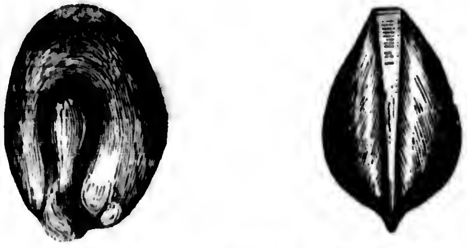

Fig. 225.—Casts of *Megalomus Canadensis* (Hall).

Amongst these, the most characteristic is the ***Megalomus Canadensis***, usually found in the form of internal casts, as shewn in fig. 224.*

As a general rule, the fossils in these beds are somewhat obscure, and not very abundant. The principal exposures of the formation occur on the River Speed in the vicinity of Guelph ; at Elora, on the Irwine and Grand River, where it presents vertical cliffs over eighty feet in height ; at Hespeler on a branch of the Great Western Railway, ; and lower down the Grand River, at Preston, Galt, and places in the township of Dumfries. At present, the Guelph formation can only be regarded as a provisional group, its strata appearing more or less to merge into the underlying Niagara beds, and in some localities, also, to offer a passage into the Onondaga deposits.

The Upper Silurian Series :—This subdivision in Canada—as separated from the Middle Silurian series—contains but two groups of strata : the Onondaga formation at the base of the series, and the succeeding Lower Helderberg division ; but the latter, as regards the greater part of the Province, is with us but feebly represented.

The Onondaga Formation :—This division, more commonly known as the "Onondaga Salt, or Gypsiferous, Group," derives its name from the village of Onondaga, near Syracuse, in the State of New York. The abundant brine-wells of that locality belong to the group. In Canada, the Onondaga deposits average in thickness between two and three hundred feet, and consist essentially of thin-bedded dolomites, usually of a yellowish colour ; with greenish shales (chiefly agillaceous dolomites), and some associated masses of gypsum. The latter substance, so largely employed as a mineral manure, and in the preparation of ***Plaster of Paris*** (see PART II.), does not occur in regular beds, but in large lenticular masses, as exhibited in the annexed figure. The dolomitic layers above the gypsum, are generally arched, and more or less fissured ; whilst those on which the gypsum rests, retain their normal condition. The disturbance, consequently, by which the upper beds have been affected, was evidently produced by some after cause connected with the presence of the gypsum. The peculiarity was originally explained by assuming the gypsum to have been

Fig. 226.

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* This fossil is described in PART IV. as occurring in the Onondaga Group, the Guelph strata having been originally referred to that subdivision.

derived from the surrounding rocks by the gradual action, upon these, of springs containing a certain amount of free sulphuric acid: springs of this kind occurring, at present, at several localities in Western Canada and New York. But it is now regarded by Professor Sterry Hunt as more probably due to the contraction of the gypsum masses having been less than that of the overlying and contemporaneously deposited shale materials, in consequence of which, the latter would gradually settle down and fold themselves around the gypsum. Another view assumes the sulphate of lime to have been originally deposited in the form of *anhydrite,* a closely related mineral but without water of crystallization. The after absorption of water would then cause an increase in bulk, and so produce the bulging and fracturing of the overlying beds.

Fossils are scarcely known in this formation. A few obscure and rare traces of organic forms are all, indeed, that have been recognized in Canadian localities. The Onondaga deposits are in great part of chemical origin, and were evidently accumulated in strongly saline waters, principally by evaporation: facts which go far to explain the absence of organic remains. The only forms of probable occurrence would be certain cyproids or bivalve entomostracans, as species of these, at the present day, inhabit brine solutions in which an active evaporation is going on. Casts of prismatic crystalline masses, however, like that exhibited in figure 214, and others of a flat and square pyramidal or hopper-shaped form, the latter evidently derived from ordinary salt, are of not uncommon occurrence. This would follow naturally from the conditions under which the beds were deposited.

The Onondaga formation (No. 13 in the sketch-map, fig. 249) crosses the Niagara River above and below Grand Island, or a short distance above the Falls, and follows the general outcrop of the Niagara and Guelph formations up to the vicinity of the Saugeen River on Lake Huron. It thus passes through portions of the Counties of Welland, Haldimand, Brant, Oxford, (north-east corner), Waterloo, Perth, and Bruce, but throughout much of this area it is covered by Drift accumulations. On the American side of Lake Huron, the picturesque island of Mackinaw is chiefly made up of Onondaga rocks, and these occur also in places on the adjoining coast of Michigan. Canadian exposures are exhibited chiefly near the village of Waterloo, in Bertie township, on the Niagara River; along the Grand River between Cayuga and Paris, and higher up the stream near the Don Mills; at places near Ayton and Newstadt, in the township of Normanby, on the Upper Saugeen; around Walkerton, on the Saugeen River, in Brant township; and at various points down the river, more especially at the elbow in the south-west corner of Elderslie township, and on the banks of the stream a little below Paisley. At the mouth of the Saugeen, and on the adjacent coast south of this, the formation is concealed by Drift sands and clay.

The gypsum or "plaster" deposits constitute the most valuable economic material of the Onondaga beds; but some of the dolomitic shales of the formation, as those at Walkerton, furnish also valuable materials for the manufacture of hydraulic cement. The gypsum is principally mined or quarried at Cayuga, Indiana, and York, in the township of Seneca; also at Mount Healy and elsewhere in the adjoining township of Oneida, on the opposite side of the Grand River; in Brantford township; and largely around Paris. The annual amount obtained at present from these localities, is between fourteen and fifteen thousand tons.*

The Lower Helderberg Group.—The group of rocks thus named, is developed somewhat extensively in the vicinity of the Helderberg Mountains and in the eastern part of New York generally, as well as in the more eastern part of Canada south of the St. Lawrence; but it thins out towards the west, and presents merely two or three outlying patches in the neighbourhood of Montreal, and a comparatively narrow strip of slight thickness in Western Canada, between the eastern end of Lake Erie and the township of Cayuga. It may probably extend beyond this latter point along the western limit of the Onondaga zone, up to Lake Huron, but no exposures of its strata have been seen west of that township. This strip, in no place exceeding fifty feet in thickness, consists of the lowest division of the group as subdivided by the New York geologists, or of the equivalents of their "Water-lime Group or Tentaculite Limestone." With us, in Western Canada, it might be called the "Bertie or Cayuga dolomite," as its only known exposures are in those townships; or a still better term would be the *Eurypterus* formation, so named from its principal and characteristic fossil: the *Eurypterus remipes*, a low form of the crustacean class, figured in woodcut 227. In the above townships its strata consist of thin-bedded greyish dolomites, interstratified towards

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* The gypsum, as quarried, sells at about $2 the ton. When ground for manure, the cost per ton is about $3.50; and when calcined for plaster, about fifteen or sixteen dollars.

the base with a few brownish shales, and with a brecciated bed composed chiefly of dolomite fragments.

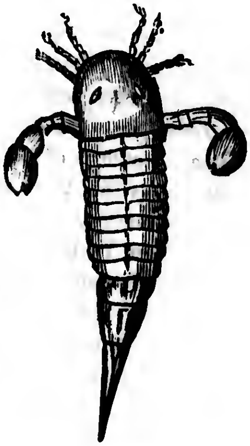

Fig. 227.
Eurypterus remipes (reduced).

At St. Helen's Island and Round Island, opposite Montreal, on Isle Bizard, and at one or two neighbouring localities, some outlying or small isolated patches of conglomeritic rock, referred to the Lower Helderberg division, have been recognised of late years. Their existence was first pointed out by Dr. Dawson. They are made up of fragments of various rocks, gneiss, Trenton limestone, Utica shale, syenite, &c., cemented together by a paste of greyish dolomite. These conglomerates are regarded as patches of strata once continuous with the Lower Helderberg series of eastern New York, their removal in intervening areas having been effected by denudation. The limestones and shales which at Cape Gaspé, and elsewhere in that region, rest unconformably on the dark shales of the Calciferous or Quebec formation, are likewise referred by Sir William Logan to the Lower Helderberg group. These beds are, at present, known provisionally as the "Upper Gaspé Limestones"—the lower limestones of the Gaspé series, already alluded to as occurring on the Chatte, Rimouski, and other rivers of that district, being referred to the Middle Silurian period. See the remarks on this point, under the Niagara formation, above.

Devonian Strata.—The rock formations of Devonian age, occurring in Canada, are restricted to the following subdivisions (here named in ascending order):—(1), The Oriskany Formation; (2), The Corniferous Formation; (3), The Hamilton Formation; and (4), The Portage and Chemung Group. Of these, however, Nos. 1 and 4 are but very slightly developed. It is in the Devonian strata, it will be remembered, (at least as regards this continent) that we find the first traces of vertebrated life and of land vegetation.

The Oriskany Formation.—In Canada the so-called Oriskany beds consist essentially of white or brownish sandstones of both fine and coarse grain, averaging about seven or eight feet in thickness. These rest on a layer of chert or hornstone. The latter contains much iron pyrites; and the bottom beds of the sandstone present here and there a brecciated structure, being chiefly made up of fragments of this chert. Fossils are very abundant, but the greater number appear to be identical with those of the overlying Corniferous formation. This fact, combined with the cherty character of the beds, renders the separation of the two groups little more than a mere arbitrary distinction. Amongst other forms, the following may be enumerated as especially abundant:—*Favosites Gothlandica* (fig. 215), *Zaphrentis prolifica* (fig. 230), *Strophomena rhomboidalis* (fig. 232), *Atrypa reticularis* (fig. 240), *Stricklandia elongata* (fig. 236), *Pentamerus aratus* (fig. 235), and *Calymene Blumenbachii* (fig. 209).

This formation, which is somewhat extensively developed in the State of New York, enters Western Canada in Bertie township (about opposite to Buffalo) and appears to extend as a thin band along the southern edge of the Eurypterus or Onondaga deposits, at least as far as the County of Norfolk; but the only known exposures occur at places in the townships of Bertie, Dunn, North Cayuga, Oneida, and Windham. From the exposure in North Cayuga, a little north of the Talbot road, good millstones have been obtained.*

The Oriskany formation is probably represented in Eastern Canada, according to Sir William Logan, by some of the sandstones of Little Gaspé and that district. A small seam of coal, under two inches in thickness, occurs in these beds, together with numerous carbonized plants. The latter have been described and figured by Dr. Dawson in the *Canadian Naturalist*, vols. V. and VI.

The Corniferous Formation.—This group of strata includes the "Onondaga limestone" and the "Corniferous limestone" of the New York geologists. Its name is derived from the occurrence of nodular masses and layers of chert or hornstone in many of its beds. It is made up essentially of limestones, generally free from magnesia, but often highly bituminous, combined with layers of chert, and with a few beds of calcareous sandstone and an occasional band of bituminous shale. The total thickness of the formation, with us, is apparently under 200 feet, but this is somewhat doubtful. The limestones are exceedingly fossiliferous; and in places (more especially towards the base of the formation) they abound in fragments of crinoids and other organic remains in a silicified condition. The fossils, indeed, are

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* These are manufactured by Mr. DeCew, Provincial Land Surveyor, of DeCewsville, near Cayuga, in Haldimand County: from whom, also, interesting suites of fossils, belonging to the formations of that district, may be procured.

mostly, though not entirely, in this condition throughout the group. They have formed the nuclei, to which, during the consolidation of the strata, much of the cherty matter has been attracted. In some of the silicified corals and brachiopods, petroleum is also found.

A few of the more important organic remains are shown in the annexed figures :—

Fig. 228.
Michelinea convexa
(D'Orbigny).

Fig. 229.
Syringopora Maclurei
(Billings).

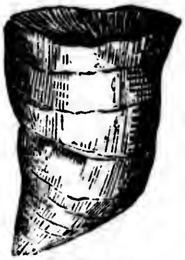

Fig. 230.
Zaphrentis prolifica
(Billings).

Fig. 231.
Cystiphyllum Senecaense
(Billings).

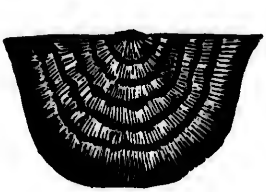

Fig. 232.
Strophomena rhomboidalis
(Wahlenberg).

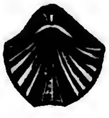

Fig. 233.
Spirifer gregarius
(Hall).

Fig. 234.
Athyris Clara
(Billings).

Fig. 235.
Pentamerus aratus
(Conrad).

Fig. 236.
Stricklandia elongata
(Billings).

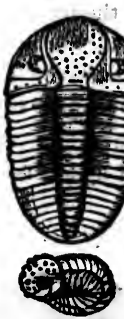

Fig. 237.
Phacops bufo
(Green).

In addition to these forms, *Spirifer mucronatus* (fig. 238), *Spirigera concentrica* (fig. 239), and *Atrypa reticularis* (fig. 240), may also be mentioned as being of common occurrence.

The Corniferous formation (No. 16 in the sketch-map, fig. 249) occupies two extensive areas in Western Canada, although covered and obscured in most places by Drift accumulations. These areas comprise portions of the counties of Welland, Haldimand, Norfolk, Brant, Oxford, Perth, Huron, and Bruce, on the one hand, and parts of Kent, Essex, and Lambton on the other. A comparatively broad tract, occupied by the Hamilton formation, intervenes between these two areas. The latter formation, as shewn some years ago by Sir William Logan, rests in a depression on the summit of a flat but important anticlinal which traverses this western peninsula in a general east and west direction. Exposures of Corniferous strata occur more particularly on or near to the shore of Lake Erie in the townships of Bertie, Humberstone (Rama's Farm, near Port Colborne), Dunn, Rainham, Walpole, Woodhouse, &c.; also in North and South Cayuga; near Woodstock village; largely at St. Mary's; in Carrick township, on a branch of the Maitland, and also in the adjoining township of Brant; at Point Douglas on Lake Huron, and elsewhere along the coast, in the townships of Bruce and Kincardine; further south, near Port Albert, and on the Maitland, near Goderich; and also at the extreme west of the peninsula, as near Amherstburg, on the River Detroit.

Many of these exposures, and more especially that of the last-named locality in Malden township on the Detroit, furnish excellent building materials; but the Corniferous formation is chiefly of importance, in an economic point of view, as the supposed source of the great oil supply of this western region. As the oil-wells in successful operation, however, occur entirely within the central area, across which, as stated above, the Hamilton formation extends, their discussion will be entered into in connexion with the latter series of strata.

In Eastern Canada, the Corniferous formation is undoubtedly represented by a portion of the Gaspé deposits, and probably also by some of the altered strata of the Eastern Townships. The beautiful yellow-veined marbles of Dudswell are thought to be of this age. In Gaspé likewise, as near Douglastown and elsewhere in that district, petroleum springs occur in Devonian strata referrible either to this series, or to the somewhat lower horizon of the Oriskany Formation.

The Hamilton Formation.—The name of this formation must not be confounded with that of Hamilton in Canada: a city situated on strata (the Medina) of a much lower geological horizon. As a misconception of this kind often occurs, it is almost to be regretted that our Provincial Geologist did not in this instance depart from the usual and strictly legitimate plan, and propose for the group in question a Canadian or palæontological name. It might be called appropriately the Lambton or Goniatite formation, the latter type first appearing in the beds of this series. The term "Hamilton," as at present applied to the group, is from the village of that name in Madison County, New York. The American geologists usually subdivide the formation into three groups, distinguished chiefly by lithological characters. The lowest group consists of dark bituminous schists known as the Marcellus shales; the second group, or Hamilton group proper, is made up of argillaceous and other shales or flags, with an interstratified bed of encrinal limestone, and in some places an overlying limestone bed called the Tully limestone; finally, the third or uppermost group is composed of dark shales closely resembling those of the first division, and known as Genesee shales. Some observers separate these latter, however, from the Hamilton formation, and place them in the succeeding Portage group: a view adopted by the Canadian Survey. The Marcellus shales thin out greatly towards the west; and on entering Canada, the formation appears to consist only of the second group; but its junction with the underlying Corniferous strata has not yet been observed. It crosses the counties of Norfolk, Elgin, Kent, Middlesex, Lambton, and the south part of Huron; but is much obscured throughout by overlying Drift deposits.

The best and almost the only known exposures occur in the township of Bosanquet in the north-west corner of the county of Lambton. As there seen, its strata are composed of soft grey calcareous shales, with one or two beds of encrinal limestone. Sir William Logan estimates the total thickness of the formation, with us, at about 300 feet. The shales contain numerous fossils, the most abundant, perhaps, being the four species figured below.*

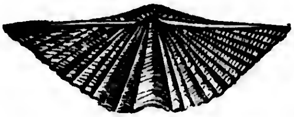

Fig. 238.
Spirifer mucronatus
(Conrad).

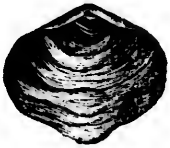

Fig. 239.
Spirigera concentrica
(Von Buch).

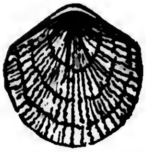

Fig. 240.
Atrypa reticularis
(Linnæus).

Fig. 241.
Orthis Vanuxemi
(Billings).

In addition to these, several corals and some other brachiopods are of common occurrence; and examples of the trilobite, *Phacops bufo*, fig. 237, are often met with.

Petroleum Springs and Wells.—As stated on a preceding page, the celebrated "oil-wells" of Western Canada are principally situated within the area occupied by the Hamilton shales, although the oil itself, more properly known as petroleum or fluid bitumen, is thought to arise from the underlying Corniferous formation. The existence

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* These species occur also abundantly in the Corniferous formation; and *Atrypa reticularis* is found as low down as the Clinton group.

of natural springs of petroleum in the valley of the Thames, appears to have been known to the Indians long before the clearing of that district. Under the name of "Seneca oil," the petroleum from these sources was employed as a popular remedy for rheumatism, &c., by the early settlers, who are said to have learnt the use of it from the Indians of the locality. In the Geological Report of the Canadian Survey, for 1850, Mr. Murray pointed out the occurrence of several of these so-called "oil springs" in the townships of Mosa and Enniskillen; and in the Report of the succeeding year, attention was called to a deposit in that district of bitumen or mineral tar, arising from the thickening or drying up of petroleum overflows. One of these concreted petroleum deposits occurs in the southern part of Enniskillen, forming two detached portions of about an acre each, and varying in thickness from about a couple of inches to two feet. Another deposit of a similar character, three or four inches in thickness, has been since discovered in the northern part of the township, eight or ten feet beneath the surface of the ground. It occurs in Drift clay above a stratum of gravel. Subsequently to the announcement of the natural springs of this locality, others have been found in the townships of Zone and Orford; and some also near Tilsonburg, in the township of Dereham. These latter lie beyond the limits of the Hamilton formation, or over the Corniferous limestone; and petroleum has been obtained by wells from that rock.

In 1857, the idea occurred to Mr. Williams, of Hamilton, C.W., then engaged in the distillation of the solid bitumen of Enniskillen, to bore through the Drift clays of that district into the underlying rock beds, in the hope of striking subterranean reservoirs of the petroleum, such as had been shown to occur in Ohio and Pennsylvania—and his attempt was rewarded by an almost unexpected success. At the present time about one hundred wells or bore-holes have been put down in Enniskillen alone. Many of these were at first "flowing-wells," the petroleum rising above the surface of the ground; but after flowing for some time, the action in the greater number suddenly ceased. Some, however, still continue to flow. Altogether, an immense quantity of petroleum has been obtained from these sources.

The wells in Enniskillen are of two kinds, known respectively as *surface* and *rock* wells. The former pass through the soil and Drift clay to a depth of about 50 or 60 feet into a stratum of gravel immediately above the rock; whilst the latter are continued into the rock itself, to an average depth of from 50 to 150 feet. The discharge from the wells is accompanied, in many cases, by salt water, and by emissions of inflammable gas. In some of the wells which have ceased to yield petroleum, salt water has taken the place of the rock oil.

The fissures or reservoirs in which the petroleum occurs, are apparently of restricted size, and very irregular in their course. Whilst in some instances, neighbouring wells affect each other, and thus evidently draw their supply from the same immediate source, in other instances, borings put down close to wells in active operation, and carried even to a greater depth, have failed to strike the oil fissure.

The origin of the petroleum is involved in great obscurity. Two views have been suggested in explanation of its occurrence. One of these connects the presence of the rock oil with the great coal deposits of Michigan, or those of Ohio and Pennsylvania. The coal-bearing strata of these districts occupy a much higher geological position than the petroleum-containing beds of Western Canada. The Pennsylvania coal strata are geologically over 10,000 feet above these latter; and a thickness of 860 feet intervenes between the top of the Hamilton formation and the coal deposits of Michigan. A long interval of time must therefore have elapsed between the deposition of the two series of strata. But the petroleum may have been generated in the Michigan beds at some subsequent epoch, and have been carried along a system of fissures into our Devonian rocks: the two formations, owing to the dip of the strata, occupying very nearly the same topographical elevations. Several facts are opposed, however, to this view. In the first place, no evidence of the occurrence of liquid petroleum amongst the Michigan coal seams has hitherto been obtained, neither are any reservoirs of petroleum known in coal rocks of other localities; secondly, small quantities of petroleum and of solid bitumen, (a closely allied substance) occur in various strata far below, and topographically far removed from coal deposits; and thirdly, the direct distance between the rim of the Michigan coal field and the oil district of Enniskillen is at least 80 miles, so that the existence of continnous fissures of communication between the two is not very probable.

The second view regards the rock oil as originating within the strata in which it occurs, by some peculiar decomposition of fucoids or animal remains. Fucoids or sea-weeds, it must be remembered, are the only vegetable matters hitherto discovered amongst the fossilized bodies of our Silurian and Lower Devonian rocks. But if we adopt this view, we must adopt, also, certain other and apparently unwarrantable conclusions. The organic remains of these strata are not more numerous than those of other strata in which not the slightest traces even of petroleum have been found; neither do they present any characters peculiar to themselves and suggestive of oil-forming capabilities. Hence we have to infer the existence in the Devonian seas in which these deposits were laid down, of a vast abundance of soft-bodied animals, or sea-weeds, of a nature altogether unknown: a most gratuitous supposition. The enormous quantity of petroleum yielded by these sources, and by others in the American States and elsewhere, renders the formation of this substance from sea weeds or perishable animal remains in the highest degree improbable.

But are we absolutely driven to the adoption of either of the above views, in order to explain the occurrence of petroleum in our Devonian strata? The question mainly turns upon this: Are we forced to assume with certain chemico-geologists—who refuse all explanations of natural phenomena incapable of being rendered evident by laboratory experiments—that all forms of carbon, and all compounds into which carbon enters (with the sole exception of carbonic acid, and that only in part) are necessarily of organic derivation? With all respect for laboratory investigations, some of which have shed much light on obscure geological problems, it cannot be doubted that this view assumes too much. There are many facts, universally recognized as such, which chemistry is quite unable to explain. The allotropic conditions of certain simple bodies, for instance, carbon amongst the number; the existence of chlorine, oxygen, &c., in the solid state in the greater number of their compounds; the peculiar condition of water in hydrated substances, and so forth. We have the positive fact likewise that carbon exists, as such, in meteoric stones; that it separates often in crystalline scales from molten iron; and that it is present in steel, a fusion-product, also, as sometimes prepared. Why, then, are we debarred from assuming its existence amongst the primary or original components of the earth-mass? During volcanic outbreaks in many parts of the world, petroleum has frequently made its appearance, through fissures on the sea-bed, or around the volcanic vent, as one of the products of the eruption. This was memorably the case in the eruption of Vesuvius in 1861.[*] The great petroleum springs of Central Asia, which have been flowing for ages also, with those of Zante (mentioned by Herodotus) and others of different localities, lie essentially in areas of volcanic action; and the so-called mud-volcanoes often pour out large quantities of bituminous matter, mixed with other products. It might be argued that in these cases the petroleum is derived from deeply-seated coal beds, but of this we have no proof. And when we consider the fact that small quantities of bitumen and petroleum occur in rocks geologically far older than those of the coal series, we have an equal right to assume that these matters may be generated, without the aid of organic bodies, by unknown chemical action within the crust of the earth, and may be poured out through fissures from time to time, both amongst deposits under process of accumulation, and amongst others already consolidated.[†] In this manner, I imagine, our petroleum springs of Western Canada have originated. And I would go beyond this, and refer to the same action a leading part in the formation of all bituminous shales, and of coal seams generally. In the latter case, the liquid bitumen or petroleum may be conceived to have flowed into broad marshes, or over low-lying districts, in which an abundant vegetation was under growth. The vegetable matters thus saturated and mixed up with the thickening petroleum, would add their substance to the formation of the coal, and would be chiefly instrumental perhaps in imparting to this its peculiar character. On this view, the formation of bituminous shales by the saturation of the finer kinds of sedimentary matter by petroleum overflows, becomes readily explained; and also the close agreement in character which exists between the shales of the coal measures and those of many Silurian strata. The old view does not explain these points in a satisfactory manner. The petroleum theory likewise obviates the necessity of assuming the growth of an enormous and unparalleled vegetation during the Carboniferous period; and it explains why the vegetation of after periods so rarely yielded coal—the outflows of petroleum having chiefly taken place during the Carboniferous epoch, and only locally at other times.

The Portage and Chemung Group.—The rocks of this group, so largely developed in the peninsula of Michigan and other districts of

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[*] See *Canadian Journal*, vol. vii , p. 126.

[†] If the term "unknown chemical action" be here objected to, we may refer, amongst other cases, to that of the diamond: a substance certainly formed by chemical action, but of a kind altogether unknown to us.

the American States, occur with us in the form only of a few isolated and inconsiderable patches. These consist of black and highly bituminous shales—the probable equivalents of the "Genesee slates," referred by some observers, as already explained, to the Hamilton formation. The principal locality of these shales is Cape Ipperwash, or Kettle Point, in the township of Bosanquet on Lake Huron; but they occur also nearly twenty miles inland from this point, on a creek near Kingston Mills in the south part of the township of Warwick; and also, still further inland, in the township of Brooke. The shales weather dull-grey, and those of Cape Ipperwash are occasionally coated with a yellow crust of oxalate of iron (see Part II. under "Humboldtine"). They contain large spherical concretions (with radiated internal structure) of carbonate of lime; and also much iron pyrites. In the shales of Kettle Point, likewise, long flattened stems of vegetable forms (mostly referred to the *Calamites inornatus* of Dawson) are of common occurrence; and impressions of fish scales are met with in those of Warwick. The thickness of the exposure at Kettle Point is under fifteen feet; and it is still less than this at the other localities.

Carboniferous Strata.—The Bonaventure Formation.—The only locality at which Carboniferous strata occur in Canada is the south-eastern extremity of Gaspé. Exposures of great thickness range along the Bay of Chaleurs and the coast of Percé, and enter Gaspé Bay. These Carboniferous strata occur consequently, for the greater part, in the district of Bonaventure; and as they make up the entire portion of the island of that name, off Percé, Sir William Logan has bestowed upon them the name of the *Bonaventure Formation*. They consist essentially of conglomerates, associated with red and brown sandstones and some reddish shales. The conglomerates are made up of pebbles of limestone, sandstone, syenite, agate, quartz, and other rock-matters, held together by an arenaceous or partly calcareous cement. Many impressions and casts of vegetable remains occur throughout this formation, but its beds are apparently destitute of coal. They belong to the base of the coal series, proper; and evidently form a portion of the northern rim of the New Brunswick coal field.

The Bonaventure Formation rests unconformably on the Gaspé sandstones and limestones, and dips generally towards the south-east. According to Sir William Logan, it presents a total thickness of about 300 feet.

SKETCH-MAP OF THE GEOLOGICAL FORMATIONS OF WESTERN CANADA.

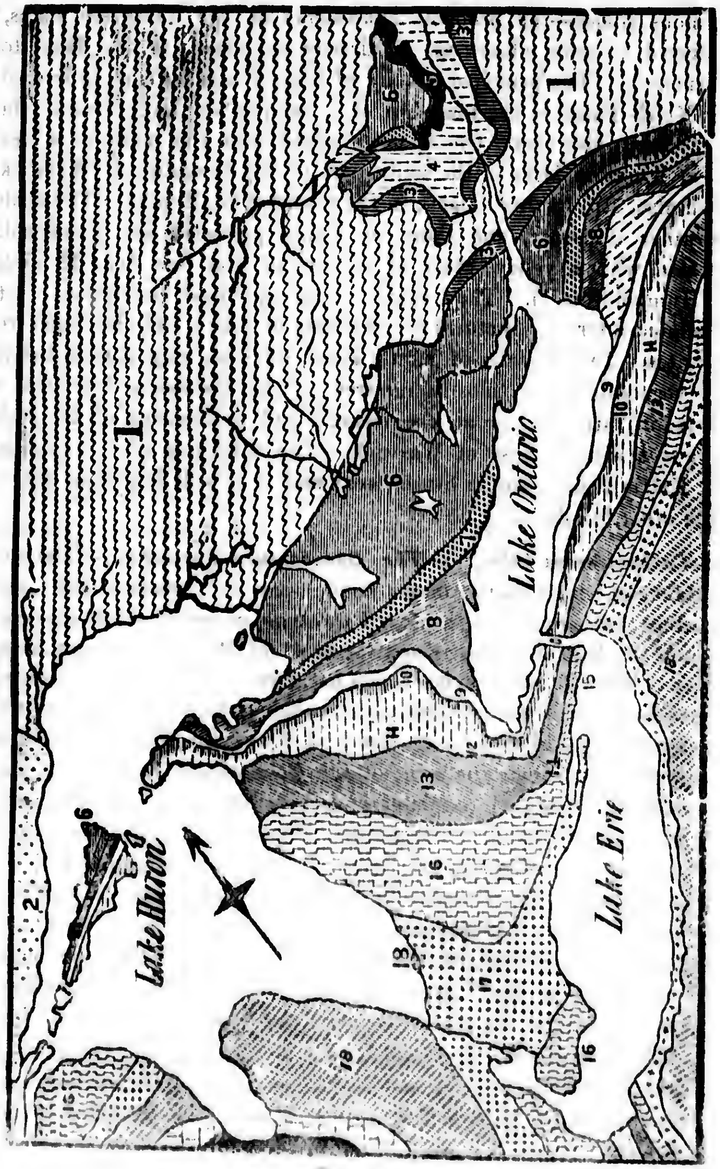

Fig. 249.

References to Map on preceding page.

DEVONIAN SERIES:

Erie Group.	No. 18.	Portage and Chemung Group, (Kettle Point Form.)
	17.	Hamilton (or Lambton) Formation.
	16.	Corniferous Formation.
	15.	Oriskany Formation.

UPPER SILURIAN SERIES:

Grand River Group	14.	Eurypterus Formation, or Lower Helderberg Group.
	13.	Onondaga or Gypsiferous Formation.

MIDDLE SILURIAN SERIES:

Niagara or Anticosti Group.	12.	Guelph Formation.
	11.	Niagara Formation.
	10.	Clinton Formation.
	9.	Medina Formation.

LOWER SILURIAN SERIES:

Ontario Group.	8.	Hudson River Formation.
	7.	Utica Formation.
	6.	Trenton (including Bird's Eye and Black River) Fn.
Quebec Group.	5.	Chazy Formation.
	4.	Calciferous Formation.
Potsdam G.(in part.)	3.	Potsdam Formation.

AZOIC SERIES:

Azoic Group.	2.	Huronian Formation.
	1.	Laurentian Formation.

THE POST-TERTIARY DEPOSITS OF CANADA.

Under this term, we include three series of deposits: the Drift or Glacial series, the Post-glacial series, and certain still more recent accumulations. These, though properly distinct, merge so gradually into each other, that no actual lines of demarcation can be drawn between them.

The Drift, or *Glacial Formation* proper, consists of thick beds of clay, sand, and gravel, with *boulders* or transported stones of various kinds and sizes, spread generally over the surface of the country, and extending on this continent to about 40° N. latitude. It does not appear to contain any fossils. Those cited as belonging to it, come properly from Post-glacial deposits. When these Drift materials are removed from the underlying rocks, the surface of the latter (where not in a partial state of disintegration) is generally found to be worn down, so as to present a smooth or even polished condition, and is traversed also by numerous thin lines or grooves, running in a general north and south direction—that is to say from some point between N. W. and N. E., towards the opposite direction in the south. The boulders vary in size from mere pebbles to masses of many tons' weight, and consist of all kinds of rock. In some places they belong to rock-masses of the immediate locality, but far more generally they have been transported by some powerful agency from other and distant sites. With the exception of certain mountainous localities, in which the boulder-courses radiate around central points, these travelled stones have been derived (as regards the northern hemisphere) invariably from northward-lying regions. In Canada, the greater number of boulders consist of gneiss or other varieties of rock belonging to the great Laurentian area described in a preceding part of this Essay; but where limestone or other strata occur in the immediate neighbourhood to the north, these gneissoid boulders are often mixed with pebbles and transported masses derived from the latter beds. Like the surface of the underlying rock, many boulders are smoothed down upon one side, and exhibit, upon this, delicate parallel furrows. Polished and striated rock-surfaces occur, in Canada, on the north shores of Lakes Superior and Huron; on the Blue Mountains, Collingwood township, at an elevation of about 1,500 feet above the sea; in the vicinity of Niagara Falls; the neighbourhoods of Belleville, Kingston, Marmora, Brockville, Ottawa, Montreal, Quebec; and at other localities.* These drift-beds vary in thickness from a mere coating in some spots, to over 100 feet in others. In all places they rest upon denuded surfaces. As a general rule, the lower beds consist of calcareous clays, frequently, if not usually, free from boulders; whilst sand, gravels, and boulders, mixed here and there with seams of clay (mostly free from lime), make up the higher portions of the mass. The conditions under which these various matters appear to have been accumulated, will be referred to presently.

The Post-glacial deposits consist, like those of the true Drift epoch, of beds of clay, sand, and gravel, with here and there a few boulders; and they appear to have been derived in most instances from re-distributed Drift materials. Hence they are often designated by the term of *Modified Drift*. In Canada, east of the gneissoid belt of the upper St. Lawrence, and throughout the New England States of the Northern Union, these Post-glacial deposits contain marine and estuary shells, referrible for the greater part, if not wholly, to species of mollusca now existing in the Gulf of the St. Lawrence, or along the coast from Labrador to Cape Cod. Shells of this kind, mixed with a few other marine types (*Balani*, &c., see PART IV), occur at various heights above the sea-level, extending, as regards Canada, up to about 500 feet. Some of the principal localities of their occurrence, comprise: Kemptville in Oxford Township, Grenville Co. (about 250 ft.); Winchester Township, Dundas Co. (about 300 ft.); Kennyon and Lochiel Townships, Glengarry Co. (270–300 ft.); Fitzroy Township on the Upper Ottawa, Carleton Co. (360 ft.); Green's Creek on the Ottawa, (about 120 ft.); Montreal Mountain (various heights up to nearly 500 feet), and environs of Montreal generally; Upton, Eastern Townships (about 270 ft.); Beauport near Quebec (about 120 ft.); Mouth of the River Gouffre (130–360 ft.); Shore of the River Matanne in Gaspé (about 50 ft.); Banks of the River Métis (130–245 ft.); and terraces of the River Ste. Anne and Rivière du Loup. At Green's Creek on the Ottawa, the shell beds contain, also, examples of the capelin (*Mallotus villosus*) and the lump-sucker (*Cyclostomus lumpus*); and the remains of the northern seal (*Phoca Grœnlandica*), with detached vertebræ of a whale, have been discovered in the Montreal deposits.

Professor Dawson divides the Eastern Post-glacial beds into two

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* As regards localities in Western Canada, see papers by the author, in *Canadian Journal*: vol. V. p. 41; and vol. VI. p. 221.

series: a comparatively deep-sea deposit, the "Leda clay;" and a shallow-sea or shore-line deposit, the "Saxicava Sand." Some of the more characteristic fossils of the Leda clay, comprise: *Leda Portlandica*, and *Rhynconella psittacea*; and those of the upper group: *Saxicava rugosa, Mya truncata, Tellina grænlandica, and Buccinum undatum.**

Fig. 242.
Leda Portlandica.

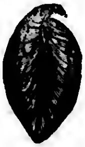

Fig. 243.
Rhynconella psittacea.

Fig. 244.
Saxicava rugosa.

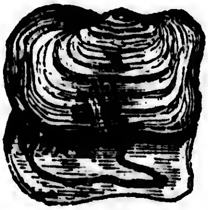

Fig. 245.
Mya truncata.

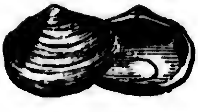

Fig. 246.
Tellina grænlandica.

Fig. 247.
Buccinum undatum.

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* The reader is referred for figures of the other fossils of these Post-glacial deposits, to valuable papers, by Dr. Dawson, in the *Canadian Naturalist*, vols. II. and IV. Also to an earlier paper on the same subject, by Mr. Billings, in the first volume of that journal.

In Western Canada, or rather in that portion of the Province west of the gneissoid belt that crosses the St. Lawrence at the Thousand Isles, the Post-glacial deposits consist principally of beds of sand, often exhibiting an oblique stratification (see fig. 54 in PART III.) No marine remains of any kind have been detected in these beds. The shells of fresh-water mollusca, on the other hand, occur in them at many localities. These belong to species which still inhabit our lakes and streams, and comprise, more especially, the following genera: *Unio, Cyclas, Amnicola, Valvata, Melania, Planorbis, Limnea*, and *Physa*. Several species of *Helix* accompany these at some localities. Examples of fresh-water deposits of this kind, formed by causes no longer in action where such deposits now occur, have been recognized in the vicinities of Collingwood and Owen Sound; Angus station on the Northern Railway; Barrie, Orillia, Paris, Brantford, Toronto, Belleville, and other places, at various elevations from 30 or 40 to over 500 feet above Lake Ontario—the present surface of the latter being 232 feet above the sea. Fresh-water shells occur also in Post-glacial deposits around Niagara Falls, where, as pointed out by Sir Charles Lyell, many years ago, they evidently indicate the former bed of the Niagara River. It is only, however, within the last two or three years, that the occurrence of these shells throughout the lake area generally, has been definitely ascertained, and the true character of the beds in which they occur correctly shewn.[*] As the shells in question occur all over this region, and at various heights above the existing levels of the lakes—and as they could not have been drifted into their present positions by freshets, or left there, viewed collectively, by the drying up of ponds, lowering of streams, or other causes—they appear to indicate incontestibly the former union of our great lake-waters, and the consequent extension of these into a vast, inland, fresh-water sea. The barrier that kept up these waters on the east —perhaps a glacier or ice-stream, see below—was undoubtedly situated

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[*] The first publication on this subject was by Robert Bell, of the Geological Survey of Canada, in the *Canadian Naturalist* for February, 1861. This was followed by a more extended article by the author of this work (who had previously communicated some of his observations to Mr. Bell), read before the *Canadian Institute* in March, 1861, and published in the *Canadian Journal*, vol. vi., p. 221, and in the *Philosophical Magazine* for July of that year. In this paper, the former union of our lake waters, and the lacustrine origin of the terraces north of Toronto, &c., was first maintained. A succeeding paper by the author (*Canadian Journal*, November, 1861, vol. vi., p. 497), described a remarkable locality—first made known to him by one of his students, Mr. A. E. Williamson, of Toronto—in which unios and other fresh-water types occur in great abundance, near the Nottawasaga River, between Lake Simcoe and Georgian Bay.

along the gneissoid belt of the Upper St. Lawrence: the line, it will be remembered, which separates the eastern or marine deposits of this period from those of lacustrine origin. In this connexion, it is interesting to observe that in the township of Pakenham (as discovered by Andrew Dickson, Esq.,) and also in that of Augusta, both immediately adjacent to this gneissoid belt, a few fresh-water types have been found in conjunction with shells of *Tellina Grœnlandica*, (fig. 246), a marine or brackish-water species. The destruction of this barrier—whether of ice or rock—accompanied probably, and perhaps occasioned, by a gradual and periodically-interrupted depression of the eastern country, eventually lowered the waters to their present levels, and caused the formation, by denuding action, of the various ridges and terraces which occur so prominently throughout the lake districts. Those north of Toronto, described as *ridges* by Sir Charles Lyell, and thought by him to be of marine origin, are really a succession of *terraces* rising one above another up to a height of about 760 feet above the present surface of Lake Ontario, and then successively descending towards Lake Simcoe and Georgian Bay—their abrupt or escarped faces being always in the direction of the nearest lake.

The mollusca of this region during the Post-glacial period, appear to have been throughout identical with those of our present lakes and rivers; and most of the mammalia were of the same genera and species as those which now inhabit Canada. Of this latter class, the more common remains comprise the jaws and other parts of the common beaver (*Castor* fiber); the horns and bones of the Wapiti (*Elaphus Canadensis*[*]); and the teeth and skull of the black bear (*Ursus Americanus*). Two at least, however, of the mammals that roamed over the shores of the great lake region during the period in question, are extinct. These are the Mammoth, an extinct species of Elephant, (*Elephas primigenius*); and the Mastodon (*M. Ohioticus?*). Their remains, hitherto found with us, consist mostly of detached molar teeth (fig. 248); but examples, more or less entire, of the skull and tusks have also been discovered. The sediments in which these occur,

Fig. 248.
a—Molar tooth of *Elephas primigenius.*
b—Molar tooth of *Mastodon Ohioticus.*

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[*] The Wapiti, although at one time common throughout Canada, is now only to be found in the extreme northern and north-western regions, and will probably become extinct at no distant day.

appear to be of the same age and character as those which at Amiens, Abbeville, Creil, Suffolk, Bedford, and elsewhere, contain flint implements of rude manufacture, mixed with the remains of the mammoth and other types, both living and extinct. The arrow-heads and other stone implements so constantly found in our Canadian superficial deposits, are of a much less primitive character, however, and belong in all probability to a comparatively recent date.

Conditions under which the Drift amd Post-glacial deposits were accumulated.—It is now universally admitted that the various deposits of the Drift, and immediately succeeding period, were accumulated under conditions more or less resembling those which at present prevail in Arctic latitudes. This conclusion is based chiefly on the following facts:—(1). The resemblance of the polished, rounded, and striated surface of the rocks beneath the Drift, to the surface-rocks of Alpine regions in which glaciers prevail, or to those which in higher latitudes have been subjected to glacial action generally. (2.) The greater development and extension of glaciers in these regions, during the interval between the close of the Cainozoic period and the commencement of the existing epoch, properly so-called. (3.) The evident signs of the occurrence of ancient glaciers in lower and more southern districts during the same period. (4.) The apparent impossibility of any other agency than that of ice to have effected the transportation of the numerous boulders scattered throughout Drift-covered regions: many of these boulders, including some of large size, having been carried across lakes, seas, ravines, and other obstacles, to far distant localities. And (5), the general arctic or northern character of the mollusca, &c., found in the modified drift or Post-glacial deposits of various countries.

The fossils which occur in Cainozoic strata, prove clearly the prevalence of a warm, if not of a tropical climate, throughout the period during which these strata were deposited. Towards the close of the Cainozoic Age, however, the relative levels of land and water, throughout all the more northern and extreme southern portions of the globe, appear to have undergone great though gradual changes, during which, a period of increasing cold came slowly on, covering all the more elevated districts with enormous glaciers, filling the sea with floating icebergs, and compelling a general southerly migration of such life-forms as were able, by this or other means, to resist its destructive influence. The greater part of Canada must certainly have been submerged beneath the sea, during a portion at least of this period. The polishing and striation of the rocks may have been occasioned in part by glaciers, and in part by stranded icebergs; but the transportation of the boulders from the northern districts, southwards, must have been chiefly effected by the agency of the latter: just as at the present day, large masses of granitic and other rocks are dropped over the bed of the Atlantic by the melting of the icebergs on which they travel from the north. It should be mentioned that, as a general rule, these icebergs are nothing more than fragments detached from the extremities of arctic glaciers, where the latter reach the level of the sea. The stones brought down by these enormous ice-rivers, or broken off their rocky shores, collect in large heaps at their lower extremities, and many are thus floated off by the detached bergs, and conveyed over broad oceanic spaces to distant and more southern spots. That the country east of the gneissoid belt of the Upper St. Lawrence was beneath the sea to a depth of at least 500 feet at one period of this glacial epoch, is shown by the numerous deposits containing marine and estuary fossils, which occur, as explained above, throughout that area and the adjoining New England States. The same thing is proved also for both portions of the province, by the thick masses of drift clay, &c., which could only have been accumulated under water. As regards Western Canada—and this may probably apply to eastern districts likewise—a gradual submersion of the Palæozoic or more southern portion must first have taken place, since the lower clays are highly calcareous, and are evidently derived from the Silurian and Devonian strata immediately beneath or closely adjacent to their areas of deposition. The depression still continuing, the higher lands and gneissoid strata of the north would be brought within the influence of the waves, and thus the sands, gravels, and boulders of the Upper Drift deposits, would be gradually accumulated. A re-sorting of these materials must have occurred to some extent during the subsequent elevation of the country, producing, in part, the various post-glacial deposits; although in the western region, most of these latter must have been formed by the great lake-waters which extended over this area, as described on a preceding page, after the final elevation of the land. The cold of the Drift period, with its accompanying phenomena, came on gradually, and as gradually diminished in intensity; or, in other words, these glacial manifestations shrunk back slowly, after a certain lapse of time, to within the higher latitudes and Alpine elevations in which they still prevail. No strong or abrupt lines of demarcation can thus be drawn between the close of the Cainozoic Age and the dawn of the existing state of things. The one period merged slowly into the other ; and certain life-forms, indeed, appear to have existed throughout all the changes which occasioned and accompanied the general deposition of the Drift.

Recent Deposits :—These comprise various formations, of limited thickness and extent, produced by causes now, or recently, in action at the localities in which these deposits occur. The principal consist of: Shell marl, calcareous tufa, bog iron ore, ochres, and peat. *Shell marl* is a soft calcareous deposit made up largely of the minute shells of certain species of planorbis, cyclas, and other fresh-water mollusks. It occurs at the bottom of almost all our lakes, ponds, and swamps ; and sometimes forms near the margin of these, a bed of several feet in thickness. This lies usually at a short depth beneath the surface of the ground. It shows the former extension of the pond or swamp near which it is met with. Several specimens, examined by the writer, contained nothing but carbonate of lime mixed with a little sand; but some are said to contain phosphate of lime. The substance on exposure to the atmosphere becomes about as hard as ordinary chalk.

Calcareous tufa is a deposit of carbonate of lime on moss, twigs stones, &c., and is of very common occurrence in many of our smaller streams. Good specimens of a solid structure, capable of receiving a fine polish, are produced by some of the springs which issue from crevices in the Niagara escarpment, as at places near Hamilton, Rockwood, Falls of Noisy River, and other localities along the line of country through which the escarpment runs. A large deposit occurs also on the Beaver River, in the townships of Euphrasia and Artemisia. See under the "Niagara Formation," above.

Bog Iron Ore (see PART II.) is a hydrated sesquioxide of iron, a variety of Brown Iron Ore or Limonite. It arises from the decomposition of iron pyrites and other ferruginous substances in rocks and soils, and the after solution of the oxide of iron, thus formed, by water containing free carbonic acid or organic acids. The iron compounds dissolved by this agency, and carried into swamps and other low-lying places, are there deposited, and are subsequently converted into hydrated sesquioxide. Patches of this kind are also occasionally found on hill tops and sides, by deposition from springs containing ferruginous matter. This bog ore occurs in small quantities in numerous localities throughout the Province; but largely in Norfolk County, C. W., and along the north side of the St. Lawrence, especially in the Three Rivers District, and in the counties of Vaudreuil and Bellechasse, Canada East. The iron ochres, generally associated with the bog ore, have a similar origin (see descriptions of these, in PART II.) The red ochre is anhydrous, but the brown and yellow varieties contain a certain amount of water, usually about 20 per cent.

Economic Materials of the Post-Tertiary Deposits:—These comprise, *Gold, Bog Iron Ore, Ochres, Brick Clay, Shell Marl, Moulding Sand,* and *Peat.*

Gold:—Native gold in fine grains, including here and there a small nugget, occurs in the Post-Tertiary sands of the metamorphic region south of the St. Lawrence: or throughout the area lying between the River Richelieu and the Gaspé peninsula; and more especially along the valleys of the St. Francis, Chaudière, Rivière des Plantes, Etchemin, and Rivière des Loups. (See under "Native Gold," in PART II., *B.* 1.)

Bog Iron Ore:—The principal localities of this substance are given above. The ore, at present, is only melted at the Radnor Furnaces, Batiscan, C. E. The neighbouring furnaces of St. Maurice, after continuing in operation for over a century, went out of blast a few years ago.

Ochres:—These are capable of extensive use as paint materials. A yellow variety, becoming brown and red on ignition, occurs abundantly in the county of Middlesex, and also at Sydenham and in the township of Nottawasaga, in Canada West. Red, brown, yellow, purple, and greenish-black ochres occur likewise in workable quantities near the mouth of the Ste. Anne River, and in the seigniories of the Cap de la Madelaine and Pointe du Lac, in Canada East. Also in the Eastern Townships. The black ochres contain a considerable quantity of peroxide of manganese.

Brick Clay:—Clays suitable for bricks and tiles, occur very generally throughout the Province. White or yellow bricks are largely manufactured in the neighbourhoods of London, Hanover, Toronto, Cobourg, Peterborough, &c. Red bricks at Walkerton, Sydenham, Toronto, Montreal, St. Jean (Lobinière), and many other places. Manufactories of drain tiles are in extensive operation at Treadwell village, on the Ottawa, and in the vicinity of Quebec.

Shell Marl:—This substance, described above, is much employed as a manure, and occasionally also as a whiting or wash-material. It occurs, more or less, all over the Province, but has been worked more especially, in the townships of Bentinck, Carrick, Brantford, King, W. Gwillimbury, Scarborough, Thurlow, Sheffield, Olden, Nepean, and W. Hawkesbury, in Canada West; and near Montreal, &c., in Canada East.

Sand for Moulding:—Good sand for this purpose, has been obtained from the neighbourhood of Dundas, and also at Sydenham (Owen Sound.)

Peat:—Large deposits of this useful substance are known to occur in many parts of the Province, but hitherto, on account of the abundance of wood, they have been generally neglected. Some of the more important localities comprise: Longueuil, opposite Montreal, and many places along the south shore of the St. Lawrence, between that point and the Rivière du Loup (Sir W. Logan). Also La Valtrie, and the seigniory of Cap de la Madelaine, on the north shore. The explorations of the Geological Survey have made known, likewise, a large peat area on the south side of the Island of Anticosti. In Western Canada, peat occurs chiefly in the townships of Plantaganet, Clarence, Cumberland, Gloster, Goulbourne, and Westmeeath, in the Ottawa region. Also in the townships of Humberstone and Wainfleet, on Lake Erie.

GENERAL OUTLINE AND RECAPITULATORY SKETCH OF THE GEOLOGY OF CANADA.

1. *Canadian Rock Formations.*—The rock groups occurring within the limits of Canada, comprise representatives of the Azoic, Lower Palæozoic, and Post-Tertiary series. The Upper Palæozoic deposits (inclusive of the Coal Measures proper) together with the entire formations of the Mesozoic and Cainozoic Ages, are altogether unknown within the limits of the Province.

2. *Azoic Series.*—The rocks of this series, composed of Sedimentary matters deposited in ancient seas, apparently before the creation of organic types, and subsequently rendered more or less crystalline by metamorphic forces, are subdivided into two formations. The lower of these is named the Laurentian, and the higher, the Huronian Formation. The Laurentian strata consist principally of highly crystalline beds of micaceous and hornblendic gneiss; hornblende rock;

crystalline limestone and dolomite; oxidized iron ores; quartzite; and anorthosites, or rocks composed chiefly of lime and soda feldspar. In an economic point of view, the Laurentian Formation is essentially characterised by the vast beds of magnetic and specular iron ore that occur within it: full details of which are given in a preceding page. The formation is many thousands of feet in thickness, and it covers an area of 200,000 square miles—running from Labrador along the north shore of the St. Lawrence to the vicinity of Quebec, and throughout all the more northern and north-western portions of the Province, as shewn in the sketch-maps, figs. 154 and 249. By reference to the latter, it will be seen that in the district between Prescott and Kingston, a narrow belt of this formation crosses the St. Lawrence, and expands over a large extent of country, comprising the Adirondack region, in the State of New York. This belt forms a somewhat important feature in the geology of Western Canada. It will be alluded to again, in connection with this sketch, under the name of the "gneissoid belt of the Upper St. Lawrence." The Huronian Formation which constitutes the higher division of the Azoic series, consists chiefly of green and greyish slate-conglomerates and other partially altered strata, interstratified with greenstone masses, and traversed by numerous trap dykes. It contains also many quartz veins, holding copper pyrites and other copper ores in workable quantities. The total thickness of the formation is probably not much under 20,000 feet. Its strata are chiefly developed along the north shore of Lake Huron (No, 2, in fig. 249), and in places on Lake Superior.

3. *Laurentide Mountains. North and South Basins of Canada.*—A high water-shed or range of mountainous country, averaging a height of from one to two thousand feet above the sea, but rising in places to nearly four thousand feet, traverses the greater portion of the Laurentian area, and forms at one part of its course the "Laurentide Mountains." It divides the Province into two great basins or geological areas: known, respectively, as the North and South Basins.

4. *Great Northern Basin of Canada.*—The area occupied by this basin, lying to the north of the Laurentian water-shed, and sloping towards Hudson's Bay, as regards its geological characters, is still comparatively unexplored. The formations known to occur within its limits, comprise the Laurentian and the Upper Silurian series. The Huronian rocks are thought to occur also, in the form of Chloritic schists, in the valley of Lake Temiscaming, but no traces of

Lower Silurian strata have anywhere been met with. Hence, it is suggested by Sir William Logan, that, the Laurentide mountainous range formed, from Labrador to the Arctic Sea, the northern shore line of the ocean during the Lower Silurian period. The land to the north, being thus above the level of the sea, would receive no deposition of Lower Silurian strata ; but an after movement of depression must have ensued during the Upper Silurian epoch, bringing down this northern district beneath the sea, and so enabling the sediments of the latter period to be laid down upon its area.

5. *Great Southern Basin of Canada: Its subdivisions:*—The southern geological area of Canada, is in itself divisible into three smaller basins: (1) the Basin of the lakes; (2) The Basin of the St. Lawrence; and (3) The Eastern or Metamorphic Basin. The two first of these are separated from each other by the gneissoid belt of the Upper St. Lawrence alluded to above; whilst the third or Eastern Basin is separated from the St. Lawrence area by a remarkable dislocation, accompanied by physical and chemical changes of great moment. This dislocation is evidently connected with the elevation of the Appalachian mountain chain. As traced in Canada by Sir Wm. Logan, it runs from near the northern extremity of Lake Champlain in a general north-easterly direction to the St. Lawrence, which it crosses immediately above Quebec; and then turns to the east, traversing the northern part of the Island of Orleans and passing down the river into the Gulf, from whence it appears to re-enter the south shore a few miles above the mouth of the Magdalen River in Gaspé. The strata within the area circumscribed by this dislocation, are thrown up generally into highly inclined beds; and they exhibit, in other respects, many signs of the action of powerful disturbing forces. See under the head of the "Calciferous Formation," on a preceding page. In the more central portion of the area, also, they are much altered, or converted into crystalline schists, &c., and rendered metalliferous by metamorphic agencies. The strata of the Lake and St. Lawrence Basins, on the other hand, betray few signs of these disturbing influences, except in the case of the upper copper-bearing series of Lake Superior, and in parts of Gaspé, as described fully in a preceding division of this Essay.

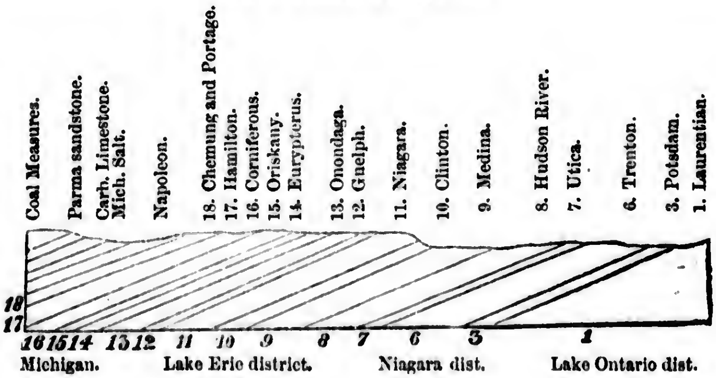
6. *The Lake Basin of Canada:*—Of this geological basin, properly speaking, only the north-eastern and northern portions actually occur within the boundaries of the Province. It includes all the area to the east or left of the Laurentian district marked 1—1 in the sketch-map

fig. 249. Though affected here and there by slight local disturbances, the strata within this area have a *general* westerly dip, extending as far as the central part of Michigan, in consequence of which, on proceeding from the gneissoid belt of the Upper St. Lawrence, just east of Kingston, towards the southern extremity of Lake Huron, the various formations (exclusive of the Calciferous and Chazy series?) from the Potsdam to the Hamilton beds, with those also of Kettle Point, are successively traversed. The dip of these strata, however, (except here and there, under local conditions) is exceedingly slight, rarely exceeding two or three degrees, and averaging in general less than half-a-degree, or about 30 or 40 feet in a mile. The annexed section will serve to convey a general idea of the sequence of these formations, as shewn on the map, between the gneissoid belt east of Kingston, and the coal strata of central Michigan. The thickness of intervening rock between the top of the Hamilton formation and the lowest of the Michigan coal seams, is about 840 or 850 feet.

Fig. 250.

SKETCH–SECTION OF FORMATIONS OF WESTERN PART OF CANADA AND EASTERN MICHIGAN.

(The dip necessarily exaggerated.)



At the extreme east of this basin, a little beyond Kingston, a narrow band of Potsdam sandstone rests on the western slope of the gneissoid or Laurentian rocks. This is followed to the west—the Calciferous and Chazy formations being apparently absent—by the strata of the Ontario group, comprising the Birds-eye, Black River, and higher limestones of the Trenton formation, the dark bituminous Utica schists, and the arenaceous shales, &c., of the Hudson River Series. The

Trenton formation is probably abont 700 or 750 feet in thickness; the Utica shales, somewhat under 100 feet; and the Hudson River series, between 700 and 800 feet. These formations are developed chiefly along the shore of Lake Ontario, between Kingston and the central part of Nelson township, west of Toronto; and also on the shore of Georgian Bay, between Cape Crocker and a spot a little south of the outlet of the River Severn; as well as throughout all the intervening country: including within the Trenton area, Lake Simcoe, Balsam Lake, Rice Lake, and other bodies of water. Kingston, Belleville, Peterborough, Cobourg, Port Hope, Barrie and Collingwood, are situated over the Trenton district; Whitby and the country just west of Collingwood harbour, over the Utica formation; and Toronto, Oakville, Sydenham (Owen Sound,) and Meaford, over the Hudson River strata. These various formations, as explained fully under their respective descriptions on a former page, run also across the northern part of the Manitoulin Islands.

The Niagara or Anticosti group succeeds the Lower Silurian strata. The Medina Formation (Map: No. 9), at its base, sweeps round by Queenston, Hamilton, &c., below the great escarpment of that district, and continuing its course, first towards the north and then towards the north-west, comes out upon Georgian Bay near Cabot's Head, forms the extreme base of that promontory, and runs, it is supposed, in a narrow belt along the central part of the Manitoulin Isles. These Medina strata consist chiefly of red marls, shales, and sandstones, capped by a grey freestone, known as the "grey band." On Lake Ontario, they exceed 600 feet in thickness, but diminish considerably towards their north-western limits. The green and red shales of the Clinton division (No. 10,) with their interstratified limestone beds, appear above the grey band of the Medina formation proper; and are succeeded by the calcareous shales and limestones of the Niagara formation, holding *Pentamerus oblongus*, fig. 213, amongst their other fossils. The Niagara limestone (Map: No. 11) appears to represent in the Middle Silurian strata, the great Trenton limestone of the Lower series. Still higher in the scale, and farther to the west, follow successively the Guelph dolomites (No. 12), the gypsiferous and fossil-free strata of the Onondaga formation (No. 13), and the slightly developed Eurypterus beds of the Lower Helderberg group. These close the Silurian series, The country between the upper part of the Niagara River and the north-eastern shores of Lake Huron, is occupied by these Middle and Upper Silurian formations, but their strata are mostly concealed by Drift-deposits. The localities in which instructive exposures occur, have been mentioned under the separate descriptions of each formation, at the commencement of this Part of our Essay. The Clinton beds near the mouth of the Niagara River are only a few feet in thickness, but they increase towards the north-west, and attain, on the shores of Georgian Bay, a thickness of about 180 feet. The Niagara formation increases in the same direction, from about 240 or 250 feet, to probably about 400 feet. The Guelph formation at its thickest part is estimated by Sir Wm. Logan at 160 feet. The Onondaga formation averages from 200 to 300 feet.

Still further to the west, a thin band of sandstone, belonging to the Oriskany Formation (Map : No. 15), crops out above the Eurypterus beds in the townships of Bertie, Cayuga, &c. This forms the base of the Devonian series. It is succeeded by a large development of the cherty limestones of the Corniferous Formation, (No. 16), averaging collectively about 200 (?) feet in thickness, and supposed to be the source of the Petroleum supplies of that district. These are followed by the encrinal limestone bands and calcareous shales of the Hamilton (or Lambton) series (No. 17,) making up an additional thickness of from 200 to 300 feet. Finally, at Kettle Point, and in the townships of Warwick and Brooke, a few isolated patches of dark bituminous shales, containing calamites and fish-scales, conclude the Devonian series as developed in this part of Canada. These bituminous shales, are referred to the base of the Portage group (No. 18). The relations of the Hamilton or Lambton shales to the underlying Corniferous strata, and the chief points of interest belonging to the occurrence of petroleum in this region, have already been sufficiently discussed.

The Drift accumulations spread so generally over this western basin, consist of thick beds of clay, overlaid in most places by deposits of sand and gravel, with boulders of gneiss, syenite, limestone, and other rocks. The thickness of the entire mass varies greatly, but in places it exceeds 100 feet. In the upper Drift beds, or rather in those formed out of Drift and other materials by Post-glacial influences, numerous shells of existing fresh-water mollusks (*planorbis*, *cyclas*, &c.), occur at different heights above our present lake-waters ; whilst there seems to be an entire absence, in these beds, of marine or estuary types, such as occur in deposits of a similar age in the St. Lawrence basin. Hence the inference, that, at a comparatively recent geological period, our great lakes were united into one vast fresh-water sea, held back, on the east, by an elevation of the gneissoid belt of the Upper St. Lawrence, or perhaps by a huge glacier-barrier extending in that direction, as explained on a former page.

7. *The St. Lawrence Basin:*—This Basin is separated from the Basin of the Lakes, just described, by the gneissoid band, which, passing southwards from the Lac des Chats on the Ottawa, crosses the St. Lawrence at the Thousand Isles, and forms the Adirondack region of New York. On the other hand, it is cut off from the Eastern or Metamorphic Basin (although, strictly considered, this forms an isolated central portion of its area) by the great dislocation alluded to under §5, above. This dislocation, accompanied both by a great upheaval and the manifestation of active metamorphic forces, runs from near the northern extremity of Lake Champlain to Quebec, and from thence along the north shore of the Island of Orleans, and down the river and gulf, as far as the coast of Gaspé, which it enters near the mouth of the Magdalen River. The area of the St. Lawrence Basin thus includes the peninsula between the gneissoid belt, the lower Ottawa, and the Upper St. Lawrence, together with a large extent of the south shore of the latter river, and all the north shore from the Ottawa to the Gulf, except a small portion (including the chief part of Quebec) lying within the above mentioned line of dislocation. It may be considered to include, also, the extreme eastern and southern parts of Gaspé; the Island of Anticosti, and the Mingan Islands. Towards the western part of this area, more especially in the peninsula just west of the junction of the Ottawa and St. Lawrence Rivers, the Potsdam and Calciferous formations (Map: Nos. 3 and 4) are well displayed, together with the Chazy and Trenton limestone beds (Nos. 5 and 6). The latter occur also largely on the eastern side of the Ottawa, as around Montreal, &c.; whilst the Utica and Hudson River formations extend more particularly along each bank of the St. Lawrence up to (and on the north, beyond) Quebec—apart from the small area, immediately around Quebec itself, cut off by the before-mentioned dislocation. At the Falls of Montmorenci, the Trenton, Utica, and Hudson River divisions occur in force; and the latter runs along the north side of the Island of Orleans. These formations occur also in the small outlying basin of Lake St. John on the Upper Saguenay. The Trenton limestones form likewise some isolated patches on the north shore of the Gulf, as at the Seven Islands, the Straits of Belle Isle, &c.; whilst the

Mingan Islands consist chiefly of the Chazy formation, the Trenton beds appearing at the south side of Large Island, one of the group. The northern shore of the Island of Anticosti is made up of Hudson River beds, the rest of the island consisting of Middle Silurian strata. In Gaspé, the Hudson River formation occurs on the north shore, between Cape Rosier and the River Marsouin. Eastward and southward the peninsula is chiefly composed of strata referred to the Devonian series, in which a thin seam of coal and numerous fossil plants are met with; whilst along the Bay of Chaleurs and the coast south of Gaspé Bay, the inclined Devonian beds are overlaid unconformably by a vast thickness (amounting to no less than 300 feet) of Carboniferous sandstones and conglomerates, the *Bonaventure Formation* of Sir William Logan. These strata, however, are quite destitute of coal.

Mountainous masses of eruptive traps and trachytes occur towards the more western extremity of the St. Lawrence Basin. These break through Lower Silurian strata, and were formed, probably, during the Upper Silurian or earlier part of the Devonian epoch. They are traversed in most cases by dykes of more recent origin—apparently erupted towards the close of the Devonian period, or perhaps at a still later date. The more important of these intrusive masses, comprise: Rigaud (in Vaudreuil Co.); Mount Royal or the Montreal mountain; Montarville or Boucherville (in Chambly Co.); Rougemont (in Rouville Co.); Belœil (in Verchères Co., near the Grand Trunk Railway); Monnoir or Mt. Johnson, south of Belœil; and Yamaska. Other masses of a similar character, as those of Brome and Shefford, lie just within the Eastern or Metamorphic Basin; but as these are evidently connected with the above series, the whole may be described together. The mountains of Montreal, Montarville, and Rougemont, are essentially augitic traps or dolerites. They present a dark color in most parts, and contain, in many places, distinct and comparatively large crystals of augite; Fig. 251. Small granular masses of olivine, with black grains of Magnetic Iron Ore and Ilmenite (minerals described in PART II.) are also commonly present, especially in the Montarville and Rougemont mountains. These trappean masses are penetrated by dykes of white or light-coloured compact trachyte (see PART III.), which contain minute crystals of iron pyrites, and generally effervesce in acids from the presence of intermixed carbonate of lime. The Rougemont mountain, is traversed also by granitic trachyte

Fig. 251.

(PART III.) of a grayish colour, and partly micaceous. The mountains of Rigaud, Belœil, Monnoir, Yamaska, Shefford, and Brome, are essentially granitic trachytes, consisting of light-coloured potash-feldspar, with small grains of black hornblende, or scales of brown or black mica; and usually containing, in addition, some small crystals of yellow sphene (see PART II.) and grains of magnetic iron ore. Much valuable information on the composition of these picturesque and interesting mountains, is given by Professor Sterry Hunt, in the Geological Report for 1859. See also the *Canadian Journal*, Vol. V., p. 426, and the *Revised Report of the Geological Survey*, 1863.

The surface of the St. Lawrence Basin, like that of the Lake area, is also very generally covered by thick accumulations of the Drift and Post-glacial epochs: comprising clays, gravels, and boulders. But the fossil shells, found in the upper part of these, are all of a marine or estuary character. They are referrible to species which still exist in the Gulf of the St. Lawrence, or on the coast of Labrador. These shells occur, not only on comparatively low levels, but at considerable heights also, above the present surface of the sea. Some of the most noted localities comprise the neighbourhoods of Ottawa and Montreal; terraces on the Montreal Mountain: one, nearly 500 feet above the sea-level; Beauport near Quebec, about 120 feet above the sea; and various terraces on the Lower St. Lawrence, the Ste. Anne River, the Matanne, the Metis, &c., in the Gaspé peninsula, at heights varying from 40 or 50, to 245 feet above the present sea-level. It is evident, therefore, that at the commencement of the Post-glacial or present period, the entire or greater part of the St. Lawrence basin must have been deeply submerged beneath the sea.

8. *The Eastern or Metamorphic Basin of Canada*:—This basin, forming strictly, a portion of the St. Lawrence area, is separated from the latter by the great dislocation already described in §§ 5 and 7. It includes the site immediately under and around Quebec, the central and southern part of the Island of Orleans, the south shore of the St. Lawrence from a little west of Point Levis to near the Magdalen River, and all the intervening area to the south (including the greater part of the eastern townships, &c.) as far as the Province boundary. In the more northern part of this region, the strata, consisting of the Calciferous and Chazy formations (united into the Quebec group), are raised along the line of the before-mentioned dislocation into a position apparently above the horizon of the Trenton series. (See the remarks,

on this point, under the head of the Calciferous Formation, towards the commencement of the present Part of our Essay). They are also highly inclined, and consist chiefly of black and other coloured graptolitic shales, with associated beds of dolomite, limestone, &c. At a certain distance south of the St. Lawrence, and more especially in the counties of Bagot, Drummond, Shefford, Orford, Brome, Stanstead, Sherbrooke, Megantic, Beauce, &c., these beds are much altered by metamorphic action: being changed into gneiss-rocks, talcose and chloritic schists, serpentines, variously coloured marbles, and other rocks of a similar metamorphic character; whilst their fossils become gradually obliterated. They are associated also in many of these localities, with vast irregular masses of copper and iron ores; and are traversed by veins containing galena, and here and there by auriferous quartz-veins. These metallic deposits, with the marbles, slates, and other economic substances of the region, are enumerated more fully under the Calciferous Formation, on a former page. The alluvial matters derived from the disintegration of the metamorphic rocks of this Eastern Basin, contain grains and occasionally small nodules of native gold—as explained at the same place, and also under the description of that metal in Part II. The Notre Dame and Shickshock Mountains, an extension of the Alleghanian chain, belong to the north-eastern part of this area. These mountains, which rise in places to a height of 4,000 feet above the sea, consist of metamorphic strata of the Quebec group, including vast beds of serpentine and intermixed chromic iron ore. The eruptive granites of the Megantic Mountains, and those which occur in Winslow, Hereford, Stanstead, Barton, Weedon, and other neighbouring townships, lie also within the limits of this metamorphic zone.

CORRECTIONS AND ADDITIONS.

Page 28, line 6 of note—for "our," read "an."

Grey Antimony Ore: page 30. This ore, accompanying *Native Antimony*, *Oxide of Antimony*, and *Kermesite* or *Red Antimony Ore*, (an oxy-sulphide), has recently been found in a vein, traversing slate rocks of the Quebec Group, in the township of South Ham, C. E.

Page 29, line 23—for "Addington Co.," read "Argenteuil Co."

Galena: page 32. The galena veins of the Township of Ramsay, Lanark Co., traverse the Calciferous Formation. Both galena and copper pyrites have recently been discovered, in considerable quantities, in the township of Lake, in North Hastings.

Garnet: page 40. Since our description of this mineral was in type, Prof. Sterry Hunt has described the occurrence of a bright green garnet, containing six per cent. of oxide of chromium, in the township of Orford, C. E. This variety occurs in microscopic crystals (chiefly rhombic dodecahedrons) and in small grains imbedded in calc spar, and is accompanied by minute specks of sulphide of nickel. A specimen, presented to the author by Prof. Hunt, is in the Musenm of the Toronto University.

Page 40, last line; page 50, line 4 from bottom; and page 59—for "Oxford," read "Orford."

Sphene: page 42. Brown crystals of this mineral occur in gneissoid rocks north of Balsam Lake, and in the crystalline limestones of Calumet Island, &c.

Augite or *Pyroxene:* page 43. The white or light-colored diopside crystals found in the crystaline limestone of the Upper Ottawa region, present the combination shewn in the following figure. The vertical faces $V\,V$ meet at an angle of 87°5′ and $\bar{V}\,\grave{V}$ at 90°; and as these latter predominate, the prisms have a remarkably square appearance. Fig 253 exhibits the same combination from Orford, C. E., but in twin crystals, with plane of union parallel to $\bar{V}$; and with these faces so greatly extended as to produce a so-called bladed or tabular form. Our sketch is drawn from memory, as the specimens kindly presented to us by Prof. Sterry Hunt, were lost in the great fire at the Rossin House.

Fig. 252

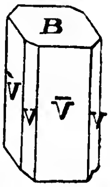
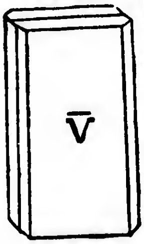


Fig. 253.



Page 46. To the minerals belonging to C 4 on this page, a a variety of *Orthite* may be added. Specimens obtained recently from Hollow Lake at the head waters of the South Muskoka, present the following characters:—Jet-black; amorphous; H = 5·5; sp. gr. = 3·288; Easily fusible with very great intumescence; yielding a little water in the bulb-tube; gelatinizing in heated hydrochloric acid. Orthite is essentially a silicate of alumina, lime, oxide of iron, and oxide of cerium, with 2 or 3 per cent of water.

Epsom Salt: page 48. This substance, a hydrated sulphate of magnesia, occurs in the form of an efflorescence, or thin crust, on the exposed surfaces of some of the Utica shales, Clinton dolomites, and other rocks: as at Montreal, Dundas, and elsewhere. It is evidently, at these localities, a more or less recent deposit from waters percolating through the strata.

Page 80, line 13—for "chiefly of some kind of limestone," read "chiefly by some kind of limestone"

Page 88, line 19—for "Enniskillen, Mosa, &c.," read "Bosanquet and Warwick."

Page 89, line 26—for "Sillery group, near the top of the Lower Silurian Series," read "Quebec group, near the bottom of the Lower Silurian Series."

Infusoria: page 98. This provisional class should probably be abandoned—some of its included forms (the *Desmideæ* and *Diatomaceæ*) belonging most probably to the Plant-world; whilst others, including the ciliated infusoria (*Paramecium*, *Vorticella*, &c.,) occupy an unknown place amongst higher types. The *Rhizopods*, as regards their fossil representatives, fall into two series: the calcareous-shelled *Foraminifera*, and the silieeous-shelled *Polycystina*. The latter, like the siliceous *Diatomaceæ*, have no action on polarized light. By this character, when in a fragmentary state, they may be readily distinguished from the ordinary *Foraminifera.*

Sponges: page 99. These forms, as stated in the body of the work, are all but unknown in our Canadian Palæozoic rocks. Two somewhat doubtful species, discovered by Mr. Richardson in the limestone of *Anse au Loup* on the north shore of the Straits of Belle Isle, have been described by Mr. Billings during the printing of this Essay. The species in question have a certain resemblance to casts of *Petraia*, and may perhaps be corals. Mr. Billings places them under a new genus, *Archeocyathus*. The limestone beds in which they occur, belong to the Potsdam and Calciferous Formations.

Page 104, line 1,—for *Syringopora tubiporoides*, read *S. Maclurei.*

Page 178, line 9 from bottom,—for *O. lateralis* read *O. lamellosum.*

Page 207, line 6 of note—in reference to the assumed union of our lake waters during the Post-glacial period—for "first maintained," read "first maintained on Geological grounds." As stated in the author's earlier communication on the subject (*Canadian Journal* (2) vol v, 299, and *Phil. Mag.*, July, 1861), the first idea of this ancient extension of our lakes, is due to the late Mr. Roy, an engineer of Toronto. Mr. Roy communicated a paper on the subject, with reference more especially to the terraces of Lake Ontario, to the Geological Society of London in 1837; but as the view, embodied in this paper, was unsupported by any geological evidence, it was rejected altogether by Sir Charles Lyell, and by geologists generally. In a short paper on the Nottawasaga valley, published in the *Canadian Journal* in 1853, Mr. Sandford Fleming, C. E., revived the opinion of Mr. Roy as to the lacustrine origin of the lake terraces, but considered the question solely in its physical, as distinguished from its geological, aspect. The subject then remained undiscussed, until prominently brought forward, and first supported on geological grounds, by the author of this work in his communications to the *Canadian Journal* and *Philosophical Magazine*, in 1861. Up to that date, the marine origin of our Drift and Post-glacial terraces, was viewed, it is believed, by most geologists as a settled point.

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