THE

# CANADIAN NATURALIST

AND

## Quarterly Journal of Science.

WITH THE

PROCEEDINGS OF THE NATURAL HISTORY SOCIETY
OF MONTREAL:

CONDUCTED BY A COMMITTEE OF THE SOCIETY.

NEW SERIES—Vol. 6.

MONTREAL:
DAWSON BROTHERS, Nos. 159 AND 161 ST. JAMES STREET.
1872.

☞ The Editors of this Journal are responsible only for such communications as bear their names or initials.

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Published August, 1872.

MITCHELL & WILSON, PRINTERS, 192 ST. PETER STREET, MONTREAL.

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## ANNUAL ADDRESS OF THE PRESIDENT OF THE NATURAL HISTORY SOCIETY OF MONTREAL, PRINCIPAL DAWSON, LL.D., F.R.S.

*Delivered May 19th*, 1871.

The first duty which devolves upon me in this address is a mournful one—that of referring to the departure from among us of two of our youngest and yet most useful and promising members, Mr. Alexander S. Ritchie, and Mr. Edward Hartley.

Mr. Ritchie died in December last, at the age of 34. He had been connected with the Society for six years, and had contributed to our proceedings seven original papers on Entomology and Microscopy. His papers were characterized by minute and painstaking research, and the facts which he studied were presented in a distinct and lucid manner and often very effectively. He was for some time a member of the Council and of the Editing Committee, and at the time of his death occupied the honourable and useful position of Chairman of the Council. In Mr. Ritchie we have lost a man always ready for any useful work, and while active and enthusiastic, most gentle and unobtrusive in his manner, and thoroughly to be relied on for the performance of all that he undertook to do.

Mr. Edward Hartley was a still younger man, and for a shorter time a member of this Society. He was born in Montreal, but received his scientific education at the Sheffield School of Yale College, and was for some time engaged in mineral surveys in the

United States. He subsequently became attached to the Geological Survey of Canada, and was employed more especially in the coal-fields of Nova Scotia, on which he prepared two elaborate and most valuable reports: one on the structure of a part of the Pictou coal-field, the other on the quality of the coals of Pictou. While in the midst of these useful labors he was suddenly struck down by disease, at the early age of 23. Mr. Hartley was a Fellow of the Geological Societies of London and of France, a member of the Institute of Civil Engineers of Scotland, and of the Institute of Mining Engineers of the North of England, and of various local societies. His attainments in Mineralogy, in Geology and in Mining Engineering were extraordinary for his years and gave promise of a brilliant career. Science in Montreal can little afford to lose two such men.

THE SCIENTIFIC PAPERS PRESENTED

to the Society in the past year have been numerous and valuable and most of them have been printed in full in our journal, the *Canadian Naturalist.* The following may be especially mentioned: "Aquaria Studies," Part 2d, by Mr. A. S. Ritchie; "On a specimen of *Beluga* recently discovered at Cornwall, Ontario," by E. Billings, Esq., F. G. S. "On the Earthquake of October 20th, 1870," by Principal Dawson, F. R. S.; "On Canadian Phosphates, in their application to Agriculture," by Gordon Broome, F.G.S.; "On the Origin of Granite," by G. A. Kinahan, Esq., of Dublin; "Notes on Vegetable Productions,; by Major G. E. Bulger; "On the species of Deer inhabiting Canada," by Prof. R. Bell, F. G. S.; "On the Sanitary Condition of Montreal," by Dr. P. P. Carpenter; "On the Foraminifera of the Gulf and River St. Lawrence," by G. M. Dawson; "On Canadian Foraminifera," by J. F. Whiteaves, F. G. S.; "On some New Facts in Fossil Botany," by Principal Dawson, F. R. S.; "On the occurrence of Diamonds in New South Wales," by Mr. Norman Taylor, and Prof. A. Thompson; communicated by A. R. C. Selwyn Esq., F. G. S.; "On the Structure and affinities of the Brachiopoda," by Prof. Morse; "On a Mineral Silicate injecting Palæozoic Crinoids," by Dr. T. Sterry Hunt, F. R. S. "On the Origin and Classification of Crystalline Rocks," by Mr. Thomas Macfarlane; "On the Plants of the West Coast of Newfoundland," by John Bell, M. A., M. D.; "On Canadian Diatomaceæ," by Mr. W. Osler; "On the Botany of the Counties of Hastings and Addington," by B. J. Harrington, B. A.

Beside these, we have reprinted in the *Naturalist* several important papers by Dr. Hunt, Mr. Billings, and others, with the view of making them more fully known to students of nature in Canada.

ERRONEOUS PUBLIC OPINIONS.

Of the scientific value of these papers, and of the amount of original work which they evince, it is unnecessary that I should speak; but it is sometimes alleged that societies of this kind are of no practical utility; that their labours are merely the industrious idleness of unpractical dreamers and enthusiasts. Nothing could be more unjust than such an assertion. Science, cultivated for its own sake, and without any reference to practical applications, is a noble and elevating pursuit, full of beneficial influence on mental culture, and by the training which it affords, fitting men for the practical business of life better than most other studies. Further, it is by this disinterested pursuit of science, for its own sake, that many of the most practically useful arts and improvements of arts have had their birth. Besides this, most of the investigations of the naturalist have a direct bearing on utilitarian pursuits. In illustration of this statement I need go no further than our own last volume. An eminent example is afforded by the paper of Mr. Gordon Broome on Canadian phosphates. Here we have set before us three pregnant classes of facts: First—Phosphates are essential ingredients of all our cultivated plants, and especially of those which are most valuable as food. In order that they may grow, these plants must obtain phosphates from the soil, and if the quantity be deficient so will the crop. Of the ashes of wheat, 50 per cent consist of phosphoric acid, and without this the wheat cannot be produced; nor if produced would it be so valuable as food. Second—The culture of cereals is constantly abstracting this valuable substance from our soils. The analyses of Dr. Hunt have shown long ago that the principal cause of the exhaustion of the worn-out wheat lands of Canada is the withdrawal of the phosphates, and that fertility cannot be restored without replacing these. In 292,533 tons of wheat and wheaten flour exported from Montreal in 1869, there were, according to Mr. Broome, 2,340 tons of phosphoric acid, and this was equal to the total impoverishment of more than 70,000 acres of fertile land. To replace it would require, according to Mr. Broome, 5,850 tons of the richest natural phosphate of lime or 13,728 tons of super-phosphates as ordinarily sold, at a cost of more than

$480,000. These facts become startling and alarming when we consider that very little phosphoric acid in any form is being applied to replace this enormous waste. Yet so great is now the demand for these manures that super-phosphates to the value of $8,750,000 are annually manufactured in England from mineral phosphate of lime, beside the extensive importations of bones and guano. Third—Canada is especially rich in natural mineral phosphates, as yet little utilized, and might supply her own wants, and those of half the world beside, if industry and skill were directed to this object.

Putting these three classes of facts together, as they are presented by Mr. Broome, we have before us, on the one hand, an immense abyss of waste, poverty and depopulation yawning before our agricultural interests; and on the other, inexhaustible sources of wealth and prosperity lying within reach of scientific skill, and the conditions necessary to utilize which were well pointed out in the paper referred to. It is true that these facts and conclusions have been previously stated and enforced, but they remain as an illustration of scientific truths of important practical value still very little acted on.

Naturalists are sometimes accused of being so foolish as to chase butterflies, and the culture of cabbages is not usually regarded as a very scientific operation; yet any one who reads a paper on the Cabbage butterfly read at one of our meetings by the late Mr. Ritche, may easily discover that there may be practical utility in studying butterflies, and that science may be applied to the culture of the most commonplace of vegetables. A valuable crop, worth many thousands of dollars, is hopelessly destroyed by enemies not previously known, and appearing as if by magic. Entomology informs us that the destroyer is a well known European insect. It tells how it reached this country and that it might have been exterminated by a child in an a hour on its first appearance. But allow it to multiply unchecked, it soon fills all our gardens and fields with its devastating multitudes, and the cultivators of cabbages and cauliflowers are in despair. But Entomology proceeds to show that the case is not yet hopeless, and that means may still be found to arrest its ravages.

Unfortunately, we have as yet no public official bureau of Entomology, and therefore we must be indebted for such information to men who, like our late associate Ritchie, snatch from arduous business pursuits the hours that enable them thus to benefit their country. Ontario is in advance of us in this, and has in the present year produced an important contribution to practical science in the report of the Fruit Grower's Association, which includes, among other matters, three papers on applied Entomology; that on Insects affecting the Apple, by Rev. C. T. S. Bethune; that on Insects affecting the Grape, by Mr. N. Saunders; and that on Insects affecting the Plum, by Mr. E. B. Reed. These are most creditable productions and of much practical value.

I would mention here that though we have among us several diligent and successful students of insects, yet we have no one at present who has taken up the mantle of Mr. Ritchie as a describer of their habits. I trust that some of our younger members will at once enter on this promising and useful field.

## WORK DONE.

Looking at the amount of work done by our Society in the course of the year, I think it will bear comparison with that of similar societies elsewhere. We have not before us so large an amount of matter as that accumulated by the great central societies of the Mother Country and the United States; but we exceed in this respect most of the local societies of Great Britain, outside of London, and most of those in America with the exception of a few of the more important. With regard to the quality of scientific matter, we can boast many papers of which any society might gladly take the credit, while all of the papers which we publish are at least of local value and importance. This Society is, on this account, now recognized as the chief exponent of Canadian Natural History, and its journal is sought by all interested in the aspects of nature in this part of America. The responsibility which devolves upon us in this aspect of our work, is, I think, worthy of our consideration, with reference to our future operations, and to this subject I would desire to devote the remainder of this address.

One of our functions as a local society I think we have well and efficiently performed. It is that of accumulating and arranging for study the natural productions of this country. Our collections of mammals, birds, insects and mollusks of Canada are now nearly complete up to the present state of knowledge, and we have also valuable collections in other departments of Zoology. Our curator, Mr. Whiteaves, has done very much to give to these collections a scientific value by careful and accurate arrangement.

We have not specially cultivated Canadian Geology, because we cannot hope to rival in this department the admirable collection of the Geological Survey; but we have aimed at and secured a general collection, useful in educating the public taste and for giving aid to learners. Our collections in American Ethnology are not contemptible; and at our last annual conversazione, by laying our friends under contribution, we were able to exhibit an admirable series of illustrations of the rude and simple arts of the tribes which preceded us in the occupation of this country.

Of our library I cannot speak in as high praise as of our Museum. It should undoubtedly be one function of a Society like this to collect for the use of naturalists at least those books of reference which they would require to consult, and especially all books of value bearing on American Natural History. It is true that the University Library and that of the Geological Survey to some extent supply this want; but there is still a large field in this department which we might occupy, and we should at least place the scientific periodicals of the day conveniently within the reach of our members. Nor is there anything more likely to prove attractive to the public than a well-stocked library and reading room, devoted especially to the scientific subjects which we cultivate. This subject is one with reference to which the Society should move vigorously in the coming year, either by soliciting special contributions for this purpose, by increasing the amount of its annual contributions from members, or by allying itself with other societies. It seems to have been an error in the construction of our building not to have provided larger space for accommodating a library and reading room, and if possible some amendment should be effected in this.

In our proper scientific work a boundless field lies before us. Scarcely any department of the natural history of this country has been satisfactorily worked out, and any active naturalist can find almost anywhere the material for original investigations, the results of which we are at all times ready to give to the public. I have already referred to the subject of Entomology as applied to practical purposes; and the natural history of our spiders, millepedes, and worms, is almost an untrodden field, while our microscopists have a vast and little explored domain in Canadian waters, with their multitudes of inhabitants of the humbler grades. There is much also yet to be done in Canadian fishes and reptiles. Mr. Whiteaves has made much progress in cataloguing Canadian mollusca, but his work is by no means complete; and such groups as the Nudibranchiates, the Tunicates and the Polyzoa, still lie in a very imperfect condition, though some materials have been accumulated. In connection with this subject, I would refer to the desirableness of exploring the deeper parts of the Gulf of St. Lawrence, in which, no doubt, many important additions to our fauna might be discovered, and which might throw much light on the post-pliocene geology of Canada. It is further much to be desired that an attempt should be made to ascertain the precise limits of the various marine animals in the brackish portions of the River St. Lawrence. In dredging in Murray Bay, in the past years, I have been surprised to find so rich a boreal fauna in that part of the river, and I have no doubt that it must extend much further upward, sustained by the cold salt water which forces its way under the warmer and fresher water of the surface. It would be interesting to know how far the marine animals extend, and also what varietal changes occur in the species as they approach the fresher portions of the river. To prosecute such researches we would require public aid, and the want of this has hitherto limited our work in this direction. Last year a committee was appointed to consider the matter, but nothing was done. With a view to some action in the coming summer, I have, as President of the Society, invited the attention of the Hon. the Minister of Marine to the subject, and have requested a passage for an observer appointed by the Society in one of the Government steamers or schooners. I have much pleasure in stating that he has entered heartily into my views, and that there is a prospect that, with the aid thus afforded, we may be able to reach with the dredge the deepest portions of the Gulf. Though these depths are small in comparison with those which have been reached in the Atlantic, I feel confident that they will afford a rich harvest of marine forms, not hitherto known to us, and that the results will be equally creditable to this Society and to the Government of Canada, which may thus, with little trouble and expense, emulate the Mother Country and the United States in the efforts which they are making to extend the knowledge of Marine Zoology. It is probable also that facts may be obtained of practical value with reference to the fisheries.

In Botany the two points which have chiefly engaged our attention are Geographical Distribution and the Cryptogamic orders. In the former, Mr. Drummond, Dr. Bell, and Mr. Matthew have done good service, but their labours merely show how much remains to be done. In the latter, Mr. Watt has been our principal worker; but here also, especially in the Algæ and Fungi, there is scope for other observers. Some one might do a most important service by directing his attention to the Parasitic Fungi of this country.

Geology, which presents the largest and most attractive field open to students of nature in Canada, has a most important public provision made for its culture in the Geological Survey. Still the function of this Society and of private workers is not unimportant. Several of the officers of the Survey have made the journal and the meetings of this Society the vehicles of their more purely scientific researches. I need only mention the valuable papers of Dr. T. Sterry Hunt on Chemical Geology, and those of Mr. Billings on Palæontology, as illustrative of this. To Mr. Hartley, Mr. Robb, Mr. Vennor, Professor Bell, and Mr. Broome, we have also been indebted in this way. Mr. McFarlane has enriched our journal with many valuable contributions, especially on the nature of rocks, and many of my own researches, especially in Post-pliocene Geology and Fossil Botany, have been published through the medium of the Society. The field for work is still, however, very wide; more especially is there large scope for industrious collectors of fossils, if they would devote themselves to the thorough exploration of such formations as may be within their reach.

### PUBLIC PATRONAGE NEEDED.

In conclusion, I must refer to what I regard as at present the most discouraging feature of our position. In the able address delivered last year by Dr. DeSola, reference was made to the slender aid and countenance which this Society receives from the public, and the same subject is illustrated by the statistics of the Society in the reports of the Council for last year, and also for the present year. A Society like this, offering to the public a well filled and well arranged museum, the advantage of attending its scientific meetings and public lectures, and of receiving its journal at a price little more than nominal, should need no advertisement; and this more especially when its working members are labouring so successfully in enlarging the boundaries of knowledge and promoting its practical applications. Those of our citizens who are not themselves naturalists, should on these grounds be members and contributors to its funds, merely as a public institute, creditable and useful to the city. But this is not all: they should also take an interest in its work. Nearly all the subjects which engage its attention possess some interest to any intelligent mind; and I believe that it is much more from want of knowledge of that which we are doing, or from want of thought, than from any other causes, that so many fail to take advantage of the privileges which we offer. I am sure that there is no intelligent man who will not find in the advantages to which I have referred much more than an equivalent for his annual subscription. Experience has, however, shown us that we cannot reckon on a work so unobtrusive as ours securing the attention it deserves. It will, therefore, be incumbent on the new Council to take steps as soon as possible for enlarging our membership by a direct appeal to the public. I trust that this will be successful, and that next year we shall be able to report that we have not only done useful work, but that our list of members has been greatly enlarged.

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## THE ORIGIN OF SPECIES.*

*(From the New York "Nation.")*

The author of the "Origin of Species" is more widely known, more eagerly read, more cordially admired, and more emphatically denounced than any other scientific man of the day. The interest in him is in great measure due to the natural desire of humanity to penetrate that "mystery of mysteries"—its origin; encomiums which even his warmest opponents (excepting those who are filled with the *odium theologicum*) have bestowed upon him, are just tributes to his long and faithful labours, and to the modesty which has compelled others to award to him some of the credit he seemed loth to claim; but much, if not all, of the indignation which many good persons feel towards him arises from misconceptions of his ideas respecting the Creator, which have

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* "The Origin of Species by means of Natural Selection. By Charles Darwin, F. R. S." Fifth edition. (Am. reprint.) New York: D. Appleton & Co. 1871. Pp. 447, 8vo.

"The Genesis of Species. By St. George Mivart, F.R.S." London and New York: Macmillan & Co. 1871. Pp. 296 (with illustrations).

their origin not in his own works, but in those of certain advocates of his general views.

In truth, the candid reader of Darwin's own works can find little fault with his conceptions of the Creator so far as regards their sincerity, although it is evident that he regards the origin of species as a legitimate subject of scientific enquiry, and ignores, as well he may, the vain attempts to reconcile the conclusions to which he is led with the commonly received interpretation of Scripture. So does the author of the "Genesis of Species," who is, however, a professedly devout man, and gives many arguments and quotations, especially in the chapter on "Theology and Evolution," to show that neither "Darwinism" nor any other derivative theory necessarily conflicts in the least degree with the most orthodox religious convictions.

This leads to the needed correction of another grave misconception—that "Darwinism" is synonymous with "derivation" or "evolution," and that either of these terms is equivalent to "transmutation." This idea has not only crept into the book catalogues, where all works upon the origin of species are grouped together under the title "Darwinismus," as if they treated of merely local varieties of the same intellectual epidemic, but it has also caused many who feel that Darwin's particular theory is wrong, to oppose all theories whatsoever involving the derivation of higher forms from lower.

A sketch of the views which preceded his own is prefixed, by Darwin, to the later editions of his work; but we have nowhere met with any grouping of these and subsequent theories which exhibits their relative nature. Such a classification we venture to offer here, admitting the impossibility of more than indicating the salient points of each theory and the names of a few of its more zealous advocates. We have also thought it best to omit the hypothesis of "acceleration and retardation," * recently proposed by Professor Cope, and spoken of by Principal Dawson as, in his view, "the most promising of all." †

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* "The Hypothesis of Evolution." University series. New Haven: C. C. Chatfield & Co.

† For farther notice of the hypothesis here referred to, see Dr. Dawson's paper on "Modern Ideas of Derivation," in the *Canadian Naturalist* for June, 1869, page 134, and also the *American Naturalist* for June, 1870, pp. 230–237, where, in a review of Dr. Dawson's paper, Prof. Alpheus Hyatt, of Boston, refers to an essay by himself "On the

| | FAMILY. | GENUS. | SPECIES. | SUPPORTERS. |
|---|---|---|---|---|
| Creation | Independent | Production of adults | | Milton. |
| | | Production of eggs | | Swedenborg. |
| | Derivative | Production of Varieties | Transmutation | Lamarck. |
| | | | Natural selection | Darwin. Wallace. |
| | | Production of Species | Ordinary Genesis | "Vestiges." Parsons. Owen. Mivart. |
| | | | Parthenogenesis | Ferris. |

The above will explain itself to those who are already familiar with the subject, but a few words may be added for others. If the species of animals and plants were created *independently* of all other species, then they must have been made as either perfect and fully formed individuals or as seeds and eggs. The former view is here ascribed to Milton rather than to Moses or Scripture, because most intelligent people now admit that the earlier chap-

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parallelism between the different stages of life in the individual and those in the entire group of the molluscous order Tetrabranchiata." (Mem. Boston Soc. Nat. Hist. Vol. I, part ii. 1867.) Prof. Hyatt remarks that Dr. Dawson has " given Prof. Cope the undivided credit of discovering the law of acceleration, whereas the memoir referred to above, which has escaped Dr. Dawson's notice, will remove all doubt that the aim of a large part of the observations there recorded, is identical with those of Prof. Cope's more elaborate essay. We have no desire for controversy . . . . . but feel that silence in the present instance would place in a false light the object of these investigations, and vitiate the original value of the results of much labour not yet published." (Loc. cit. 234.)

We may add that Prof. Hyatt's paper was read Feb. 21, 1866, and Prof. Cope's on the Cyprinoid Fishes, in which his views were first enunciated, in Oct. 19 of the same year, though only published in the Trans. Amer. Philos. Soc., vol. 13, in 1869, after his elaborated views on the origin of species had appeared in the Proc. Phil. Acad. Sciences for 1868. No one who knows Prof. Cope can doubt that he, like Dr. Dawson and the author of the review here copied from *The Nation*, was unacquainted with the views of Prof. Hyatt. In justice to the latter, however, as an independent worker in this field, it is well to put these facts on record to avoid any future misconceptions.

It should perhaps be explained that Dr. Dawson's reasons for preferring the theory of Messrs. Hyatt and Cope did not imply any adhesion on his part to the hypothesis of derivation, but was based merely on the circumstance that the possibility of the passage of an animal from one genus to another by acceleration or retardation of development, seems to be proved by at least a few though perhaps exceptional facts, open to observation ; while the change of one species into another is totally destitute of any observed examples or positive proof.—*Eds.* CANADIAN NATURALIST.

ters of Genesis cannot reasonably be interpreted in their literal sense; so that for a distinct statement of this view we must look to the great English poet, who, however, was not a scientific man.* The idea that organisms were created as eggs, which have a simpler structure, is less difficult to comprehend than the foregoing, but it is not easy to see how this could occur with the higher animals whose young are born *alive*, and not in the form of eggs. A rather vague enunciation of this idea is contained in a little work by Swedenborg,† which is probably to be regarded as purely philosophical and not as one of his theological works.

The second and more numerous family of theories is called "Derivative," because they all involve the supposition that in some way the lower and earlier forms have served as the means of producing higher and later ones. But it will be seen that they differ essentially as to the *manner* of this derivation. Lamarck was impressed with the amount of variation in size and form which the parts of an animal may undergo in consequence of their use or disuse, and so indirectly from any desire or "appetency" which the animal experienced, *e. g.*, a fish might thus become a quadruped if forced to live upon the land, and an ape might become a man. The amount of change in any one generation might be very slight, but the next generation would inherit, increase, and perpetuate the transformation.

In the endeavour to give a concise statement of Darwin's own theory, we suffer from an "embarras de richesses;" for not only is his own work one long presentation of it in many different aspects, but each later writer upon the subject has given his particular version, and from a different stand-point. Summary expressions of the theory are given by our author on pages 40, 70, 178, 412, 437; but a more diagrammatic enunciation is that of Wallace, who not only presented publicly an independent theory of natural selection at the same time with Darwin (1858), but has since paid a warm tribute to the latter's work, while expressing a doubt respecting the sufficiency of that theory for the production of man. With a few unimportant changes, his presentation is as follows: ‡

* "Paradise Lost," Book VI.

† "Worship and Love of God," Section 3.

‡ "Contributions to the Theory of Natural Selection." London and New York: 1870. Pp. 302.

"1. Tendency of individuals to increase in number, while yet the actual number remains stationary.

"2. A struggle for existence among those which compete for food and endeavour to escape death.

"3. Survival of the fittest; meaning that those which die are least fitted to maintain their existence.

"4. Hereditary transmission of a general likeness.

"5. Individual differences among all.

"6. Change of external conditions universal and unceasing.

"7. Changes of organic forms to keep them in harmony with the changed conditions: and as the changes of condition are permanent, in the sense of not reverting back to identical previous conditions, the changes of organic forms must be in the same sense permanent, and thus originate species."

The following passages from the "Origin of Species" may aid the comprehension of what the author admits to be a complex hypothesis:

"There is a struggle for existence leading to the preservation of profitable deviations of structure and insects"—(p. 412.) "Natural selection acts solely through the preservation of advantageous variation, and it acts with extreme slowness, at long intervals of time, and only on a few inhabitants of the same region" (p. 108.) "It is not probable that variability is an inherent and necessary contingent under all circumstances; variability is governed by many unknown laws (p. 50). "We are profoundly ignorant of the cause of each slight variation or individual difference (p. 192). "Nature gives successive variations; *man* adds them up in certain directions useful to him" (p. 40).

We italicise *man* because we are convinced that the grand fallacy in Darwin's theory lies just here, in the assumption that the selection and propagation of useful variations by *man* is in any way comparable to what takes place in nature. What is proved by all his works is this: that, so far as experience goes, no two created things are identical; that in many cases naturalists differ in their estimate of the value of the distinctions existing between individuals, so that what some call varieties others regard as species (a mighty question, which can only be decided by comparing great numbers of individuals of an undoubted species, and especially the progeny of a single pair); that by constant attention, by saving such as meet his wants and rejecting the rest, man has produced very strongly marked varieties, which continue "permanent" so long as this care is given, but which, the instant it is relaxed and a free crossing with other breeds is allowed, show that they are only varieties and not true species by reverting to the original stock. It may also be admitted that in nature a somewhat similar selection takes place, especially under the form of "sexual selection," but there is as yet no evidence whatever that natural species can be compared to the breeds of domesticated animals; and to ascribe to "selection" of any kind the power of originating *species* merely because it can preserve useful individual *varieties*, is as illogical as—if so homely a simile is allowable—to suppose that the man who is able to manage his own house is, therefore, competent to "keep a hotel." Natural selection may be a *true* cause, but it is not shown to be a *sufficient* cause.

It may here be noted that *reversion* is not mentioned in any of the statements of the theory of natural selection by either Darwin or Wallace. Yet the former treats of the subject at length, and even depends upon its agency, after the lapse of thousands of years, to account for the sudden reappearance of otherwise inexplicable structures; so that, if we give to reversion the weight which Darwin himself allows it when it favours his views, his arguments against its action (pages 28 and 160) do not remove what is really a very serious objection to the theory of natural selection as applied to the production of specific forms in nature.

This whole subject is well presented by Mivart in the chapter on "Specific Stability;" and we have alluded to it here because it has always seemed to us to involve a fundamental fallacy which the author of "Natural Selection" is bound to remove.

The object of the "Genesis of Species" is "to maintain the position that natural selection acts, and, indeed, must act; but that still, in order that we may be able to account for the production of known kinds of animals and plants, it requires to be supplemented by the action of some other natural law or laws, as yet undiscovered" (page 5). This is, we may remark, but one of the numerous evidences that, while the general theory of "derivation" has been steadily gaining adherents even from among its original opponents, yet "natural selection"—Darwinism "pure and simple"—has been, and is still, losing ground even with those who were inclined to adopt it. Huxley "adopts it only provisionally."* McCosh† admits that "it contains much truth, but not all, and overlooks more than it perceives." Lesley‡ says, "All agree that it is true if kept within the regions of *variety*, but it is disputed whether it be true for actual *specific* differences." Wallace denies its sufficiency in the case of man. and Darwin himself has modified his views somewhat in this last edition of the "Origin of Species;" furthermore, he admits "the existence of difficulties so serious that he can hardly reflect on them without being staggered" (p. 167); and that "scarcely a single point is discussed on which facts cannot be adduced often apparently leading to conclusions opposite to mine" (p. 18). Indeed, with characteristic candour, he specifies certain ideas which if proved, would be fatal: "If it could be proved that any part of the structure of one species had been formed for the exclusive good of another species, it would annihilate my theory" (p. 196). We may, for example, yet learn the use which the "rattle" and the expanded hood have for the rattlesnake and the cobra, but Mivart is inclined to believe they are rather injurious, since they warn the prey (p. 50). Another such "fatal idea" is the doctrine that "many structures have been created for beauty in the eye of man or for mere variety" (p. 194). And here our author seems to contradict himself when, upon the same page, he admits that "many structures are now of no direct use to their possessors, and may never have been of any use to their progenitors"—a subject which has been well discussed by the Duke of Argyll.§

The theory of natural selection implies that all changes are minute and gradual; and also that only useful structures are preserved and augmented. Prof. Mivart points out the difficulty of explaining the origin of the unsymmetrical form of the flounders, etc. (p. 37), of the limbs of animals which, in their earliest and minutest form, must have been mere buds or roughnesses, and thus rather impediments to the progress of our ancient aquatic progenitor (p. 39). Darwin further admits that "it is impossible to conceive by what steps the electric organs of fishes were produced (p. 184), also that the absence of imperfectly organized forms in the lowest strata of the earth's crust is inex-

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* "Man's Place in Nature," p. 128.

† Report of recent lectures.

‡ "Man's Origin and Destiny."

§ "Reign of Law," seventh edition, p. 230.

plicable" (p. 292); and his explanation of the absence of the transitional forms which must have existed, according to his theory of "minute modifications in time," between such forms as the elephant, the giraffe, the galeopithecus, the bats, and the ordinary quadrupeds, is very unsatisfactory. His theory of rudimentary organs, also, is extremely imperfect. He accounts for all such from the *disuse of previous perfect organs* (p. 408); but he nowhere hints at the far more essential question as to how these original organs became perfect; for upon his own general hypothesis they must have been rudimentary in the beginning. With regret, and after the closest and most sincere examination of all his remarks upon this subject, we confess that we have rarely seen such an absolute lack of logical argument as is evinced in the section upon rudimentary and functionless structures. In fact, the immense amount of evidence which he has collected does not seem to us to bear upon the main point, the *origin of species*, at all, but only upon the *preservation of favourable individual variations.*

We have not space for further presentation of our own difficulties or those which others have urged against the theory of natural selection, and will simply quote the general grounds upon which Prof. Mivart has been led, with no prejudice against it, to regard that theory as playing only a subordinate part in the production of new species (p. 21):

"Natural selection is incompetent to account for the incipient stages of useful structures. It does not harmonize with the co-existence of closely similar structures of diverse origin."

"Certain fossil transitional forms are absent which might have been expected to be present; and some facts of geographical distribution supplement other difficulties. There are many remarkable phenomena in organic forms upon which natural selection throws no light whatever."

"Still other objections may be brought against the hypothesis of 'pangenesis'* which, professing as it does to explain great difficulties, seems to do so by presenting others not less great—almost to be the explanation of *obscurum per obscurius.*"

These difficulties, which are set forth with equal cogency and fairness in the earlier chapters of the "Genesis of Species," have

* Propounded at the close of the work upon "Variation under Domestication."

led its author to a view which he alludes to throughout his work, but presents in detail in the chapter entitled "Specific Genesis."

"According to this view, an internal law presides over the actions of every part of every individual, and of every organism as a unit, and of the entire organic world as a whole. It is believed that this conception of an internal innate force will ever remain necessary, however much its subordinate processes and actions may become explicable. That by such a force, from time to time, new species are manifested by ordinary generation, these new forms not being monstrosities, but consistent wholes. That these 'jumps' are considerable in comparison with the minute variations of 'natural selection'—are, in fact, sensible steps, such as discriminate species from species. That the latent tendency which exists to these sudden evolutions is determined to action by the stimulus of external condition."

The part assigned to natural selection is stated as follows:

"It rigorously destroys monstrosities, favours and develops useful variations, and removes the antecedent species rapidly when the new one evolved is more in harmony with surrounding conditions."

Professor Mivart has so frankly admitted the essential coincidence of the above view with the one expressed by Professor Owen in 1868,* that we do not hesitate to call his attention to the similar views previously advanced by Professor Parsons, of Harvard University, and by the anonymous author of "Vestiges of Creation;" believing that his own conclusions were reached in entire independence of all of them, as is said of Professor Owen's. The author of the "Vestiges" expresses himself as follows: †

"My idea is, that the simplest and most primitive type, under a law to which that of like-production is subordinate, gave birth to the type next above it, that this again produced the next higher, and so on to the very highest, the stages of advance being in all cases very small, namely, from one species only to another. . . . . . Yet in another point of view, the phenomena are wonders of the highest kind, in so far as they are direct effects of an Almighty will, which had provided beforehand that everything should be very good."

* "Comp. Anat. and Phys. of Vertebrates," vol. iii. p. 808.

† "Vestiges of the Natural History of Creation," third edition, p. 170.

Professor Parsons* writes as follows:

"Suppose the time to have come when there is to be a new creation, and it is to be a dog, or rather two dogs, which shall be the parents of all dogs. How shall they be created? . . . . The fifth view is, they will be created by some influence of variation acting upon the ova of some animal nearest akin—a wolf, or a fox, or a jackal—and the brood will come forth puppies, and grow up dogs to become dogs."

Besides the above, several other authors (Gray,† Argyll,‡ and Neale§) had already hinted at the necessity of admitting the sudden production of new specific forms, in some cases at least; and Darwin himself, as we shall see hereafter, appears to have a dim idea that something of the kind might happen in defiance of natural selection.

Nothing like direct evidence can be given in support of this theory of "specific genesis;" but the question really is, as stated by Parsons, whether, as a provisional hypothesis, it is not on the whole, less improbable than any other, and open to fewer objections. Those who, like Spencer, are unwilling to admit the action of any but known physical laws and agencies, may say, and truly, that the supposition of an "innate internal tendency" only removes the difficulties one step further back, and is at best merely re-stating the case in a general way; but little more can be said of the theory of gravitation.

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## ON A NEW FOSSIL CRUSTACEAN FROM THE DEVONIAN ROCKS OF CANADA.

*Extract from a paper in the Geological Magazine, Vol. 8, No. 3, "on some new Phyllopodous Crustaceans from the Palæozoic Rocks.*

By Henry Woodward, F.G.S., F.Z.S.

Amongst a series of Crustacean remains, from the collection of Prof. Bell, of Canada, obtained in the Middle Devonian of Gaspé, and left with me for examination by the kindness of Principal Dawson, F.R.S., of McGill College, Montreal, is a portion of a

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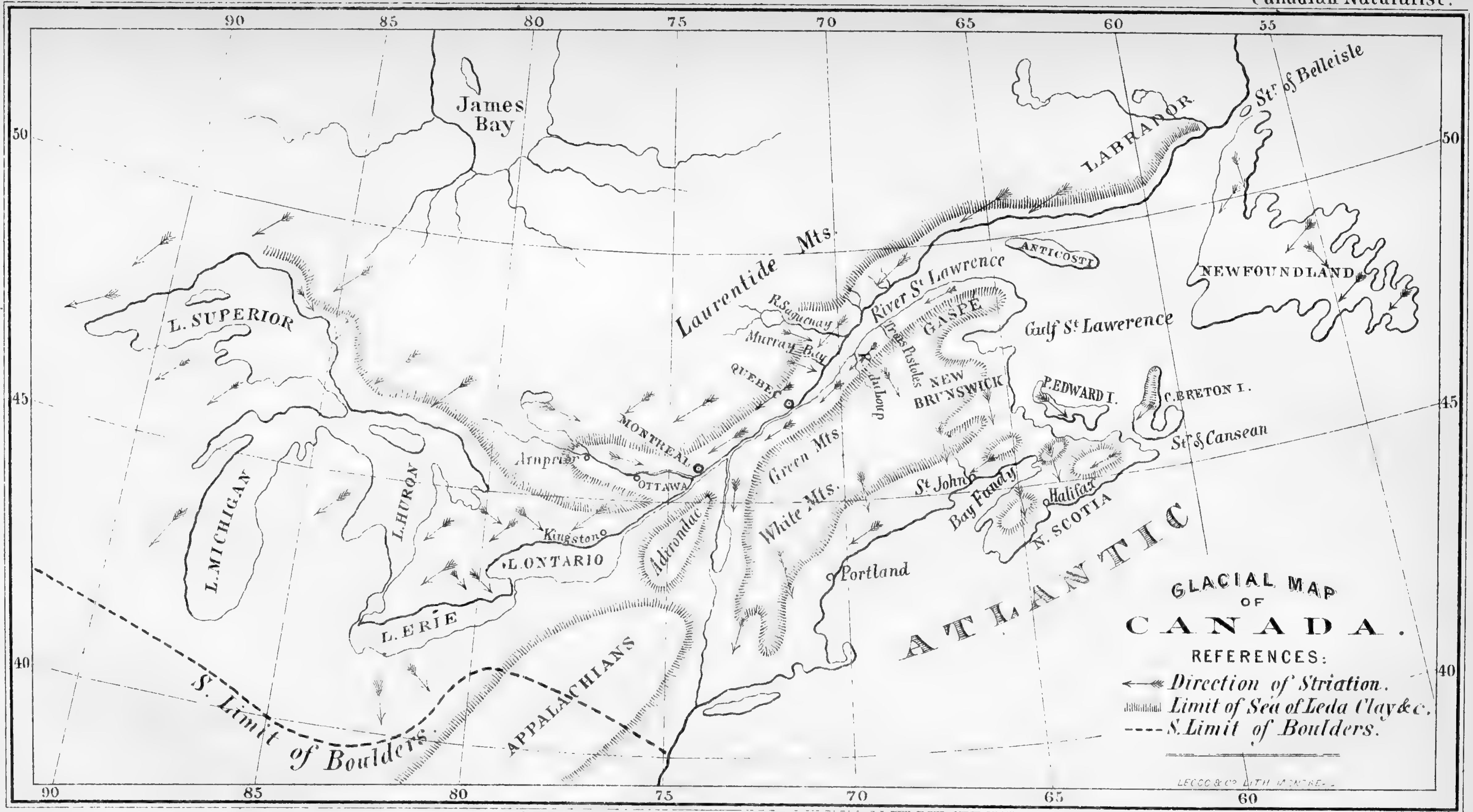
* *American Journal of Science*, July, 1860.

† *Am. Journ. of Science*, March, 1860; *Atlantic Monthly*, July, Aug., Oct., 1860.

‡ "Reign of Law" p. 237.

§ *Proc. Zool. Soc. of London*, Jan. 18, 1861.




To illustrate a paper by Principal Dawson.

valve of *Dithyrocaris?* most beautifully sculptured, of which the following is a description. The specimen is eleven lines in breadth, and probably measured, when entire, nearly two inches in length. The dorsal border is rounded in a corresponding degree with the ventral border; a small rostrum is observable at the anterior end, from which two prominent ridges also take their rise and pass over the side, one arching towards the dorsal, the other bending towards the ventral line, but uniting again on the centre of the valve at one inch from the anterior end. The fine striæ above and below these prominent ridges are parallel, but those inclosed in the central elliptical space cross one another so as to form a finely reticulated pattern on its surface. The eye spot is distinct and prominent at the anterior end, near the intersection of the two curved ridges. Other slight, scarcely visible, folds traverse the carapace parallel to the ventral and dorsal border, indicating that the original shell was of extreme tenuity, like that of the recent *Apus* and *Estheria*.

Should the discovery of other and more perfect specimens prove this to be a true *Dithyrocaris*, it will be the first specimen of this genus met with in rocks of Devonian age.

I had proposed to call this form *D. striatus*,* but as there is already a *D. tenuistriatus*, it will be better not to give it so indistinct a name. I therefore beg to name it *Dithyrocaris? Belli*, after its discoverer.

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# THE POST-PLIOCENE GEOLOGY OF CANADA.

By J. W. Dawson, LL.D., F.R.S., F.G.S.

## *Introductory.*

When in 1855 the writer, in consequence of accepting the office of Principal of McGill College, was removed from the Carboniferous Districts of Nova Scotia, and thus to some extent debarred from the prosecution of his researches in the carboniferous rocks of that Province and their fossil plants, he determined, with the advice of Sir W. E. Logan, then Director of the Geological Survey of Canada, to take up as an occasional pursuit the study of the Drift Deposits of Canada, a work which had, at

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* British Association Reports, Section C., Liverpool, 1870.

least, this link of connection with previous occupations, that it related in part to marine animals, with which his Zoological studies on the sea coast had made him familiar.

The results of these studies have, in part, been published in the following papers:—

(1.) On the Newer Pliocene and Post-Pliocene of the Vicinity of Montreal.—*Canadian Naturalist*, 1857.

(2.) Additional Notes on the Post-Pliocene Deposits of the St. Lawrence Valley.—*Ib.* 1859.

(3.) On the climate of Canada in the Post-Pliocene Period.—*Ib.* 1860.

(4.) On Post-Tertiary Fossils from Labrador.—*Ib.* 1860.

(5.) On the Geology of Murray Bay (Part 3, Post-pliocene deposits)—*Ib.* 1861.

(6.) Address as President of the Natural History Society of Montreal.—*Ib.* 1864.

(7.) On the Post-pliocene Deposits of Riviere du Loup and Tadoussac.—*Ib.* 1865.

(8.) Comparison of the Icebergs of Belle-isle and the Glaciers of Mont Blanc, with reference to the Boulder-clay of Canada.—*Ib.* 1866.

(9.) On the Evidence of Fossil plants as to the Post-pliocene climate of Canada.—*Ib.* 1866.

In addition to these papers I placed in the hands of Sir W. E. Logan, all my notes and lists of fossils up to 1863, for his Report of that year;* and gave a resumé of the subject, in so far as the Post-pliocene of the Acadian Provinces is concerned, in the second edition of my "Acadian Geology," published in 1868.

Much of the matter contained in these detached publications now requires revision, more especially the lists of fossils; and many additional facts have accumulated. I purpose therefore now to summarize the facts and conclusions of my previous papers and to unite them with the new facts, so as to present as complete a view as possible of the geology of the superficial deposits of Canada. I shall also prepare a complete list of the fossils up to date, with revised nomenclature and synonymy. In this last part of the work I have been aided by Dr. P. P. Carpenter and Mr. Whiteaves. I have had the benefit, in the case of several critical species, of the advice of Mr. J. G. Jeffreys, and Mr. R. MacAn-

* Quoted in this paper as the "Geology of Canada."

drew of London. I am also indebted to Mr. G. S. Brady for determining the Ostracoda, to the Rev. H. W. Crosskey for opportunities of comparing specimens with those of the Clyde Beds, and to Prof. T. R. Jones and Dr. Parker and Mr. G. M. Dawson for help with the Foraminifera.

The present memoir will, I am sure, be welcomed by all who are engaged in the study of the subject to which it relates, if for no other reason, because the Post-pliocene deposits of Canada from their great extent and perfect development, are well fitted to throw light on many of the controversies which are now agitated with regard to these deposits.

It may be proper here to indicate the nomenclature which will be followed. When the whole geological series is divided into Primary, Secondary, and Tertiary, the deposits to which this paper relates are usually named Post-tertiary or Quaternary. These terms are, in my judgment, unfortunate and misleading. If we take the relations of fossils as our guide, then, as Pictet has well remarked, whether we regard the land or the sea animals, there is no decided break between the Newer Pliocene and the Post-pliocene, the changes not being greater than those between the Pliocene and the older Tertiary ages. There is, therefore, no such thing in nature as a Quaternary time distinct from the Tertiary, as the Tertiary is distinct from the Secondary. Where therefore the terms Primary, Secondary, and Tertiary are used, the latter should include the whole time from the Eocene to the modern, inclusive, unless indeed the advent of man be considered an event of sufficient geological importance to warrant a separation of the modern from the Tertiary period. When the terms Palæozoic, Mesozoic and Kainozoic or Neozoic are used, then the two latter terms cover perfectly the Post-pliocene as well as the Eocene, Miocene and Pliocene.

I would therefore include the Post-pliocene in the Neozoic or Tertiary period and define it to be that geological age which is included between the Pliocene and the Recent. From the former it is separated by the advent of the cold or glacial* period, and the accompanying subsidence of the land, as well as by the disappearance of many species of animals and plants. From the latter it is separated by the extinction of many mammalian

* I use the term "glacial" in this paper in its general sense, as including the action of floating ice as well as of land ice.

forms and by the establishment of our continents at their present elevation above the water and with their present fauna and flora and drainage systems. In Canada the absence of the Pliocene deposits and the immediate superposition of the Post-pliocene on the Palaeozoic formations, remove all difficulty on the subject of the beginning of the period. The line of separation between the Post-pliocence and the recent, especially in Western Canada, is less distinct; but in Eastern Canada the upper part of the Post-pliocene is always marine, while the recent deposits are land and fresh-water.

With regard to the subdivisions of the Post-pliocene in Canada, if we confine our attention to the clearly marked marine and glacial beds of the lower part of the St. Lawrence Valley, we have no difficulty in establishing the following divisions, suggested in my paper of 1857:

3. *Saxicava Sand*, shallow-water sand and gravels, equivalent to the Champlain and Terrace epochs in part of Dana, to the modified drift of Hitchcock in part, to the Tertiary sands of Capt. Bayfield; and to the Upper fossiliferous sands and gravels of Scotland and Scandinavia.

2. *Leda Clay*, moderately deep-water clays, equivalent to lower part of Champlain epoch, Dana, and Tertiary clays of Bayfield. Fossiliferous Clays of Scotland and Scandinavia.

3. *Boulder-Clay.*—Hard clay or sometimes sandy clay or sand, with stones and boulders, and not distinctly laminated. Equivalent to Glacial clays of Dana and unmodified drift of Hitchcock. Till and older Boulder-clay of Scotland and Scandinavia.

In Lower Canada these three deposits can often be seen in actual superposition, and the order is invariable. In some places all contain marine shells, in others these are limited to the upper part of the Leda clay or the lower part of the Saxicava sand.

In Western Canada, around the great lakes, are extensively distributed beds of clay and gravel, which have been described in the Report of the Geological Survey, and which have afforded fresh-water and land remains only. Of these the Algoma sand and Saugeen clay and sand may possibly correspond in age to the Saxicava sand, and the Erie clay to the Leda clay. This identification is, however, uncertain, as the marine Leda clay has been traced up no further than the vicinity of Kingston, on the St.

Lawrence, and of Arnprior on the Ottawa. Below these points the Valleys of the Ottawa and St. Lawrence present everywhere the deposits above tabulated, in a greater or less degree of completeness. They are connected with the similar deposits of New England, through the valley of Lake Champlain, and across the low lands of Nova Scotia and New Brunswick.

Whittlesey has described the Western Drift Deposits in the Smithsonian Contributions, vol. xv., and according to him the Boulder drift is there the upper member of the series. More recently Prof. Newberry has given a summary of the facts in his Report of the Geological Survey of Ohio for 1869. From these sources I condense the following statements,

The lowest member of the Western drift, corresponding to the Erie clays of the Canadian Report, is very widely distributed and fills up the old hollows of the country, in some cases being two hundred feet or more in thickness. Toward the north these clays contain boulders and stones, but do not constitute a true Boulder-clay. They rest, however, on the glaciated rock surfaces. They have afforded no fossils except drifted vegetable remains.

Above these clays are sands of variable thickness. They contain beds of gravel, and near the surface teeth of elephants have been found. On the surface are scattered boulders and blocks of northern origin, often of great size, and in some cases transported two hundred miles from their original places.

More recent than all these deposits are the "Lake Ridges" marking a former extension of the great lakes. Dr. Newberry considers the Erie clay to be the deposit of a period of submergence following the action of a continental glacier, and he maintains that the old channels now filled with Erie clay are so deep as to indicate that in the earlier glacier period the land was at least five hundred feet higher than its present level. At the close of this period of submergence the boulder drift was deposited by northern currents and ice, and then the land gradually rose to its present level.

The facts thus summed up by Dr. Newberry indicate, in proceeding from the older to the newer.

1. An elevated continent and the erosion of deep valleys.
2. Glaciation of the surface.
3. Filling of the valleys with Erie clay.
4. Distribution over the surface, of boulders and Northern drift.

My interpretation of the phenomena would differ from that of Dr. Newberry in the following particulars—(1) I would refer the continental elevation and the deep erosion to the Pliocene period, before the advent of the glacial epoch. (2) I would refer the glaciated surfaces and the lower part of the Erie clay to the time of the Canadian Boulder-clay, and would regard it as an evidence of subsidence and an ice-laden sea, with the arctic current passing over the continent from the North-East. (3) I would regard the upper part of the Erie clay as equivalent to the Leda clay. (4) I would place the upper and confessedly water-borne drift as the equivalent of the Saxicava sand, and as belonging to the period of elevation.

It is a difficulty, both in Dr. Newberry's view and mine, that marine shells are not found in the Erie clay and surface drift. The following considerations, however, diminish this. (1) The greater part of the Leda clay is very poor in fossils, even near the ocean, and so is the boulder clay. (2) The submergence of a vast continental area under cold water might have continued for a long time before the marine animals could widely spread themselves over it, especially under the unfavourable circumstances of ice erosion. (3) The few and scattered marine remains to be expected in these deposits may have escaped observation. The occurrence of much drift-wood in the Erie clay is also, in my judgment, inconsistent with the occurrence of a general glacier immediately previous to the deposition of the clay.

We may now consider the several members of the Post-pliocene in succession, beginning with the oldest.

## GENERAL DESCRIPTION.

### 1. *The Boulder-Clay.*

Throughout a great part of Canada there is a true "Till," consisting of hard gray clay, filled with stones and thickly packed with boulders. In some places, however, the clay becomes sandy, and in some portions of the carboniferous areas, the paste is an incoherent sand. The mass is usually destitute of any stratification or subordinate lamination; but sometimes in thick beds horizontal lines of different texture or colour can be perceived, and occasionally the clay intervening between the stones becomes laminated, or at least shows such a structure when disintegrated by frost. The Boulder-clay usually rests directly on striated rock surfaces;

but I have observed in Cape Breton a peaty or brown coal deposit, with branches of coniferous trees, to underlie it, and in other places there are deposits of rolled gravel under the Boulder-clay. At the Glen brick-work, near Montreal, a peculiar modified Boulder-clay occurs, consisting of very irregularly bedded sand and gravel, with many large boulders, and only thin layers of clay.

The stones of the Boulder-clay are often scratched and ground into those peculiar wedge-shapes, so characteristic of ice-worked stones. Very abundant examples of this occur in the Boulder clay of Montreal and its vicinity.

At Isle Verte, Riviere du Loup, Murray Bay, Quebec, and St. Nicholas, on the St. Lawrence, the Boulder-clay is fossiliferous, containing especially *Leda truncata*, and often having boulders and large stones covered with *Balanus Hameri* and with Bryozoa, evidencing that they have for some time quietly reposed in the sea bottom before being buried in the clay. This is indeed the usual condition of the Boulder-clay in the lower part of the St. Lawrence River. Further up, in the vicinity of Montreal, it has not been observed to contain fossils, but it presents equally unequivocal evidence of sub-aqueous origin in the low state of oxidation of the iron in the blue clay, which becomes brown when exposed to the weather, and in the brightness of the iron pyrites contained in some of the glaciated stones, as well as in the presence of rounded and glaciated lumps of Utica shale and other soft rocks, which become disintegrated at once when exposed to weathering.

The true Boulder-clay is in all ordinary cases the oldest member of the Post-pliocene deposits, and it is not possible to ascertain the existence of Boulder-clays of different ages, superimposed on one another. It may be observed, however, that in so far as the Boulder-clay is a marine deposit, that which occurs at lower levels is in all probability newer than that which occurs at higher levels. It is also to be observed that boulders with layers of stones occasionally occur in the Leda clay; and that the superficial sands and gravels sometimes contain large boulders; but these appearances are not, I think, sufficiently important to induce any experienced observer to mistake such overlying deposits for the true Boulder clay.

In some localities the stones in the Boulder-clay are almost exclusively those of the neighbouring rock formations, and this is especially the case at the base of cliffs or prominent outcrops, whence a large quantity of material would be easily derived. In other cases material travelled from a distance largely predominates. Throughout the valley of the Lower St. Lawrence, the gneiss and other hard metamorphic rocks of the Laurentian hills to the north-east are very abundant, and in boulders of large size and much rounded. Occasional instances also occur where boulders have been transported to the northwards; but these are comparatively rare. I have mentioned some examples of this in Acadian Geology, p. 61. Similar instances are mentioned in the Geology of Canada, page 893.

Though the boulder clay often presents a somewhat widely extended and uniform sheet, yet it may be stated to fill up all small valleys and depressions, and to be thin or absent on ridges and rising grounds. The boulders which it contains are also by no means uniformly dispersed. Where it is cut through by rivers, or denuded by the action of the sea, ridges of boulders often appear to be included in it. Those on the Ottawa referred to in the "Geology of Canada," page 895, are very good illustrations, and I have observed the same fact on the Lower St. Lawrence and on the coast of Nova Scotia. It is also observable that these lines and groups of boulders are often not of local material, but of rocks from distant localities, and that a number of the same kind seem often to have been deposited together in one group.

Loose boulders are often found upon the surface, and sometimes in great numbers. In some instances these may represent beds of boulder clay removed by denudation. In other cases they may have been derived from the overlying members of the formation, or may have been deposited on the surface, without any covering of clay or gravel. In "Acadian Geology," p. 64, I have illustrated the manner in which large stones, sometimes 8 feet or more in diameter, are moved by the coast ice and sometimes deposited on the surface of soft mud, and I have had occasion to verify the observations of the same kind made by Admiral Bayfield, and quoted by Sir C. Lyell in the "Principles of Geology." Lastly, on certain high grounds there are large loose boulders, which have probably been moved to their present positions by means of land ice or glaciers.

The Boulder-clay not only presents, as above stated, indications of successive beds, but it occasionally contains surfaces on which lie large boulders striated and polished on the upper surface, in the manner of the pavements of boulders described by Miller, as occurring in the Till of Scotland. These appearances are, however, rare, and few opportunities occur for observing them.

A very general and important appearance is the polishing and striation of the underlying rocks usually to be observed under the Boulder-clay, and which is undoubtedly of the same character with that observed under Alpine glaciers. This continental striation or grooving is obviously the effect of the action of ice, and its direction marks the course in which the abrading agent travelled. This direction has been ascertained by the Canadian and United States Surveys, and by local observers, over a large part of Eastern America, and it presents some broad features well deserving attention. A valuable table of the direction of this striation is given in the Geology of Canada, which I may take as a basis for my remarks, adding to it a few local observations of my own.* The table embraces one hundred and forty five observations, extending along the valleys of the St. Lawrence and the Ottawa and the borders of the great lakes. In all of these the direction is south, with an inclination to the West and East, or to state the case more precisely, there are two sets of striae, a South-west set and a South-east set. In the table eighty-four are westward of South and fifty-eight are eastward of South, three being due South. It further appears, when we mark the localities on the map, that in the valley of the St. Lawrence and the rising grounds bounding it, the prevailing course is South-west, and this is also the prevalent direction in Western New York, and behind the great Laurentide chain on the North side of Lake Huron. Crossing this striation nearly at right angles, is a second set, which occurs in the neck of land between Georgian Bay and Lake Ontario, in the valley of the Ottawa and in the hilly districts of the Eastern Townships of the Province of Quebec, where it is connected with a similar striation which is prevalent in the valleys of Lake Champlain and the Connecticut River and elsewhere in New England. In New England this striation is said to have been observed on hills 4800 feet high, as for example on Mansfield Mountain, where according to Hitchcock there are striae bearing S. 30° E. at an elevation of 4848 feet. In Nova Scotia and New Brunswick, as

* See also, for the Western districts, Whittlesey's Memoir in the Smithsonian Contributions, and Newberry's Report on Ohio.

in New England, the prevailing direction is South Eastward, though there are also South-west and South striation, and a few cases where the direction is nearly East and West.

It is obvious that such striation must have resulted from the action of a solid mass or masses of ice bearing for a long time on the surface and abrading it by means of stones and sand. It is further obvious that the different sets of striation could scarcely have been produced at the same time, especially when, as is not infrequent, we have two sets nearly at right angles to each other in the same locality. Hence it becomes an important question to ascertain the relative ages of the striation and also the direction in which the abrading force moved.

Taking the valley of the St. Lawrence in the first instance, the crag-and-tail forms of the isolated hills of trap, like the Montreal mountain, with abrupt escarpments to the north-east and slopes of debris to the south-west, the quantity of boulders carried from them far to the south-west, and the prevailing striation in the same direction, all point to a general movement of detritus up the St. Lawrence valley to the south-west. Further, in some cases the striae themselves show the direction of the abrading force. For example, in a fine exposure recently made at the Mile-end quarries, near Montreal, the polished and grooved surface of the limestone shows four sets of striae. The principal ones have the direction of S. 68° W. and S. 60° W respectively, and the second of these sets is the stronger and coarser, and sometimes obliterates the first. The two other sets are comparatively few and feeble striae, one set running nearly N. and S., and the other N.W. and S.E. These last are probably newer than the two first sets. Now with regard to the direction of the principal sets of striae, this at the locality in question was rendered very manifest by the occurrence of certain trap dykes crossing the limestone at right angles to the striae. The force, whatever it was, had impinged on these dykes from the N. E., and their S. W. side had protected the softer limestone. The locality is to the North-east of the mass of trap constituting the Montreal mountain, and the movement must have been up the St. Lawrence valley from the N.E., and toward the mountain, but at this particular place the striae point West of its mass. This, I have no hesitation in saying, is the dominant direction in the St. Lawrence valley, and it certainly points to the action of the arctic current passing up the valley in a period of submergence. Further, it is the Boulder-clay connected with this S. W. striation that has hitherto proved most rich in marine shells.

If, however, we pass from the St. Lawrence Valley up the valleys which open into it from the North, as for example the gorge of the Saguenay, the Murray Bay River, or the Ottawa River, we at once find a striation nearly at right angles to the former, or pointing to the South-east.

At the mouth of the Saguenay, near Moulin Bode, are striae and grooves on a magnificent scale, some of the latter being ten feet wide and four feet deep, cut into hard gneiss. Their course is N. 10° W. to N. 20° W. magnetic, or N. 30° to 40° W. when referred to the true meridian. In the same region, on hills 300 feet high, are roches moutonnees with their smoothest faces pointing in the same direction, or to the North-west. This direction is that of the valley or gorge of the Saguenay, which enters nearly at right angles the valley of the St. Lawrence. At the month of the Saguenay the Lark Shoals constitute a mass of debris and boulders, both inside and outside of which is very deep water; and many of the fragments of stone on these shoals must have been carried down the Saguenay more than fifty miles.

In like manner at Murray Bay there are striae on the Silurian limestones near Point au Pique, which run about N. 45° W. but these are crossed by another set having a course S. 30° W., so that we have here two sets of markings, the one pointing upwards along the deep valley of Murray Bay River to the Laurentide Hills inland, the other following the general trend of the St. Lawrence valley. The Boulder-clay which rests on these striated surfaces is a dark-coloured Till, full of Laurentian boulders, and holding *Leda truncata*, and also Bryozoa clinging to some of the boulders. In ascending the Murray Bay River, we find these boulder-beds surmounted by very thick stratified clays, with marine shells, which extend upward to an elevation of about 800 feet, when they give place to loose boulders and unstratified drift. About this elevation, the laminated clays meet a ridge of drift like a moraine, crossing the valley, which forms the barrier of a small lake, Petite Lac, and a second similar barrier separates this from Grand Lac. If the valley of Murray Bay River was occupied with a glacier descending from the Laurentian hills inland, which are probably here 3000 to 4000 feet high, this glacier or large detached masses pushed from its foot, must have at one time extended quite to the border of the St. Lawrence, and at another must have terminated at the borders of the two lakes above mentioned.

On a still larger scale the N. W. and S. E. striation appears in the valley of the Ottawa, and farther west between the head of Lake Ontario and Lake Huron. In these places there is no elevation capable of giving rise to local glaciers, and therefore, as in New England and Nova Scotia, we must ascribe the glaciation either to general ice-laden currents from the North-west, or to the great continental glacier imagined by some geologists.

A most important observation bearing on this subject appears in the Report of Mr. R. Bell, in the region of Lake Nipigon, North of Lake Superior. He observed there the prevailing South-west striation, but with a more westerly trend than usual. Crossing this, however, there was a southerly and S. E. set of striae which were observed to be older than the South-west striae. In some other parts of Canada these striae seem to be newer than the others, but there would be nothing improbable in their occuring both at the beginning and end of the Boulder-clay period.

In summing up this subject, I think it may be affirmed that when the striation and transfer of materials have obviously been from N.E. to S.W., in the direction of the Arctic current, and more especially when marine remains occur in the drift, we may infer that floating ice and marine currents have been the efficient agents. Where the striation has a local character, depending upon existing mountains and valleys, we may on the other hand infer the action of land ice. For many minor effects of striation, and of heaping up of moraine-like ridges, we may refer to the presence of lake or coast ice as the land was rising or subsiding. This we now see producing such effects, and I think it has not been sufficiently taken into the account.

As to the St. Lawrence valley, it is evident that its condition during the deposit of the Boulder-clay must have been that of a part of a wide sound or inland sea extending across the continent, and that local glaciers may have descended into it from the high lands on the north and possibly also on the south. During this state of the valley great quantities of boulders were bronght down into it, especially from the Laurentide hills, and were drifted along the valley, principally to the south-west. Extensive erosion also took place by the combined action of frost, rain, melting snows, and the arctic current and the waves, and thus was furnished the finer material of the Boulder-clay.

It is further to be observed that oscillations of land must be taken into account in explaining these phenomena. Elevations increasing the height and area of land might increase the space occupied by snow and land ice. Depressions, on the other hand, would bring larger areas under the influence of water-borne ice and marine deposits, and these might take place either in a shallow sea loaded with field and coast ice, or in deeper water in which large icebergs might float or ground. There is reason to believe that such alternations were not infrequent in the Post-pliocene, and that their occurrence will explain many of the complexities of these deposits.

If we adopt the iceberg hypothesis, we must be prepared to consider in connection with this subject a subsidence so great as to place the Laurentides and all but the highest summits of the Appalachians under water. In this case a vast volume of Arctic ice and water would pour over the country of the great lakes to the S.W., while any obstruction occurring to the south would throw lateral currents over the Appalachians to the eastward. If we adopt the glacier hypothesis, we may on the other hand imagine a great movement of land ice to the S.W., westward of the Appalachians, and a separate outward movement eastward from these hills and down the Atlantic slope of America. On either hypothesis there are difficulties in accounting for some sets of striae, but on that last-mentioned I believe them to be insuperable.

It is evident from the descriptions of Smith, Geikie, Jameson, Crosskey, and others, that the Boulder-clay of Scotland and Scandinavia corresponds precisely in character with that of Canada, and there, as in America, the theory of a continental glacier has been resorted to for its explanation. The objections to this hpyothesis are very ably stated by Mr. Milne Home in a paper on the "Boulder-clay of Europe," in the Transactions of the Royal Society of Edinburgh, 1869.

To this period and these causes must also be assigned the excavation of the basins of the great American lakes. These have been cut out of the softer members of the Silurian and Devonian Formations; but the mode of this excavation has been regarded as very mysterious; and like other mysteries has been referred to glaciers. Its real cause was obviously the flowing of cold currents over the American land during its submergence. The lake-basins are thus of the same nature with the deep hollows intervening between the banks cast up by the Arctic currents on the present American coast, and like those deep channels of the Arctic current in the Atlantic recently explored by Dr. Carpenter. Their arrangement geographically as well as their geological relations, correspond with this view.

Another consideration with regard to the great lakes deserves notice. Dr. Newberry has collected many facts to show that the lake basins are connected with one another and with the sea by deep channels now filled up with drift deposits. It is therefore possible that much of the erosion of these basins may have occurred before the advent of the glacial period, in the Pliocene age, when the American continent was at a higher level than at present. Dr. Newberry has given in the Report in the Geology of Ohio a large collection of facts ascertained by boring or otherwise, which go far to show that were the old channels cleared of drift and the continent slightly elevated, the great lakes would be drained into each other and into the ocean by the valleys of the Hudson and the Mississippi, without any rock cutting, and if the barrier of the Thousand Islands were then somewhat higher, the St. Lawrence valley might have been cut off from the basin of the great lakes.

I shall close the discussion of this subject by quoting from one of the papers above referred to, my views in 1864; reserving, however, some points respecting the present action of floating ice, to which I shall refer in the sequel.

" Our American lake-basins are cut out deeply in the softer strata. Running water on the land would not have done this, for it could have no outlet; nor could this result be effected by breakers. Glaciers could not have effected it; for even if the climatal conditions for these were admitted, there is no height of land to give them momentum. But if we suppose the land submerged so that the Arctic current, flowing from the northeast, should pour over the Laurentian rocks on the north side of Lake Superior and Lake Huron, it would necessarily cut out of the softer Silurian strata just such basins, drifting their materials to the southwest. At the same time, the lower strata of the current would be powerfully determined through the strait between the Adirondac and Laurentide hills, and, flowing over the ridge of hard rock which connects them at the Thousand Islands, would cut out the long basin of Lake Ontario, heaping up at the same time in the lee of the Laurentian ridge, the great mass of boulder-clay which intervenes between Lake Ontario and Georgian Bay. Lake Erie may have been cut by the flow of the upper layers of water over the Middle Silurian escarpment; and Lake Michigan, though less closely connected with the direction of the current, is, like the others, due to the action of a continuous eroding force on rocks of unequal hardness."

"The predominant southwest striation, and the cutting of the upper lakes, demand an outlet to the west for the Arctic current. But both during depression and elevation of the land, there must have been a time when this outlet was obstructed, and when the lower levels of New York, New England, and Canada were still under water. Then the valley of the Ottawa, that of the Mohawk, and the low country between Lakes Ontario and Huron, and the valleys of Lake Champlain and the Connecticut, would be straits or arms of the sea, and the current, obstructed in its direct flow, would set principally along these, and act on the rocks in north and south and northwest and southeast directions. To this portion of the process I would attribute the northwest and southeast striation. It is true that this view does not account for the southeast striæ observed on some high peaks in New England; but it must be observed that even at the time of greatest depression, the Arctic current would cling to the northern land, or be thrown so rapidly to the west that its direct action might not reach such summits."

"Nor would I exclude altogether the action of glaciers in eastern America, though I must dissent from any view which would assign to them the principal agency in our glacial phenomena. under a condition of the continent in which only its higher peaks were above the water, the air would be so moist, and the temperature so low, that permanent ice may have clung about mountains in the temperate latitudes. The striation itself shows that there must have been extensive glaciers as now in the extreme Arctic regions. Yet I think that most of the alleged instances must be founded on error, and that old sea-beaches have been mistaken for moraines. Even in the White Mountains the action of the ocean-breakers is more manifest than that of ice almost to their summits; and though I have observed in Canada and Nova Scotia many old sea-beaches, gravel-ridges, and lake-margins, I have seen nothing that could fairly be regarded as the work of glaciers. The so-called moraines, in so far as my observation extends, are more probably shingle beaches and bars, old coast-lines loaded with boulders, or "ozars." Most of them convey to my mind the impression of ice-action along a slowly subsiding coast, forming successive deposits of stones in the shallow water, and burying them in clay and smaller stones as the depth increased. These deposits were again modified during emergence, when the old ridges were sometimes bared by denudation, and new ones heaped up."

"I conclude these remarks with a mere reference to the alleged prevalence of lake-basins and fiords in high northern latitudes, as connected with glacial action. In reasoning on this, it seems to be overlooked that the prevalence of disturbed and metamorphic rocks over wide areas in the north is one element in the matter. Again, cold Arctic currents are the cutters of basins, not the warm surface-currents. Further, the fiords on coasts, like the deep lateral valleys of mountains, are evidences of the action of the waves rather than of that of ice. I am sure that this is the case with the numerous indentations of the coast of Nova Scotia, which are cut into the softer and more shattered bands of rock, and show, in raised beaches and gravel ridges like those of the present coast, the levels of the sea at the time of their formation."

## 2. *The Leda Clay.*

This deposit constitutes the subsoil over a large portion of the great plain of Lower Canada, varying in thickness from a few feet to 50 or perhaps even 100 feet in thickness, and usually resting on the Boulder clay, into which it sometimes appears to graduate, the material of the Leda clay being of the same nature with the finer portion of the paste of the Boulder clay. Its name is derived from the presence in it of shells of *Leda truncata*, often to the exclusion of other fossils, and usually in a perfect state with both valves united.

The Leda clay in its recent state is usually gray in colour, unctuous, and slightly calcareous. Some beds, however, are of a reddish hue; and in thick sections recently cut, it can be seen to present layers of different shades and occasional thin sandy bands, as well as layers studded with small stones. It sometimes holds hard calcareous concretions, which, as at Green's creek on the Ottawa, are occasionally richly fossiliferous, but more usually are destitute of fossil remains. When dried, the Leda clay becomes of stony hardness, and when burned it assumes a brick-red colour. When dried and levigated it nearly always affords some foraminifera and shells of ostracoids; and in this as well as in its colour and texture, it closely resembles the blue mud now in process of deposition in the deeper parts of the Gulf of St. Lawrence.

The lamination of the Leda clay and its included sand layers, show that it was deposited at intervals, between which intervened spaces when currents carried small quantities of sand over the surface. In these intervals shells as well as sand were washed over the bottom, while ordinarily Leda, Nucula and Astarte burrowed in the clay itself. The layers and patches of stones I attribute to deposit from floating ice, and to the same cause must be attributed the large Laurentian boulders, occasionally though rarely seen imbedded in the clay.

The material of the Leda clay has been derived mainly from the waste of the lower Silurian shales of the Quebec and Utica groups, which occupy a great space in the basin of the Gulf and River St. Lawrence. The driftage of this material has been to the South-west, and in that direction it becomes thinner and finer in texture. The supply of this mud, under the action of the waves, of streams, of the arctic currents and tidal currents, and floating ice, must have been constant, as it now is in the Gulf and River St. Lawrence. It would be increased by the melting of the snows in spring and by any oscillations of level, and it is probably in these ways that we should account for the alternations of layers in the deposit.

The modern deposit in the Gulf of St. Lawrence, the chemical characters and coloration of which I explained many years ago,* shows us that the Leda clay when in suspension was probably reddish or brown mud tinted with peroxide of iron, like that which we now see in the lower St. Lawrence; but like the modern mud, so soon as deposited in the bottom, the ferruginous colouring matter would in ordinary circumstances be deoxidised by organic substances, and reduced to the condition of sulphide or carbonate of the protoxide. This colour, owing to its impermeability, it still retains when elevated out of the sea; but when heated in presence of air, or exposed for some time at the surface, it becomes red or brown. The occasional layers of reddish Leda clay indicate places or times when the supply of organic matter was insufficient to deoxidise the iron present in the mass.

The greater part of the Leda clay was probably deposited in water of from twenty to one hundred fathoms in depth, corres-

* Journal of Geological Society of London, vol. v. pp. 25 to 30.

ponding to the ordinary depths of the present Gulf of St. Lawrence; and as we shall find, this view is confirmed by the prevalent fossils contained in it, more especially the Foraminifera. The most abundant of these in the Leda clay is *Polystomella striato-punctata* var. *arctica*, which is now most abundant at about twenty-five to thirty fathoms. Since, however, the shallow-water marine Post-pliocene beds extend upwards in some places to a height of six hundred feet on the hills on the north side of the St. Lawrence, it is probable that deposits of Leda clay contemporaneous with these high-level marine beds were formed in the lower parts of the plain at depths exceeding one hundred fathoms.

The Western limits of the Leda clay appear to occur where the Laurentian ridge of the Thousand Islands crosses the St. Lawrence, and where the same ancient rocks cross the Ottawa; and in general the Leda clay may be said to be limited to the lower Silurian plain and not to mount up the Laurentian and metamorphic hills bounding it. Since, however, the level of the water, as indicated by the Terraces in Lower Canada, and by the probable depth at which the Leda clay was deposited, would carry the sea level far beyond the limits above indicated, and even to the base of the Niagara escarpment, we must suppose, either—(1) that the supply of this sediment failed toward the west; or (2) that it has been removed by denudation or worked over again by the fresh waters so as to lose its marine fossils; or (3) that the relative levels of the Western and Eastern parts of Canada were different from those at present. As already stated there are indications that the first may be an element in the cause. The second is no doubt true of the clays which lie in the immediate vicinity of the lake basins. There are, as yet no certain evidences of the third; but the facts previously stated on the authority of Dr. Newberry, lend it some countenance; and detailed surveys of the Terraces and raised beaches would be required to determine it. I believe, however, that much more rigorous investigations of the clays of Western Canada are required before we can certainly affirm that none of them are marine.

I believe the Leda clays throughout Canada to constitute in the main one contemporaneous formation. Of course, however, it must be admitted that the deposit at the higher levels may have ceased and been laid dry while it was still going on at lower levels nearer the sea, just as a similar deposit still continues in the Gulf of St. Lawrence. On the whole, then, while we regard this as one bed stratigraphically, we may be prepared to find that in the lower levels the upper layers of it may be somewhat more modern than those portions of the deposit occurring on higher ground and farther from the sea.

Where the Leda clay rests on marine Boulder-clay, the change of the deposits implies a diminution of ice-transport relatively to deposition of fine sediment from water; and with this more favourable circumstances for marine animals. This may have arisen from geographical changes diminishing the supply of ice from local glaciers, or obstructing the access of heavy icebergs from the Arctic regions. At the present time, for example, the action of the heaviest bergs is limited to the outer coasts of Labrador and Newfoundland, and a deposit resembling the Leda clay is forming in the Gulf of St. Lawrence; but a subsidence which would determine the Arctic current and the trains of heavy bergs into the Gulf, would bring with it the conditions for the formation of a Boulder-clay, more especially if there were glaciers on the Laurentide hills to the north. Where the Leda clay rests on Boulder-clay, which may be supposed to be of terrestrial origin, subsidence is of course implied; and it is interesting to observe that the conditions thus required are the reverse of each other. In other words, elevation of land or sea bottom would be required to enable Leda clay to take the place of marine Boulder-clay, but depression of the land would be necessary to enable Leda clay to replace the moraine of a glacier. I cannot say, however, that I know any case in Canada where I can certainly affirm that this last change has occurred; though on the north shore of the St. Lawrence there are cases in which the Leda clay rests directly on striated surfaces which might be attributed to glaciers; just as in the West the Erie clay occupies this position.

### 3. *The Saxicava Sand.*

When this deposit rests upon the Leda clay, as is not unfrequently the case, the contact may be of either of two kinds. In some instances the surface of the clay has experienced much denudation, being cut into deep trenches, and the sand rests abruptly upon it. In other cases there is a transition from one deposit to the other, the clay becoming sandy and gradually passing upwards into pure sand. In this last case the lower part of the sand at its junction with the clay is often very rich in fossils, showing that after the deposition of the clay a time of quiescence supervened with favourable conditions for the existence of marine animals, before the sand was deposited. It is usually, indeed, in this position that the greater part of the shells of our Post-pliocene beds occur; the Saxicava sand being generally somewhat barren, or containing only a few shallow-water species, while the Leda clay is usually also somewhat scantily supplied with shells, except toward its upper layers. Hence it is somewhat difficult to refer a large part of the shells to either deposit, I have however usually regarded the richly fossiliferous deposit as belonging to the Leda clay; and where, as sometimes happens, the clay itself is absent and merely a thin layer rich in fossils separates the Saxicava sand from the Boulder-clay, I have regarded this layer as the representative of the Leda clay.

The Saxicava sand, in typical localities, consists of yellow or brownish quartzose sand, derived probably from the waste of the Potsdam sandstone and Laurentian gneiss, and stratified. It often contains layers of gravel, and sometimes is represented altogether by coarse gravels. It is somewhat irregular in its distribution, forming banks and mounds, partly no doubt in consequence of original irregularities of deposit, and partly from subsequent denudation. In some outlying localities it is liable to be confounded with the modern river sands and gravels. Large travelled boulders often occur in it; but it rarely contains glaciated stones, the stones and pebbles seen in it being usually well rounded.

From the nature of the Saxicava sand, it is obvious that it must be a shallow water deposit, belonging to the period of emergence of the land; and it must have been originally a marginal and bank deposit, depending much for its distribution on the movement of tides and currents. In some instances, as at Cote des Neiges, near Montreal, and on the Terraces on the Lower St. Lawrence, it is obviously merely a shore sand and gravel, like that of the modern beach. Ridges of Saxicava sand and gravel have often been mistaken for moraines of glaciers; but they can generally be distinguished by their stratified character and the occasional presence of animal remains, as well as by the water-worn rather than glaciated appearance of their stones and pebbles.

The Saxicava sand sometimes rests on the Leda clay or Boulder-clay and sometimes directly on the rock, and the latter is often striated below this deposit; but in this case there is generally reason to believe that Boulder-clay has been removed by denudation.

### 4. *Terraces and Inland Sea Cliffs.*

These are closely connected with the deposits last mentioned, inasmuch as they have been formed by the same recession of the sea which produced the Saxicava sand. At Montreal, where the isolated mass of trap flanked with Lower Silurian beds, constituting Mount Royal, forms a great tide-guage for the recession of the Post-pliocene sea, there are four principal sea margins with several others less distinctly marked. The lowest of these, at a level of about 120 feet above the level of the sea at Lake St. Peter, may be considered to correspond with the general level of the great plain of Leda clay in this part of Canada. On this Terrace in many places the Saxicava sand forms the surface, and the Leda and Boulder-clay may be seen beneath it. This may be called at Montreal the Sherbrooke Street Terrace. Another, the Water-work Terrace, is about 220 feet high, and is marked by an indentation on the Lower Silurian limestone. At this level some Boulder-clay appears, and in places the calcareous shales are decomposed to a great depth, evidencing long sub-aerial action. Three other Terraces occur at heights of 386, 440, and 470 feet, and the latter has, at one place above the village of Cote des Neiges, a beach of sand and gravel with Saxicava and other shells. Even on the top of the Mountain, at a height of about 700 feet, large travelled Laurentian boulders occur. On the Lower St. Lawrence, below Quebec, the series of Terraces is generally very distinctly marked, and for the most part the lower ones are cut into the Boulder and Leda clays, which are here of great thickness. I give below rough measurements of the series as they occur at Les Eboulements, Little Mal Bay and Murray Bay, where they are very well displayed. I may remark in general with respect to these Terraces, that the physical conditions at the time when they were cut must have been much the same with those which exist at present, the appearances presented being very similar to those which would occur were the present beach to be elevated.

### TERRACES LOWER ST. LAWRENCE.

*Heights in English feet, roughly taken with Locke's Level and Aneroid.*

| Les Eboulements. | Petite Mal Bay. | Murray Bay. |
|---|---|---|
| 900 | | |
| 660 | 748 | |
| 479 | 505 | 448 |
| | | 378 |
| 325 | 318 | 312 |
| 226 | 239 | 281 |
| | | 139 |
| 116 | 145 | 116 |
| | | 81 |
| 22 | 26 | 30 |

With reference to the differences in the above heights, it is to be observed that the Terraces themselves slope somewhat, and are uneven, and that the principal Terraces are sometimes complicated by minor ones dividing them into little steps. It is thus somewhat difficult to obtain accurate measurements. There seems, however, to be a general agreement of these Terraces, and this I have no doubt will be found to prevail very extensively throughout the Lower St. Lawrence. It will be seen that three of the principal Terraces at Montreal correspond with three of those at Murray Bay; and the following facts as to other parts of Canada, gleaned from the Reports of the Survey and from my own observations, will serve farther to illustrate this:

| | | | |
|---|---|---|---|
| Kemptville, sand and littoral shells, | | 250 | feet. |
| Winchester, | do. | 300 | " |
| Kenyon, | do. | 270 | " |
| Lochiel, | do. | 264 & 290 | " |
| Hobbes' Falls, Fitzroy, | do. | 350 | " |
| Dulham Mills, De L'Isle, | do. | 289 | " |
| Upton, | | 257 | " |

The evidence of sea action on many of these beaches, and the accumulation of shells on others, point to a somewhat long residence of the sea at several of the levels, and to the intermittent elevation of the land. On the wider Terraces, at several levels it is usual to see a deposit of sand and gravel corresponding to the Saxicava sand.

In the following table I have endeavoured to represent to the eye the facts observed in the internal plain of the great Lakes, and in the marginal area of the Atlantic slope, with the mode of accounting for them on the rival theories of glacier ice and floating ice.

TABULAR VIEWS OF GLACIAL DEPOSITS AND THEORIES.

| *Facts observed.* | | *Theoretical Views.* | |
|---|---|---|---|
| INLAND PLAINS. | MARGINAL AREAS. | GLACIER THEORIES | FLOATING-ICE THEORIES. |
| Terraces. | Terraces and raised beaches. | Emergence of modern Land. | |
| Travelled boulders and glaciated stones and rocks. Stratified sand and gravel. (Algoma sand, &c.) | Sand and gravel, with sea shells and boulders. (Saxicava sand). | Shallow Seas and Floating Ice. | |
| Stratified clay with drift-wood, and a few stones and boulders. (Erie clay.) | Stratified clay with sea shells. (Leda clay). | Deep water with Floating Ice. | |
| | Clay and boulders with or without sea shells. (Boulder-clay). | Submergence of the land. | Much floating ice and local glaciers. |
| Striated rocks. | Striated rocks. | Great continental mantle of Ice. | Submergence of Pliocene land. |
| Old channels, indicating a higher level of the land. | Old channels indicating previous dry land. | Erosion by continental glaciers. | Erosion by atmospheric agencies, & accumulation of decomposed rock. |

It will be observed that the theoretical views diverge with respect mainly to the Boulder-clay and the striation under the Erie clay, and to the cause of the erosion of valleys in the Pliocene land. I would merely remark, in addition to the considerations already advanced, that the occurrence of drift-wood in the Erie clay, and of sea shells in the Boulder-clay, are both most serious objections to the glacier hypothesis, reserving for the sequel a more full discussion of the rival theories.

While the marginal marine area strictly corresponds to the marginal areas of Europe, I have no distinct evidence that the internal plains and table lands of the old continent correspond in their formations to the internal lake area of America.

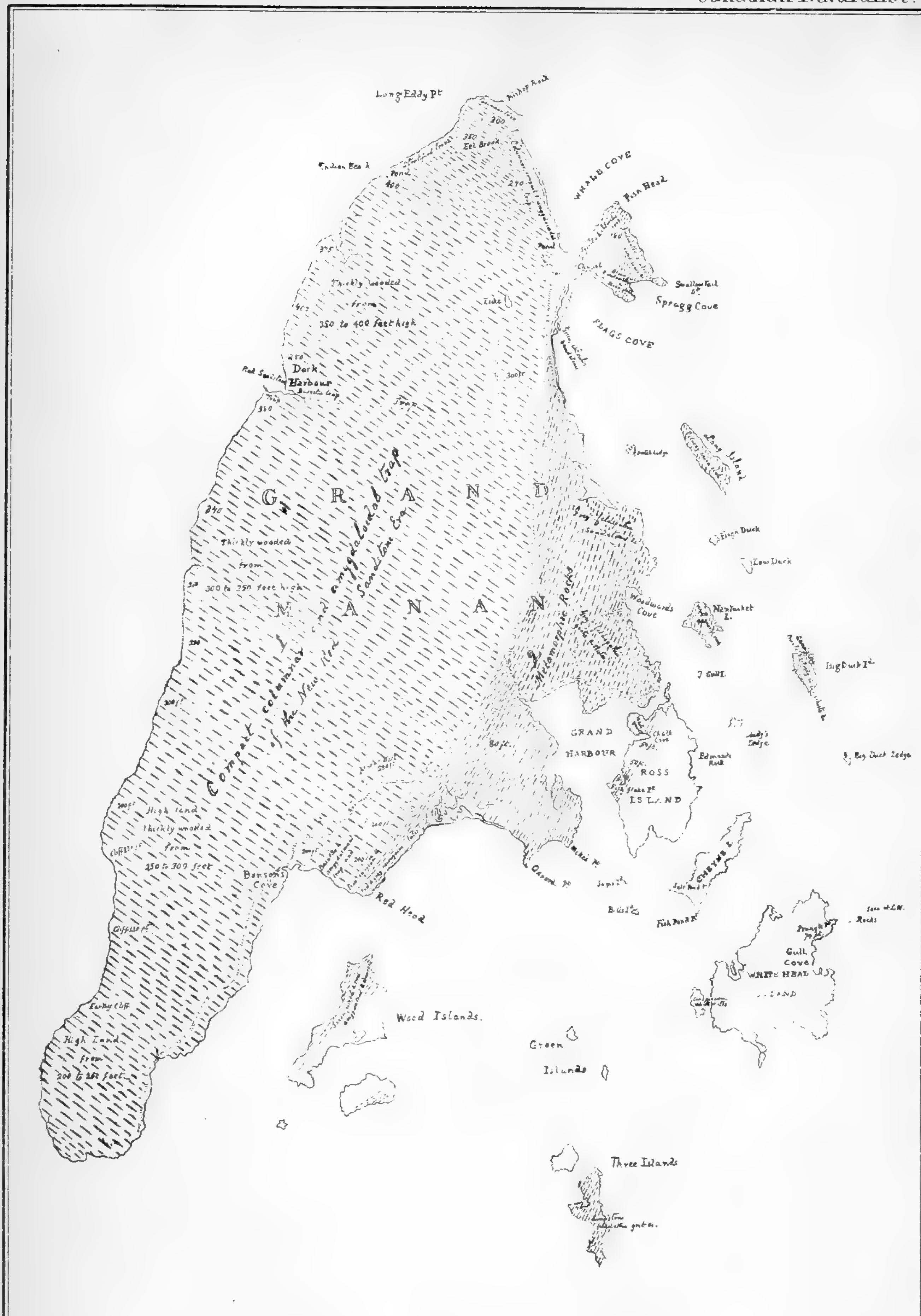
An interesting fact with reference to the Erie clay, stated in the Report of the Survey of Canada is, that these clays burn into white brick, while the marine Leda clay burns into red brick. The chemical cause of this I have already referred to, but whether it implies that the inland clays are fresh-water, or only that they have been derived from a different material, is uncertain. The gray clays of the Hudson River series in Western Canada, might, according to Mr. Bell, have afforded such clays.

Under the theory of a glacial sea immediately succeeding the elevated Pliocene land, the great amount of decomposed rocks which must have accumulated upon the latter constitutes an important element in the estimation of the rate of deposit of the Erie and Boulder and Leda clays. It is also to be observed that this glacial sea might have had to scour out of the lake basins of Canada only the soft mud of its own deposition, the rock-excavation having apparently been in great part effected in the previous Pliocene period. On this subject I find that Dr. Sterry Hunt had, before the publication of Dr. Newberry already alluded to,* shown that not only channels but considerable areas about Lakes Erie and St. Clair had been deeply excavated in the palæozoic rocks and filled with Post-pliocene deposits. The Devonian strata, he remarks, "are found in the region under consideration at depths not only far beneath the water level of the adjacent Lakes Erie and St. Clair, but actually below the horizon of the bottom of these shallow lakes." He shows that around these in various localities the solid rocks are only met with at depths of from one to two hundred feet below the level of the lakes, while "the greatest depth of Lake St. Clair is scarcely thirty feet and that of the South-western half of Lake Erie does not exceed sixty or seventy feet, so that it would seem that these present lake basins have been excavated from the Post-pliocene clays, which, in this region, fill a great ancient basin previously hollowed out of the palæozoic rocks, and including in its area the South-western part of the peninsula of Ontario."

It would thus appear that in the Pliocene period the basin of the lakes may have been a great plain with free drainage to the sea. Whether or not it was afterwards occupied by a glacier, this plain and its channels leading to the ocean were filled with clay at the beginning of the Post-pliocene subsidence; and at a later date the mud was again swept out from those places where the Arctic current could most powerfully act on it.

*(To be continued.)*

* On the Geology of South-western Ontario. Am. Jour. Sci. 1868.




GEOLOGICAL MAP
OF
GRAND MANAN
by
Prof. Bailey.

REFERENCES:

Triassic Trap.

Metamorphic Rocks.

LEGGO & Co LITH, MONTREAL

# ON THE PHYSIOGRAPHY AND GEOLOGY OF THE ISLAND OF GRAND MANAN.

By Prof. L. W. Bailey.

The Island of Grand Manan, near the entrance of the Bay of Fundy, though so long and so well-known for its picturesque scenery and from the richness of the surrounding waters as a fishing-ground for marine invertebrates, has received comparatively little attention at the hands of the geologist. Statements bearing more or less directly upon its geological structure have indeed appeared from time to time, but since the date of Dr. Gesner's first exploration of the island (in 1838) no examinations with a special view to the determination of that structure have been made until quite recently. The most discordant views have in consequence been entertained with reference to the age of its rock formations. A visit, of some four days duration, made during the summer of 1870, in pursuance of duties connected with the Geological Survey of Canada, having enabled me to examine a considerable portion of the island and to compare its rocks with those recognized upon the main-land of New Brunswick, I propose to give here some of the conclusions at which I have arrived.

The general form of the island of Grand Manan is that of an irregular elongated oval, of which the greater diameter is about fifteen and the shorter about seven miles. Its surface, for purposes of description, may conveniently be divided into two distinct regions, contrasted equally in their physical and in their geological features. Of these the westerly and more extensive tract, embracing more than two-thirds of the main island, has the character of a somewhat elevated plateau, traversed in a direction parallel to its length by a series of minor ridges and depressions, and exposing upon the western shore, which is remarkably uniform and entirely free from islands, a series of bold bluffs, varying from two to four hundred feet in elevation.* This plateau is for the most part well wooded (with birch, maple, beech, &c.,)

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* Among flowering plants observed on the island (August 22nd) were *Asters* and *Solidagots* of several species, *Scutellaria galericulata*, *Potentilla fruticosa*, *Campanula rotundifolia*, *Epilobium angustifolium*, *Sedum rhodiola*, &c.

except near the surfaces of exposed cliffs or upon rocky ledges which are often densely covered with a low growth of Juniper (Juniperus.)

The descent from this plateau to the lower lands which form the eastern side of the island, though less abrupt than that just alluded to, is nevertheless everywhere well defined, much of the last named region, including nearly all the settled portions of the island, being commonly not above a height of twenty or thirty feet above tide-level, and often much less.* This side of the island is further contrasted with that which forms its western half in its great irregularity of outline and in the numerous islands, of greater or less size, by which it is bordered. The many harbours which indent this shore afford a safe refuge to those engaged in the pursuit of fishing, an occupation to which the inhabitants of the island are almost solely devoted.

The first published observations on the geology of Grand Manan are those of Dr. Gesner, who in his first report to the legislature of New Brunswick (1838) describes at some length its general topographical and mineralogical features. The two regions above contrasted were recognized, and described as consisting, the one of trap and the other of slates (talcose, hornblendic and chloritic) and quartz rock, intersected by trappean dykes; but beyond an allusion to the resemblance of the first named rocks in general aspect and in the contained minerals to those of Blomidon in Nova Scotia, no attempt at determining the age of either of these formations was made. In the geological map of Dr. Robb, which was for the most part based upon the observations of Dr. Gesner, the belt of rocks last mentioned is simply indicated as trappean, while those of the eastern coast are colored as of Cambrian age. From this time until the appearance of the second edition of the Acadian Geology of Dr. Dawson, no published references to the geology of Grand Manan appear to have been made. In an Appendix, however, to the last named work a summary of some observations bearing upon this subject is given by Prof. A. E. Verrill, who, though visiting the island chiefly for zoological purposes, had at the same time been able to devote some attention to its geological structure. The formations

* An exception to this low and level character occurs at the north-eastern end of the island, where the large peninsula separating Whale Cove and Flag's Cove is somewhat high and broken.

distinguished by Prof. Verrill, and described as being unconformable, correspond to the two belts recognized by Dr. Gesner, and to which allusion has already been made in describing the physical features of the island. That which forms its eastern side, and which was supposed to be the oldest, was found to consist of talcose and clay slates, mostly grayish, but sometimes black, calcareous grits, altered grey sandstones, the latter by induration sometimes becoming quartzites, or (when impure) imperfect syenites, and at some points black fissile carbonaceous shales;—the series, as a whole, being highly altered and disturbed, with numerous immense dykes and masses of trap. The sandstones in one case are described as containing vegetable traces. These rocks were found to occupy not only the belt of low land skirting the eastern border of the main island, but also (as far as examined) the adjacent islands, excepting Inner Wood Island, composed in part of conglomerates and red sandstones, possibly of more recent origin, and the outer of the Three Islands, wherein were found beds of crystalline limestone.* The second series, embracing the trappean belt which forms the western side and the major portion of the main island, is described by Prof. Verrill as consisting of thick-bedded, regularly stratified massive rocks of various composition, but mostly amygdaloidal, trap ash, and compact quartzose rocks, the beds being in some places nearly horizontal, and in others dipping to the W. or S. W. $>$ 10° to 20°. The traps at some points were found to be columnar, while from the cavities of the amygdaloids were obtained calcite, stilbite, apophyllite and other zeolitic minerals. With regard to the age of the two formations thus distinguished, Prof. Verrill makes no reference to that of the former beyond the statement that it is apparently the older of the two, but offers the conjecture that the latter, judging from the *appearance* of the rocks alone, may be of Devonian age.

In commenting on these observations the author of the Acadian Geology thinks it probable that the outer and older series above mentioned may be either the equivalent of the St. John group (Primordial) or of the Kingston series (at that time supposed to be of Upper Silurian age), and that the traps, with some associated sandstones, might be Devonian or Upper Silurian. In the geological map accompanying this work these formations are re-

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* Observed also by Dr. Gesner.

presented in accordance with one of these conjectures, the one as of Lower and the other as of Upper Silurian age.

That the great belt of trappean rocks which form so marked a feature both in the physical structure and in the geology of Grand Manan, is of much more recent date than is supposed in the above observations, will, I think, with a full knowledge of the facts, scarcely admit of doubt. After a careful examination of a considerable part of their area, both as exposed in the shore cliffs and over the interior, I have no hesitation in re-affirming the comparison, long since made by Dr. Gesner, between these rocks and those of the North Mountains of Nova Scotia. So far as I have had an opportunity of examining the latter, their resemblance to those of Grand Manan is very striking, as well in their composition as in their general aspect, while both are quite unlike anything met with among the older recognized formations of New Brunswick. These traps at Grand Manan, though largely stratified, have evidently come up through the older metamorphic rocks of the island (which are at some points, as at the Swallow Tail Light, intersected by large dykes of exactly similar character), and were probably contemporaneous with the similar outflows at Blomidon and elsewhere, but whether the period of this eruption is to be assigned to the Triassic or to a still more recent epoch, is as yet undetermined. As tending to confirm the view of the Mesozoic age of these rocks, I was fortunate in being able to examine *in situ* the sandstones referred to, but not seen by Prof. Verrill, as sometimes occurring with them. These are rarely met with, (at least in that part of the island visited by me) being exceedingly soft and easily worn away except where protected by overlying masses of harder trap. They may, however, be seen near the entrance of Dark Harbor, the principal and almost the only break in the continuity of the western shore, and are said to be exposed at other points as well. In their features of softness and incoherence, as well as in their peculiar light red colour, these sandstones resemble very closely those of the Annapolis and Cornwallis valleys in Nova Scotia, or those which, at Quaco and elsewhere on the southern coast of New Brunswick, have been referred to the New Red Sandstone Era.*

* G. F. Matthew—Observations on the Geology of St. John County, N. B. Also, Bailey and Matthew—Observations on the Geology of Southern New Brunswick.

Another feature in which these red sandstones resemble those of the province of Nova Scotia, is to be found in their apparent relations to the associated trap. At Dark Harbor the first named rocks form a low terrace along and below the trappean bluffs, which here form an almost precipitous wall of over four hundred feet, and at their outer edge may be seen to dip towards the latter at an angle of about 20°. The direct superposition of the traps upon the arenaceous beds is not seen at this point, but I am told that further South the line of contact between the two is visible for some distance along the face of the shore-bluffs. *

In reference to the nature and composition of the trappean rocks in question, I have little to add to what has already been stated by Dr. Gesner and Prof. Verrill. The best view to be had of their structure is that furnished in the sea-cliffs which intervene between Whale Cove and Long Eddy Point, constituting what is known as the Northern Head of Grand Manan. Along the western of the first-named indentation, these cliffs, having a maximum elevation of about 240 feet, may be seen to consist of alternating beds, from five to ten in number and varying from ten to twenty feet in thickness, the thicker beds being composed of a hard grey and greenish compact trap, which is sometimes columnar, while the softer intervening beds are amygdaloidal. These amygdaloids vary a good deal in texture as well as in colour, being sometimes fine grained and sometimes coarse, and exhibiting various shades of grey, green, red or purple. Their contained minerals are calcite and the ordinary zeolites, frequently with a considerable admixture of deep green chloritic matter, and more rarely scales of black mica. Native copper is sometimes met with, and considerable masses of this mineral are said to have been found at different times in the superficial drift of the islands. The zeolites are less perfect and in less variety than those of Nova Scotia.

Between the head of Whale Cove and Eel Brook the trappean beds form a low synclinal, distinctly visible at a considerable distance from the shore. Northward of this brook, the stratifica-

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† These red sandstones of Grand Manan in some parts contain considerable quantities of copper ores, which were examined and described by Prof. E. J. Chapman of Toronto in a report with a section, published in 1869. In this he refers the sandstones with their associated traps to the Triassic or New Red Sandstone period.—Eds. Can. Nat.

tion is less evident, the high bluffs of the Northern Head (300 to 350 feet) consisting for the most part of columnar trap; but Westward of this Head the bedding is again seen along the shore from Long Eddy Point to Dark Harbor. In this last named indentation may be seen another fine display of the columnar structure, its northern side being almost entirely built up of well-marked prismatic blocks, from a few inches to a foot or more in diameter, at some points nearly vertical but at others standing out like needles at various inclinations and sometimes (though rarely) horizontal. From Dark Harbor to the Southern head of the island its Western shore has not been examined by me, but is described by Prof. Verrill as consisting of cliffs of trap. (From 200 to 300 feet. Admiralty survey).

The Eastern side of the great trappean plateau, though less regular and abrupt than that last described, is nevertheless well defined throughout the entire length of the island. From the Southern Head to Benson's Cove it fronts the shore, but just East of the latter, near the promontory of Red Head, it is met by the older stratified rocks, which thence form the remainder of the Eastern shore, the line of separation between the two describing a broad curve from Benson's Cove, just in rear of the settlements, to Whale Cove. The greatest breadth of the trappean mass is about the centre of the island, being between four and five miles.

The older rocks of Grand Manan present considerable diversity, and may belong to more than one series. They are everywhere highly disturbed, being thrown into innumerable folds and frequently broken by faults, which render the determination of their true succession somewhat difficult. My stay upon the island was not sufficiently long to enable me to ascertain this order satisfactorily, and I have accordingly, in the following observations, described their features nearly in the order in which they were examined.

Between Whale Cove and Flag's Cove, near the Northern extremity of the island, is a large peninsula, terminating in the promontories of Fish Head and the Swallow Tail. This peninsula (which is considerably more elevated than any other portion of the eastern metamorphic belt) exhibits, as seen in the shore, bluffs between the two headlands last named, features not elsewhere met with in the region under consideration. Towards the promontory of Fish Head these bluffs are composed of hard and very homogeneous compact rocks, of crystalline texture, in some parts approaching a grey syenite and in others becoming greenish by an admixture of chlorite. No very distinct stratification is visible here, but further south, towards the Swallow Tail Light, this is more apparent, the beds becoming at the same time less crystalline and associated with considerable beds of fine grained indurated shales. These beds near the centre of the peninsula exhibit a series of low undulations, but as the last named headland is approached their inclination becomes greater and their dip (to the northward) more uniform. They are here associated with altered gray sandstones and some thin beds of impure limestone, and are traversed by veins of heavy spar, holding small quantities of galena and copper pyrites. Considerable masses of diorite are occasionally met with along this shore, and at one point broad lenticular sheets of fine-grained flesh-red felsite.

In the small indentation known as Spragg's or Pette's Cove, a somewhat abrupt transition in the character of the rocks may be seen, for while the Eastern side of this Cove, forming the promontory of the Swallow-Tail Light, has the uniform grey colour and other features alluded to in the preceding remarks, the Western exhibits a most marked contrast, being conspicuous, even for a considerable distance, from the almost chalky whiteness of its low cliffs. This appearance is due to the peculiar weathering of a thick mass of pale liver-grey micaceous slates, which here form the shore, dipping northward (N. 50° E.) at an angle of 50°. Between these slates and the grey rocks first alluded to, thinner beds of grey micaceous shales and impure pyritiferous dolomites are poorly exposed along the beach, and near its northern side fine-grained fissile black shales. The contact between these two sets of rocks is obscure, but so far as I could judge, they appear to be conformable and to be connected together by intermediate gradations. That those last enumerated form a single series is evident from their frequent alternation, as may be well seen on either shore of the promontory separating Spragg's or Pette's from Flag's Cove. The pale grey unctuous or nacreous slates and black slates are here associated with hard grey somewhat slaty sandstones (including thin layers of black slate) and coarse grey and purplish sandy shales, many of the beds being more or less filled with veins of brown spar or dolomite, and the whole several times repeated by faulting. On that side of the peninsula looking toward's Flag's Cove, some of the finer purplish beds are ribbanded, and exhibit numerous and abrupt corrugations. Their general dip, however, is northward (N. 20° to 30° E.).

The section afforded by the peninsula above described between Whale Cove and Flag's Cove may be taken as affording a fair representation of the whole metamorphic belt of the Eastern shore of Grand Manan, strata similar in their general aspect to those alluded to being met with at various points along the latter as well as in the adjacent islands. With these, however, are some beds but imperfectly represented or altogether wanting in the area first alluded to.

Along the Western side of Flag's Cove the metamorphic belt is greatly reduced in breadth, being confined to a narrow strip along the shore and to a series of ledges mostly covered by the tide. The rocks exposed here are coarse greenish-grey somewhat chloritic sandstones, with strong slaty cleavage, having numerous imbedded nodules of mixed quartz and spar from a quarter of an inch to two inches in length, besides numerous little crystalline spots resembling spathic iron. Beds of precisely similar character may be seen on Big Duck Island several miles to the southward, being here associated with bluish-grey somewhat unctuous feldspathic schists, and pale grey dolomites. There are also upon this island (beneath the first named beds) white-weathering nacreous slates with green and purple shales, the whole porphyritic as above with numerous little rhombohedral crystals, and more or less filled with sparry nodules. The white nacreous slate has been examined by Dr. Sterry Hunt, who finds it to consist of an admixture of silicious matter with a hydrous potash-mica, containing only traces of magnesia and iron. The imbedded crystalline spar is a triple carbonate, consisting of carbonate of iron 39.20, carbonate of magnesia 40.40, carbonate of lime 20.40 = 100.00. These beds have here a breadth of over 100 rods, and rest upon coarse purplish-grey quartzose grits, the general dip being westerly at an angle of about 60°. The whole series is evidently the same as that of Flag's Cove, with which these rocks are connected through those of Long Island.

Along the road connecting Flag's Cove with Woodward's Cove and Grand Harbour the rocks met with are chiefly grey light-weathering felsites and coarse grey feldspathic sandstones and slates, much broken and seamed with quartz, and sometimes becoming true quartzites. Similar rocks form Nantucket Island, near the entrance of the last named Cove, but here the quartzite of a nearly pure white colour, rises into a conspicuous ridge, having a low westerly dip (W. 10° N. > 20°), and a breadth of over one-eighth of a mile.* It rests upon soft dark green shales, and with these extends through the length of the island, reappearing in Gull Rock and in Chalk Cove towards the northern end of Ross Island. This large island, as well as the shore from Woodward's Cove to Grand Harbour, I had not leisure to examine, but in passing around the shore of the last named haven, and thence along the beach to Red Head, was enabled to obtain a fair idea of the structure of the remaining portion of the metamorphic belt.

Along the western side of Grand Harbour the strata exposed to view, near its head, are greenish-grey chloritic and grey feldspathic schists, and grey feldspathic sandstones, with a strong slaty cleavage and variable dip; while nearer its entrance there are with these fine-grained greenish and purplish rocks, containing epidote, and more or less amygdaloidal. A few beds of fine-grained grey felsite, or felsite with an admixture of quartz and chlorite, or talcoid mica, are intercalated with these. The dip here is N. 60 to 70 E. > 30° to 50°. Similar beds, but with a larger proportion of shales, sometimes purple and sometimes dark green with films of chlorite, skirt the shore westward of the entrance of the harbour, forming the promontories of Mike's and Oxnard's Points. A long curving beach, broken at intervals by beds of yellowish-grey slaty felsite, separates this point from a line of low bluffs running out and terminating in the promontory of Red Head. The beds exposed in these bluffs bear much resemblance to some of those described above, as seen upon the shores of Flag's Cove, towards the head of the island. They are grey and bluish-grey (sometimes purple or black) fine-grained beds, conspicuously ribbon-banded and thrown into innumerable sharp corrugations. With these are grey feldspathic sandstones, coated with specular iron, and coarse green chloritic beds, similarly plicated, but having a general northerly dip at an angle of about 30°. Towards the head the finer beds predominate, becoming soft and rubly and conspicuously stained with red oxide

* The quartz rock is here associated with dark grey fissile shales and green chloritic schists, dipping S. 40 W. > 30. It has almost the aspect of a white quartz vein. Similar rocks form conspicuous cliffs on the western side of Whitehead Island but have not been visited by me.

of iron, having evidently suggested the name by which the promontory is known. The latter, as stated in a preceding paragraph, marks the southern limit of the metamorphic belt, the contact of this with the Mesozoic traps being well exposed in a small cove upon its western side. The red slates last described, dipping northward, here meet and are covered by a coarse conglomerate made of dark trap pebbles, which in turn underlies and passes into coarsely columnar trap, these being the first of a succession of such beds forming the northern shore of Benson's Cove.

Several small groups of islands lie to the south and east of the promontory last described. These I have only partially examined, but as they exhibit some features not met with upon the mainland, they may be briefly alluded to here. The first of these groups is that known as the Wood Islands, distinguished as the Inner and Outer Wood Islands. Upon the former the rocks bear much resemblance to those seen along the western side of Grand Harbour, described above. They are rather fine grained rocks, of bright green, red, and purple colours, often diversified with paler bands and blotches, and more or less filled with amygdules of calcite and epidote. These beds are associated with sandstones (and some conglomerates) of deep red and purplish red colours, sometimes finely banded and alternating with thinner beds of pale grey feldspathic schist and impure dolomite. These rocks, with occasional masses of trap, form nearly the whole of the western side of the island, as well as its northern extremity, their dip being somewhat variable, but where most regular, about N. 20 to 60° E. $>$ 40°. The sandstones are at some points very curiously and conspicuously marked by narrow veins (one-fourth of an inch wide) of fibrous calcite or satin spar, which fill short lenticular cavities arranged in parallel and overlapping lines, at right angles to the bedding of the rock.

Outer Wood Island, at the only point seen by me (on its eastern side), is composed of hard greenish-grey silico-feldspathic rocks, with very obscure stratification.

The group of the Three Islands lies to the south and east of that last described, and with the exception of Gannet Rock, on which a light-house is built, is the most southerly of the chain of islands about the entrance of the Bay of Fundy. On the larger island of this group, known as Kent's Island, are beds of crystalline limestone. They are mostly light coloured but mottled with shades of green, grey, or pink, and are rendered impure by a considerable admixture of quartz. The associated rocks are pale grey light weathering feldspathic grits, somewhat granitoid in aspect, grey feldspathic quartzites, and greenish and purplish altered schists, all much broken and disturbed. The other islands in this group I have not examined.

With reference to the age of the metamorphic rocks described above, I can only add to the various conjectures already made by other authors. In doing so, however, I may say that I have had the advantage of being able to compare them directly with the formations of the mainland, and thus of arriving at a more probable estimate of their true position than is likely to be obtained from the mere study of the rocks themselves. Of the recognized formations in New Brunswick, they bear no resemblance to either the Laurentian, Primordial, Upper Silurian, or Carboniferous. They are equally unlike the Devonian rocks, so far as these have been clearly determined on palæontological evidence. They do, however, bear much resemblance to an assemblage of strata met with at various points along the southern coast of the Province as well as in the interior, and to a portion of which a Devonian age has been assigned in earlier publications. The rocks in question, embracing like those of Grand Manan a series of coarse red sediments, grey clay slates, chloritic slates and grits, with some limestones and dolomites, were at some points found to rest upon undoubted Devonian beds, and were for this reason referred to that horizon. It is not yet certain that such is not their age, but a careful study of the district having shewn the existence therein of several great faults and overlaps, it is possible that the beds in question, notwithstanding the superposition referred to, are really much more ancient. If this is the case, there can be no doubt that they are to be looked upon as a subordinate division of the great Huronian series, to the other members of which, as recognized in southern New Brunswick, they bear much resemblance. The metamorphic rocks of Grand Manan have been compared by Dr. Dawson (from Prof. Verrill's description) with what has been termed the Kingston series on the mainland of the Province. They differ from these latter in some respects, but as these Kingston rocks are now also believed to be a subdivision of the Huronian system, (and not Upper Silurian, as at one time supposed) this comparison may be taken as an additional argument in support of the view here advocated.

Prof. Verrill has suggested that possibly more than one group may be represented among the metamorphic rocks of Grand Manan. I also incline to this opinion (more particularly as regards the strata first described between Whale Cove and Pette's Cove as compared with those on the coast and islands southward of the latter,) but think that neither will be found to be more recent than the earliest Primordial Silurian.

The accompanying map is a copy of the Admiralty chart of Grand Manan, slightly modified to show the position and extent of its geological formations.

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## ON THE OIL-BEARING LIMESTONE OF CHICAGO.

By T. Sterry Hunt, LL.D., F.R.S.

(Read before the American Association for the Advancement of Science, at Troy, August, 1870.)

When in 1861,* I first published my views on the petroleum of the West, I expressed the opinion that the true source of it was to be looked for in certain limestone formations which had long been known to be oleiferous. I referred to the early observations of Eaton and Hall on the petroleum of the Niagara limestone, to numerous instances of the occurrence of this substance in the Trenton and Corniferous formations and, in Gaspé, in limestones of Lower Helderberg age. Subsequently, in this Journal for March, 1863, and in the Geology of Canada, I insisted still farther upon the oleiferous character of the Corniferous limestone in south-western Ontario, which appears to be the source of the petroleum found in that region. I may here be permitted to recapitulate some of my reasons for concluding that petroleum is indigenous to these limestones, and for rejecting the contrary opinion, held by some geologists, that its occurrence in them is due to infiltration, and that its origin is to be sought in an unexplained process of distillation from pyroschists or so-called bituminous shales. These occur at three distinct horizons in the New York system, and are known as the Utica slate, immediately above the Trenton limestone, and the Marcellus and Genesee slates which lie above and below the Hamilton shales, the latter being separated from the underlying Corniferous limestone by the Marcellus slate.

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* Montreal Gazette, March 1, and this Journal, July, 1861.

First, these various pyroschists do not, except in rare instances, contain any petroleum or other form of bitumen. Their capability of yielding volatile liquid hydrocarbons or pyrogenous oils, allied in composition to petroleum, by what is known to chemists as destructive distillation, at elevated temperatures, is a property which they possess in common with wood, peat, lignite, coal, and most substances of organic origin, and has led to their being called bituminous, although they are not in any proper sense bituminiferous. The distinction is one which will at once be obvious to all those who are familiar with chemistry, and who know that pyroschists are argillaceous rocks containing in a state of admixture a brownish insoluble and infusible hydrocarbonaceous matter, allied to lignite or to coal.*

Second, the pyroschists of these different formations do not, so far as known, in any part of their geological distribution, whether exposed at the surface or brought up by borings from depths of many hundred feet, present any evidence of having been submitted to the temperature required for the generation of volatile hydrocarbons. On the contrary they still retain the property of yielding such products when exposed to a sufficient heat, at the same time undergoing a charring process by which their brown colour is changed to black. In other words these pyroschists have not yet undergone the process of destructive distillation.

Third, the conditions which the oil occurs in the limestones, are inconsistent with the notion that it has been introduced into these rocks by distillation. The only probable or conceivable source of heat, in the circumstances, being from beneath, the process of distillation would naturally be one of ascension, the more so as the pores of the underlying strata would be filled with water. Such being the case, the petroleum of the Upper Silurian and Lower Devonian limestones must have been derived from the Utica slate beneath. This rock, however, is ualtered, and moreover, the intermediate sandstones and shales of the Loraine, Medina and Clinton formations, are destitute of petroleum, which must, on this hypothesis, have passed through all these strata to condense in the Niagara and Corniferous limestones. More than this, the Trenton limestone which, on Lake Huron and elsewhere, has yielded considerable quantities of petroleum, has no pyroschists beneath it, but on Lake Huron rests on ancient crystalline rocks,

* Silliman's Journal, II, xxxv, 159-161.

with the intervention only of a sterile sandstone. The rock-formations holding petroleum are not only separated from each other by great thicknesses of porous strata destitute of it, but the distribution of this substance is still farther localized, as I many years since pointed out. The petroleum is in fact in many cases, confined to certain bands or layers in the limestone, in which it fills the pores and the cavities of fossil shells and corals, while other portions of the limestone, both above, below, and in the prolongation of the same stratum, though equally porous, contain no petroleum. From all these facts the only reasonable conclusion seems to me to be that the petroleum, or rather the materials from which it has been formed, existed in these limestone rocks from the time of their first deposition. The view which I put forward in 1861, that petroleum and similar bitumen have resulted ftom a peculiar "transformation of vegetable matters, or in some cases of animal tissues analogous to those in composition," has received additional support from the observations of Lesley,* in West Virginia and Kentucky, and from the more recent ones of Peckham.†

The objection to this view of the origin and geological relations of petroleum, have been for the most part founded on incorrect notions of the geological structure of southwestern Ontario, which has afforded me peculiar facilities for studying the question. In this region, it has been maintained by Winchell that the source of the petroleum is to be sought in the Devonian pyroschists. I however showed in 1866, as the result of careful studies of the various borings: first, that none of the oil-wells were sunk in the Genesee slates, but along denuded anticlinals where these rocks have disappeared, and where, except the thin layer of Marcellus slate sometimes met with at the base of the Hamilton shales, no pyroschists are found above the Trenton limestone. Second, that the reservoirs of petroleum in the wells sunk into the Hamilton shales are sometimes met with in this formation, and sometimes, in adjacent borings, only in the underlying Corniferous. Examples of this have been cited by me in wells in Enniskillen, Bothwell, Chatham, and Thamesville, where petroleum has first been found at depths of from thirty to one hundred and twenty feet in the

* Rep. Geol. Canada, 1866, 240; and Proc. Amer. Philos. Soc. x, 33, 187.

† Ibid, x, 445.

Corniferous limestone, in all of these places overlaid by the Hamilton shales. It was also shown, that in two localities in this region, viz. in Tilsonburg and at Maidstone, where the Corniferous is covered only by quaternary clays, petroleum in considerable quantities has been obtained by sinking into the limestone.* That the suppiies are less abundant than in parts where a mass of shales and sandstones overlies the oil bearing limestone is explained by the fact that both the pores and the fissures in the superior strata serve to retain the oil, in a manner analogous to the quaternary gravels in some parts of this region, which are the sources of the so-called surface oil-wells. It is therefore not surprising that examples of pyroschists impregnated with oil should sometimes occur, but the evidence of the existence of indigenous petroleum, which is so clear in the various limestones, is wanting in the case of the pyroschists; although concretions holding petroleum have been observed in the Marcellus and the Genesee slates of New York. There is, however, reason to believe, as I have elsewhere pointed out, that much of the petroleum of Pennsylvania, Ohio and the adjacent regions, is indigenous to certain sandstone strata in the Devonian and Carboniferous rocks.†

At the meeting of the American Association for the Advancement of Science at Chicago, in August, 1868, in a discussion which followed the reading of a paper by myself on the geology of Ontario,‡ it was contended that, although the various limestones which have mentioned are truly oleiferous, the quantity of petroleum which they contain is too inconsiderable to account for the great supplies furnished by oil-producing districts, like that of Ontario for example. This opinion being contrary to that which I had always entertained, I resolved to submit to examination the well-known oil-bearing limestone of Chicago.

This limestone, the quarries of which are in the immediate vicinity of the city, is so filled with petroleum that blocks of it which have been used in buildings are discoloured by the exudations, which mingled with dust, form a tarry coating upon the exposed surfaces. The thickness of the oil-bearing beds, which

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* Silliman's Journal II, xlvi, 360; and Report Geol. Canada. 1866, pp. 241–250.

† Ibid, 240.

‡ Silliman's Jour. II, xlvi, 355.

are massive and horizontal, is, according to Prof. Worthen, from thirty-five to forty feet, and they occupy a position about midway in the Niagara formation, which has in this region a thickness of from 200 to 250 feet. As exposed in the quarry, the whole rock seems pretty uniformly saturated with petroleum, which exudes from the natural joints and the fractured surfaces, and covers small pools of water in the depressions of the quarry. I selected numerous specimens of the rocks from different points and at various levels, with a view of getting an average sample, although it was evident that they had already lost a portion of their original content of petroleum. After lying for more than a year in my laboratory they were submitted to chemical examination. The rock, though porous and discoloured by petroleum, is, when freed from this substance, a nearly white, granular, crystalline and very pure dolomite, yielding 54·6 p. c. of carbonate of lime.

Two separate portions, each made up of fragments obtained by breaking up some pounds of the specimens above mentioned, and supposed to represent an average of the rock exposed in the quarry, were reduced to coarse powder in an iron mortar. Of these two portions, respectively, 100 and 138 grammes were taken, and were dissolved in warm dilute hydrochloric acid. The tarry residue which remained in each case, was carefully collected and treated with ether, in which it was readily soluble with the exception of a small residue. This, in one of the samples, was found equal to ·40 p. c., of which ·13 was volatilized by heat with the production of a combustible vapour having a fatty odour; the remainder was silicious. The brown etherial solutions were evaporated, and the residuum freed from water and dried at 100°C, weighed in the two experiments equal to 1·570 and 1·505 per cent. of the rock, or a mean of 1·537. It was a viscid reddish-brown oil, which, though deprived of its more volatile portions, still retained somewhat of the odour of petroleum which is so marked in the rock. Its specific gravity as determined by that of a mixture of alcohol and water, in which the globules of the petroleum remained suspended, was ·935 at 16°C. Estimating the density of the somewhat porous dolomite at 2·600, we have the equation ·935 : 2·600 : : 1·1537 : 4·26; so that the volume of the petroleum obtained equalled 4·26 per cent of the rock. This result is evidently too low for two reasons; first, because the rock had already lost a part of its oil, while in the quarry, and subsequently, before its examination; and secondly, because the more volatile portions had been dissipated in the process of extraction just described.

In assuming 100·00 parts of the rock to hold 4·25 parts by volume of petroleum, we are thus below the truth in the following calculations. A layer of this oleiferous dolomite one mile (5280 feet) square, and one foot in thickness will contain 1,184,832 cubic feet of petroleum, equal to 8,850,069 gallons of 231 cubic inches, and to 221·247 barrels of forty gallons each. Taking the minimum thickness of thirty-five feet, assigned by Mr. Worthen to the oil-bearing rock at Chicago, we shall have in each square mile of it 7,743,745 barrels, or in round numbers seven and three quarter millions of barrels of petroleum. The total produce of the great Pennsylvania oil-region for the ten years from 1860 to 1870 is estimated at twenty-eight millions of barrels of petroleum, or less than would be contained in four square miles of the oil-bearing limestone band of Chicago.

It is not here the place to insist upon the geological conditions which favour the liberation of a portion of the oil from such rocks, and its accumulation in fissures along certain anticlinal lines in the broken and uplifted strata. These points in the geological history of petroleum were shown by me in my first publications already referred to, March and July, 1861, and independently, about the same time, by Prof. E. B. Andrews in this Journal for July, 1861.*

The proportion of petroleum in the rock of Chicago may be exceptionally large, but the oleiferous character of great thickness of rock in other regions is well established, and it will be seen from the above calculations that a very small proportion of the oil thus distributed would, when accumulated along lines of uplift in the strata, be more than adequate to the supply of all the petroleum wells known in the regions where these oil-bearing rocks are found. With such sources existing ready formed in the earth's crust, it seems to me, to say the least, unphilosophical to seach elsewhere for the origin of petroleum, and to imagine it to be derived by some unexplained process from rocks which are destitute of the substance.

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* Sill. Jour. II, xxxii, 85. See also papers on the subject by him and by Prof. Evans, Ibid. II, xl. 33, 334; and one by the author, II, xxxv, 170; also Report Geol. Survey of Canada, 1866, pp. 256–257.

## GEOLOGICAL SURVEY OF CANADA.

Alfred R. C. Selwyn, Director.

The Report of Progress from 1866 to 1869 is a bulky volume of 475 pages, with five maps, containing the results of a large amount of work ranging over the whole vast territory from Lake Superior to Nova Scotia inclusive. It embraces the following documents:

1. Letter of Mr. Selwyn introducing the Report.
2. Report of Sir W. E. Logan on part of the Coal-field of Pictou, Nova Scotia.
3. Report of Mr. Edward Hartley on part of the same Coal-field.
4. Report of Mr. R. Bell on the Manitoulin Islands.
5. Report of Mr. James Richardson on the South Shore below Quebec.
6. Report of Mr. Henry G. Vennor on Hastings County, Ontario.
7. Report of Mr. Charles Robb on part of New Brunswick.
8. Report of Dr. T. Sterry Hunt on the Goderich Salt Region, and on Iron and Iron Ores.
9. Report of Mr. James Richardson on the North Shore of the Lower St. Lawrence.
10. Report of Mr. Robert Bell on Lakes Superior and Nipigon.
11. Reports of Mr. Edward Hartley on the Coals of Nova Scotia.
12. An Appendix, containing lists of Plants by Dr. John Bell, and a Note on the Nipigon Region by Sir W. E. Logan.

Out of such a mass of matter it would be almost in vain to attempt to select specimens of each of the separate treaties of which the Report consists. A melancholy interest attaches to that part of it which bears the name of Mr. Edward Hartley, a young man of great ability and information, and high promise, and whose work in this Report would alone be sufficient to give him a permanent place among our scientific men, but who was cut off by death in the midst of his practical and useful labours. From his elaborate survey of part of the great Pictou coal-field, we may extract the part having reference to areas, in which Canadian capitalists are largely interested:

" The Acadia Coal Company own three mining rights, which are as follows:

The Fraser area, south of the General Mining Association's area; the Carmichael area, southwest of the General Mining Association's area; and No. 3 area, lying to the south of the Fraser area.

FRASER AREA.

Workings have been carried on for many years upon the Fraser area; first by the General Mining Association, and more lately by Mr. J. D. B. Fraser, of Pictou, from whose possession it passed by lease to the present company.

Attempts have been made by former owners to work the Deep Seam on the western portion of the area at the McKenzie pit, and a slope has also been driven some distance on the crop of the Third coal seam, both of which workings are now abandoned, and therefore require no special description. The present workings are confined to the McGregor seam and two openings on the Oil-coal.

*McGregor Colliery.*

In the McGregor colliery the openings consist of No. 1, an adit, No. 2, a slope, and No. 3, a pair of slopes.

Adit No. 1 was opened by the General Mining Association on the left bank of Coal Brook, near the crossing of the Middle River road, and driven N. W. a distance of about 800 yards. The seam was irregularly worked by the General Mining Association and Mr. Fraser, but is, I believe, for the present abandoned.

Slope No. 2 is a single slope to the lower level of No. 3 slopes, and was formerly the working slope, but is now used only as a travelling way. It stands on the left bank of Coal Brook near the mouth of No. 1. Slopes No. 3 are the principal working. Their situation is 170 yards S. E. of No. 2, on the right bank of the brook. Their total depth is 510 feet. Main levels extend 260 yards N. W. and but 20 yards in the contrary direction. The dimensions of the slope are: Drawing slope (a double railway track) 9 feet post, 9 feet cap and 14 feet ground sill. The tracks are all of T iron 25 lbs. to the yard. The second slope, a travelling way for horses and men, is separated from the drawing slope by a 14 feet barrier of coal; its height is the same as that of the drawing slope, with 6 feet cap and 8 feet ground sill. A temporary engine is of 14 nominal English horse-power, with a horizontal single cylinder, driving the hoisting drum by shafting with clutch gearing; and also pumping through the Fleming pump pit by a wire rope running over sheave pullies to the pump bob. In working the McGregor seam the upper coal (included in the upper six feet of the seam) is the only portion taken out, the lower bench being unsaleable. The seam is found to rapidly improve going west, as will be seen from the following sections:

*McGregor seam, upper coal.*

| | At No. 2 slope. | | At western face. | |
|---|---|---|---|---|
| | *Ft.* | *In.* | *Ft.* | *In.* |
| Good coal.................... | 1 | 9 | 2 | 9 |
| Arenaceous fire-clay parting.. | 1 | 0 | 0 | 6 |
| Good coal .................. | 3 | 0 | 4 | 0 |
| | 5 | 9 | 7 | 3 |

Near the western face, the bord and pillar system with incline gate roads has been commenced. Elsewhere in the working the back-balance system is used.

## *Oil-coal Workings.*

Two slopes have been sunk upon the oil-coal seam, namely the Fraser mine on Coal Brook, near No. 3 slopes, and the Stellar mine on McCulloch's Brook. The principal value of this seam consists in the large quantity of oil contained in the bench mentioned as oil-coal in the general section, which in former years was extensively worked, the oil-coal or *stellarite*, as it has been named by Professor Henry How, who first described it, selling for a high price for gas-making and distillation. The present low price of coal-oil from the extensive working of petroleum in this country and the United States, combined with the high tariff on imported coal imposed by the United States, have combined to render the working of this seam unprofitable, and both workings are for the present abandoned.

As the quality of this peculiar coal will receive especial attention in the Appendix to this report, I will merely state in conclusion that from the large content of oil this seam must at some time prove of considerable value. From pits sunk by the Acadia Coal Company it would appear that the size and quality of the

Oil-coal bench improves towards the east, the greatest thickness (1 foot 10 inches) being procured in a pit sunk at the corner of Grove street and Pennsylvania avenue in Acadia village, which coal produced 120 gallons of crude oil to the ton; the average obtained from the Fraser mine being about from 60 to 65 gallons per ton.

### CARMICHAEL AREA.

For many years no workable coal was known to exist to the west of the McCulloch-brook fault, on which the Albion coal seams are lost; and though many attempts were made to ascertain the position of these seams no coal was found until the 18th April, 1865, when Mr. Truman French, in prospecting for the Nova Scotia Coal Company, discovered the fine seam of coal now known as the Acadia seam, and presumed to be equivalent to the Main seam of the Albion mines. The first opening of this seam was on the area under consideration, near its western boundary, from which point it was traced north and south, as described in treating the general distribution of the coal seams.

#### *Acadia Colliery.*

The Acadia colliery, locally known as the Acadia west slope, is situated near the south-western corner of the Carmichael area, and within the village of Westville. Two slopes, corresponding in dimensions to the No. 3 McGregor slopes, have been sunk on the Acadia seam to a depth of about 140 yards from the crop.

The section of this seam and the strata immediately overlying, as measured in the air shaft of this colliery, is as follows:

| | | Ft. | In. | Ft. | In. |
|---|---|---|---|---|---|
| Brown carbonaceous shale | | | | 4 | 6 |
| Black bituminous oil shale | | | | 0 | 7 |
| Brown carbonaceous shale | | | | 6 | 6 |
| Good coal, (1st bench) | Fall coal. | 2 | 9 | | |
| Good coal, (2nd bench) | Fall coal. | 3 | 6 | | |
| Light arenaceous fireclay or holing | | 0 | 3 | | |
| Good coal (3rd bench) | Bench coal | 3 | 8 | | |
| Coarse hard coal with iron pyrites, easily separated by dressing from the other coals | Bench coal | 0 | 1 | | |
| Good coal (4th bench) | Bench coal | 3 | 3 | | |
| Coarse coal of fair quality | Bench coal | 2 | 4 | | |
| Coarse coal not taken out | Bench coal | 2 | 4 | | |
| | | | | 18 | 2 |
| | | | | 29 | 9 |

Above the section given, no details for a column of strata can be procured, no record having been preserved of the numerous pits in the overlying measures. The remains from these pits, however, will enable me to state that at this colliery the seam is overlaid with a great mass of barren measures, consisting of black and brown carbonaceous and argillaceous shales, with occasional bands of dark arenaceous shale, and at least two thin bands of thinly laminated sandstones of a general white colour, with black partings, as in the sandstones described in the Foster pit section. Under the seam there is a yellowish-drab *Stigmaria* underclay of at least four feet in thickness. The measures are then concealed for forty-two feet, at which point a heavy bedded sandstone appears, of a light brownish-drab colour, containing, where exposed in a quarry near the Acadia slope, large *Stigmaria* roots well preserved, as well as occasional stems of *Lepidodendron*.

At this colliery the seam has been proved to be without fault, by the main level, which now extends about 500 yards south and 400 yards north, the exact direction across the area being N. 41° W., (or N. 18° W. magnetic) corresponding to the dip of the seam, N. 49° E. (or N. 72° E. magnetic), which varies only in inclination, being 19° at the surface and about 23° at the lowest level. The under-ground workings are on the counter-balance system, and are remarkably regular and well laid out. Counter-balances are driven 15 feet wide and 100 yards apart, throughout the workings. An air course 8 feet wide is also driven up at 10 yards to the left of each counterbalance. Working bords are 15 feet in width, with 15 feet of pillar, 75 feet of barrier being left above the main level.

### *Machinery.*

The platforms at the head of the slope are roofed in. They extend from the mouth of the slope to the banks, and also to the shutes over the railway track. At this mine the fine slack is not sold, being carefully screened out, the rest of the coal being divided into two sizes, *round* and *chesnut*. The drawing engines were built in New York, and are fair specimens of the best type of American engines, being compact and easily handled, with none of the slightness of design usually observable in American machinery. They are horizontal high-pressure connected engines, 16 by 48 inch cylinders, working by a 24-inch pinion into a 16-feet spur-wheel on a 14-feet drum. The engine house is of brick and cut stone, with a corrugated iron roof. Pumping is effected by a small donkey engine, which is also arranged to hoist bank coal to the screening platform, the quantity of water in this mine being so insignificant that a two-inch column-pipe is sufficient to deliver it.

*Second Seam.*

The discovery of the Acadia seam was followed by the discovery of a second seam, underlying at about 160 feet, by Capt. Blacker of the Acadia colliery. At the pit sunk by him the following thickness was found :

| | *Ft.* | *In.* |
|---|---|---|
| Shaly coal........................... | 3 | 10 |
| Good coal ........................... | 7 | 8 |
| | 11 | 6 |

The bench known as *good coal* seems, from the specimens I have seen, to be of a shaly character, and none that has come before me would be saleable. On the Carmichael area this is opened by only one trial-pit, now filled up.

AREA NO. 3.

Upon the No. 3 Acadia area no coal has been found, but from the presence, as proved by trial-pits, of the black shales overlying the Main seam, it is probable that the representatives of this and underlying seams occur beneath a portion of this area to the west of the McCulloch-brook fault. Of the size or character of the coal no information can be obtained without extensive prospecting. The only opening which is near this area is the Culton adit, and from the strike of the Culton seam at that point, it may be presumed that it will continue on to No. 3 area.

*Railway.*

The Acadia Coal Company have built a fine single-track railway of about three and a-half miles in length, the main line extending from the west slope to the track of the government railway at a point near Coal Mines station, and passing through the Acadia village near the McGregor colliery, with which it is connected by sidings. From the junction at the railway station the coal is conveyed over the government railway to the Acadia loading ground at Fisher's Grant, on the east side of Pictou harbour, near the entrance. The shipping wharf extends into the harbour 850 feet to 26 feet of water at low tide. It is a well-built structure, 20 feet in height, with shutes at both sides and end, empty trains being made up on a centre track.

### *Buildings.*

Thirty double houses have been provided for miners and labourers at the Acadia village, which is very tastefully laid out in regular streets and avenues, the houses being very substantially built, and of a much better class than it is usual to provide for like purposes.

The rest of the plant at both slopes, including the blacksmith and machine shops, office building and overmen's houses, is very complete.

## INTERCOLONIAL COAL MINING COMPANY OF MONTREAL.

Two mining areas are owned by this company, the Bear Creek area to the south of the Carmichael area of the Acadia Coal Company, and the Sutherland area, which lies to the north of the area of the General Mining Association.

## BEAR CREEK AREA.

The Acadia seam was opened upon this area soon after its discovery in 1865, at a point known as Campbell's pit, near the north line of the area, and from this pit, as worked by the then owners of the area, and subsequently by the agents of this company, a considerable amount of coal was taken for consumption in the immediate neighbourhood. After a careful survey by Mr. William Barnes of Halifax, a competent mining engineer (which survey will again be alluded to) the company decided upon the location of the present colliery.

### *Drummond Colliery.*

The erection of buildings and machinery at this colliery and the first work at the present slopes was commenced about November, 1867, since which time works of considerable importance have been erected, a railway has been built, and a large amount of coal (about 70,000 tons) has been shipped.

The section of the Acadia seam at this point is as follows, the measurement being taken in the air shaft of the colliery:

| | Ft. | In. |
|---|---|---|
| Good coal with a smooth parting two feet nine inches from the bottom, (*full coal*) | 5 | 9 |
| Light gray soft fireclay; it varies slightly in thickness; (*holing*) | 0 | 3 |
| Good coal, top bench | 5 | 6 |
| Gray hard coal, giving a pink ash. | 0 | 6 |
| Good coal, second bench | 4 | 6 |
| Coarse coal, not worked | 2 | 1 |
| | 18 | 7 |

*Underground Workings.*

The present workings consist of two working slopes driven about 900 feet from the crop of the seam, the dip being about 16° at the surface, decreasing to 14° at the lower level, at 730 feet from the surface. The size of these slopes is 9 by 9 feet, with a central barrier of coal between them of 28 feet, each slope having a single track and travelling-way. Main levels for two lifts have been driven from the slopes *north* and *south* upon the seam, the north levels being worked from No. 1 slope and the south from No. 2; thus far I believe the lower levels have been most extensively worked, a considerable amount of coal being left near the crop for safety. I have not had an opportunity of examining a detailed plan of the workings, but my inspection of them would lead me to believe that the system of pillarage is planned with more than usual regard for safety. Both the post and stall and counterbalance systems of *getting* the coal were at first tried with a view of ascertaining their comparative economy, and I believe that Mr. Dunn has selected the counterbalance system for the future working of the mine.

But little water has as yet been met with, and it is at present raised by water cars, no pump having been found necessary.

*Over-ground Works.*

The arrangements at the surface seem exceptionally well planned and have given great satisfaction. At the head of the slopes a large heapstead or covered screening platform is erected for the separation of different sizes and qualities of coal, and for banking out. The coal boxes are drawn on to this platform in trams of from five to twelve (holding from 500 to 600 pounds each) and thence delivered by dumps on to the screens, where the coal is separated, as at the Acadia colliery, into three sizes: round coal, nut coal and slack. The platform extends over eight railway tracks, four for each slope; its floor is level with the top of the bank, for banking out, and in shipping bank-coal a railway track is run along the foot of the bank, and from this level the bank cars are raised to the main platform in a cage lifted by a small donkey engine, which is also arranged to drive a circular saw for the car shop of the colliery.

The drawing engines are horizontal connected engines of about 50 nominal English horse-power; they are of Scotch manufacture, and are fitted with an extremely ingenious arrangement of friction gearing, by means of which the two slopes may be worked independently, by one engine, a matter of great convenience.

*Railway.*

The railway of this company extends from the Drummond colliery to their shipping wharf at Granton on the Middle River, near Abercrombie Point, the position of which will be seen on a map. The main line of single track railway is laid with 56-pound rails, with the new steel scabbard joint, which has proved so successful on the Pictou and Truro branch of the Nova Scotia railway. This railway was built in 1868 by Mr. Joseph B. Moore, contractor, in the most complete manner, the track being well ballasted with broken sandstone and a coarse conglomerate from the cuttings near Waters's Brook, the culverts of cut stone, and the bridge of trestlework with cut stone foundations.

The rolling stock of this railway consists of three locomotives, miscellaneous platform and construction cars, and sixty new coal waggons carrying from six to seven tons of round coal each, twenty of which were built at the Drummond colliery car shop. In connection with the railway are provided at the colliery, car shops, locomotive-sheds and weigh-houses. The length of the main line of railway from the colliery to the wharf is about seven and one quarter miles, which, with sidings, turn-outs and standing tracks at the colliery, will probably raise the total length of single track to about ten miles.

The shipping wharf of the Intercolonial Coal Company is a fine structure of wood upon stone and crib work piers, extending in a curve into the channel of the Middle River to about 22 feet of water. The arrangement at the platform of the wharf is such that there is a slight incline of one track downward from the shore to the end of the wharf, and thence a further down grade on a second track back to the shore, the design being that as fast as coal is required at the shipping places or *shutes*, the full cars are allowed to run by their own gravity to the point required, whence, on being emptied, they will again return by their own weight to the shore, to be made up into *empty* trains. They are switched back at the end of the wharf on to the *empty* or inside track, running parallel to the *full* track, upon which they are pushed by the locomotive in coming from the colliery. This arrangement has, I believe, given great satisfaction, as it results in a saving of the horses usually necessary for handling coal cars at the shipping wharves.

The railway and wharf were opened for traffic about the 1st of October, 1868, and before the close of navigation several thousand tons of coal were shipped. During the present season the colliery has been in successful operation, and a considerable quantity of the coal has found a market in the provinces of Ontario and Quebec.

In the description of the general distribution of the coal in the Bear Creek synclinal it has been stated that at a few hundred yards to the south of the Drummond Colliery the crop of the Acadia seam comes against the West fault. The fact that the crop of the seam was here lost upon a fault "with a S. W. upthrow and a bearing of N. 10° W." magnetic, (or N. 33° W. astronomical) was proved and stated by Mr. Barnes. A few yards to the west of the spot where the coal of the Acadia seam was lost, another seam of inferior coal, about three feet in thickness, was found, and beyond it, to the south-west, a second fault, with a south-west upthrow was observed, bringing up red and gray sandstones. These sandstones I have examined and believe to belong to the Milstone grit series.

The first fault mentioned appears to coincide in position and bearing with the general run of the West fault, and, as it will certainly be the western boundary of the workable coal, I have in the map shown it as that fault, but it is quite possible that here the great West dislocation may turn a few yards, leaving a small patch of the lower portion of the coal measures to the west of Mr. Barnes' first fault, its throw being completed by the second fault found by Mr. Barnes, bringing up the Millstone Grit.

The amount of coal of the Acadia seam removed by this fault, as at present understood, will be unimportant. This is known from the fact that the measures overlying the seam have been traced along the east side of the fault, and as they dip at very low angles, it is probable that only some 70 or 100 yards of coal next the crop will be cut off by the fault. No reason is at present known why the second levels from the Drummond colliery should not run around regularly to the south-eastern portion of the area.

SUTHERLAND AREA.

But little work has been done upon this area, and no coal has as yet been opened. It will be seen that the north fault runs diagonally through it, cutting it into two portions. To the south of this fault the area is probably underlaid with the lower seams or a portion of them. The Montreal and Pictou seam, and any seams which may be found above it, will, if no dislocation exist, turn to a westerly dip upon this area, and at a few chains from the east line their crops will come against the fault.

The coal in this area might, perhaps, be successfully worked in connection with the Montreal and Pictou area, and a small portion of the northern part of the area of the General Mining Association."

The report on the quality and economic value of the coals is most exhaustive and elaborate, but does not afford material for extracts.

Sir William Logan, late Director of the Survey, gives the results of a detailed survey of the difficult and broken coal district lying to the eastward of the East River of Pictou, the complexities of which he has to a great extent unravelled, and has illustrated by an excellent map, which very well illustrates the limits of the coal as at present ascertained, and the values of the respective coal properties. Much, however, still remains to be done; and it is to be hoped that the work so well begun by Sir William and Mr. Hartley will be efficiently followed up.

Dr. Hunt's portion of the Report is replete with scientific and practical information. The geological relations of the Salt Region are thus described:

THE GODERICH SALT REGION.

"In the Report which I had the honor to submit to you in 1866, there will be found, on pages 263–272, an account of the salt deposit then recently discovered by boring, at a depth of 1,000 feet from the surface, near the town of Goderich, in Ontario. As regards its geological position, it was there shewn from the results of the boring that the Onondaga formation attains in that region a thickness of about 1,000 feet, of which the lower 200 feet consists of reddish and bluish shales, including beds of gypsum, and near the base a layer of rock salt, which in the Goderich well was said to have a thickness of about forty feet, including some layers of blue clay. From this depth there was obtained, by pumping, a saturated brine, my analysis of which was given. Attention was in this Report called both to the strength and the remarkable purity of the brine, and comparative results were given to show its great superiority over the brines of Saginaw in Michigan, and of Syracuse in New York. A table showing the strengths of brines of different specific gravities, and the number of gallons required for a bushel of salt, was also given in this connection. It is deemed advisable, however, to give in the present Report a more extended table of the same kind, which is reprinted from Professor Alex. Winchell's Report on the Geology of Michigan, published in 1861.

Since the publication of that Report, the well then described, which belongs to the Goderich Company, has been constantly pumped, and large quantities of salt have been manufactured from the brine. Encouraged by the success of this well, several other borings have been sunk in the immediate vicinity, and are yielding brines like the first one. The record of all these wells is essentially the same as that of the first. The presence of a stratum of rock-salt has been established by the grains of salt brought up by the sand pump from the borings. In the course of 1867 Mr. Ransford sunk a well at Clinton, thirteen miles to the south-east of Goderich, on the line of the Buffalo and Lake Huron railway, and was rewarded by the discovery of the salt-bearing stratum, offering, it is said, a thickness of sixteen feet of rock-salt. The depth of this well is 1,180 feet, and the greater thickness of rock overlying the salt at Clinton is due to the south-eastward dip of the strata; from which it results that the summit of the Onondaga formation, which appears at the surface at Goderich, is at Clinton covered by about 200 feet of the Corniferous limestone. This overlying formation occupies, to the north of Goderich, a broad triangular area extending north-eastward nearly forty miles, and bounded to the nort-east and north-west by the out-crop of the underlying Onondaga formation.

Upon this latter, at Kincardine, thirty miles north-east of Goderich, another well was sunk last year, and showed the existence of the salt-bearing stratum at a depth of about 900 feet. The record of the boring furnished me was as follows:

| | *Ft.* | *In.* |
|---|---|---|
| Sand and gravel | 91 | 6 |
| Limestone and hard strata | 508 | 6 |
| Red shale | 23 | 0 |
| Blue shale with a red band | 117 | 0 |
| Limestone | 30 | 0 |
| Blue and red shale, partly very soft | 125 | 4 |
| Rock salt | 13 | 8 |
| | 909 | 0 |

By comparing the above result with that obtained in the first well at Goderich, it will be seen that while the amount of shaly strata from the base of the limestone to the bottom of the salt was only 205 feet at Goderich, it attains at Kincardine a thickness of 309 feet; in which, however, are included thirty feet of a rock described as limestone, but which may perhaps be gypsum, masses of which were encountered in the shales in boring at Goderioh. Of the 775 feet of limestone belonging to the formation at Goderich, only 508½ remain at Kincardine, the upper portion being removed by erosion. It is not, however, certain that the original thickness of the Onondaga, or Salina formation as it is sometimes called, was precisely the same here as at Goderich, and thus the amount which has been removed by erosion may be somewhat greater or less than would at first appear. In like manner, the thickness of the same formation at Clinton may differ somewhat from that at Goderich, so that the overlying portion of Corniferous limestone at that place may be greater or less than 200 feet, according as the volume of the Salina formation is less or greater than at Goderich. Careful examinations of future borings would enable us to determine these important points, and for this end samples of the material extracted at intervals of fifteen or twenty feet, should be carefully preserved.

The base of the Onondaga formation comes to the surface at the mouth of the Saugeen river. Here, at Southampton, an ill-advised attempt was last year made in search of salt by boring. According to the record furnished me, the solid rock was only reached at a depth of 230 feet,* after which 350 feet of white and gray limestone had been penetrated up to August 22, 1868. The subsequent record is incomplete, but beneath the limestones were encountered several hundred feet of red shales, and the boring was finally abandoned at a depth of 1,251 feet from the surface. Another well also was sunk last year at Port Elgin, five miles below Southampton, on the coast, and the boring in November last, had attained a depth of 890 feet, and was still going on in the red shales. In this connection may be noticed a well which was sunk in 1867, at the village of Waterloo, about eighty miles to the south-east of Port Elgin, but in the same geological position, that is to say near the base of the Onondaga formation, and was abandoned at the depth of 1,120 feet. The record of the boring was as follows:

| | | | |
|---|---|---|---|
| Superficial clays and gravels † | | 130 | Feet. |
| Limestone | 40 | | |
| Gypsum | 17 | 77 | |
| Shale | 20 | | |
| Limestone, gray and white | | 340 | |
| Blue shale | | 114 | |
| Red shale | | 459 | |
| | | | 1120 |

At this depth the well was abandoned; bitter saline waters were met with at depths of 800 and 900 feet, and were probably similar to the bitter water found at St. Catherines at the same geological horizon. In the Report for 1866, on pages 271, 272, the waters of this class are noticed, and their unfitness for the manufacture of salt pointed out. The 77 feet of limestone, gypsum and shale in the Waterloo section belong to the base of the Onondaga, or salt-bearing series, beneath which no valuable brines

* The account of this portion of the boring is as follows:

| | | |
|---|---|---|
| Gravel and sand, with trunks of trees at the base | 23½ | Feet. |
| Hard-pan and boulders | 36 | |
| Blue clay | 5 | |
| Coarse sand and gravel | 16 | |
| Hard-pan and boulders | 4½ | |
| Soft marly beds | 50 | |
| Blue clay with boulders | 67 | |
| Hard-pan and boulders, with gravel | 28 | |
| | | 230 |

† For a notice of the superficial deposits of this region, see the *Geology of Canada*, page 897.

have yet been found. The 340 feet of limestone underlying the shale, represent the Guelph, Niagara and Clinton formations, and the red and blue shales beneath these belong to the Medina formation. By referring to the account of a boring at Barton, near Hamilton, it will be seen that these shales have there a total thickness of about 600 feet. (Report for 1866, page 251.)

It will be noticed that the Onondaga formation, as shewn in the borings of Goderich and its vicinity, consists of several hundred feet of limestone, chiefly magnesian, underlaid by two or three hundred feet of red and blue shales, which carry rock-salt at their base. These are succeeded, in descending order, by the magnesian limestones of the Guelph, Niagara and Clinton formations, which rest upon the red shales of the Medina, as seen in the Southampton and Waterloo borings. We have the following succession in going downwards:

1. Limestones of the Onondaga or Salina formation.
2. Red and blue shales of the same.
3. Limestones of the Guelph and Niagara formations.
4. Red and blue shales of the Medina formation.

On account of the resemblances in color between the upper and lower couples of the above series mistakes may easily occur, as at Southampton, where the strata of 3 and 4 were supposed to be those of 1 and 2. Such errors, which have caused the expenditure of considerable sums of money at Southampton, Port Elgin, and Waterloo, would be avoided by a careful study of the distribution of the various geological formations of this region, as described in the *Geology of Canada*. The accuracy with which the limits of the various formations throughout this region were traced out by Mr. Alex. Murray, has received repeated confirmation in the course of the various explorations for oil and salt which have been made within the past few years.

As regards the possible extent of the salt-bearing area now under consideration, I take the liberty of quoting the following passage from my Report for 1866, page 271:—

With regard to the probabilities of obtaining salt wells by other borings in this region, it is to be remarked that the thickness of the deposit of salt traversed in the Goderich well may warrant us in expecting that its area may be considerable; though whether its greatest extent will be inland, or beneath the waters of the lake, can only be known by experiment. It has already been explained that salt deposits have been formed in basins whose limits were determined by the geographical surface at the time; and it is worthy of remark that both here and in New York the salt deposits are connected with a thickening of the Onondaga formation, which, in its thinner intermediate portion, is apparently almost destitute of salt; a fact suggesting former geographical depressions, in which the two salt-bearing portions of the formation may have been deposited. Although it would be unsafe to predict that this development of salt at the base of the Onondaga formation is so widely extended, its thickness at Tilsonburg, St. Mary's, London, and Enniskillen, is such, that it seems probable that farther borings in these localities, where deep wells have already been sunk, may reach saliferous strata capable of yielding valuable brines."

In confirmation of the first portion of the above extract, we can now point to the existence of salt at Clinton, thirteen miles to the S.E., and at Kincardine, thirty miles N.N.E. of Goderich. These two stations are forty miles apart, and a line connecting them would pass about seven miles to the east of Goderich. It is, therefore, extremely probable that the whole region between Clinton and Kincardine will be found underlaid by salt, and may belong to a single basin, whose extent yet remains to be ascertained.

The success of the borings at Goderich and in its vicinity has, as we have seen, led to the sinking of wells for brine, below the salt-bearing horizon. At the same time, other trials have been made in the hope of reaching it, by boring through rocks overlying those of the Goderich region. For the information of inquirers, it may therefore be well to recall briefly some of the facts with regard to the nature and thickness of these rocks, of which the details are given in my Report for 1866. It will there be seen that the most recent rocky strata in south-western Ontario are the greenish sandstones of the Portage formation. These pass downwards into hard black slates (the so-called Genessee slates) which, in their turn, rest upon the soft gray strata of the Hamilton formation. This group of sandstone and hard shale, which appears at the surface at Kettle Point in Bosanquet, and also in Warwick, is generally concealed by the clays of the region; but from the records of numerous borings, chiefly made in search of petroleum, we have been enabled to determine its thickness in many places. Thus, in a boring at Corunna, on the St. Clair river, near Sarnia, it measures 213 feet; in two borings in Camden, 146 and 200; in Sombra, 100; in Alvinstone, eighty feet; in Warwick, and near Wyoming station, about fifty; a little north of Bothwell, about eighty; and further south, towards the shore of Lake Erie, about sixty feet in thickness. It will be understood that this varying thickness is due to the erosion along the anticlinals, before the deposition of the clays, so that in many parts of the region only the lower portions of the black slates remain, while in other places they are entirely wanting.

The hard strata just described are conformably underlaid by those of the Hamilton formation, which in some parts of New York attains a thickness of 1,000 feet, but is reduced to 200 feet in the western part of the State. It consists, in Ontario, chiefly of soft grey marls, called soapstone by the well-borers, but includes at its base a few feet of black beds, probably representing the Marcellus shale. It contains, moreover, in some parts, beds of from two to five feet of solid gray limestone, holding silicified fossils, and in one instance impregnated with petroleum; characters which, but for the nature of the organic remains, and for the associated marls, would lead to the conclusion that the underlying Corniferous limestone had been reached. The thickness of the Hamilton formation varies in different parts of the region under consideration. From the record of numerous wells in the south-western portion it appears that the entire thickness of soft strata between the Corniferous limestone below and the black shale above, varies from 275 to 230 feet, while along the shore of Lake Erie, it is not more than 200 feet. Further north, in Bosanquet, beneath the black shale, 350 feet of gray shale were traversed in boring, without reaching the hard rock beneath; while in the adjacent township of Warwick, in a similar boring, the underlying limestone was reached 396 feet from the base of the black shales. It thus appears that the Hamilton shale (including the insignificant representative of the Marcellus shale at its base) augments in volume from 200 feet on Lake Erie to about 400 feet near to Lake Huron.

The Hamilton formation, as just defined, rests directly upon the solid non-magnesian limestones of the Corniferous formation. The thickness of this formation in western New York is about ninety feet, and in southern Michigan is said to be not more than sixty, although it increases in going northward, and attains 275 feet at Mackinac. In the townships of Woodhouse and Townsend its thickness has been found to be 160 feet; but for a great portion of the region in Ontario underlaid by this formation, it is so much concealed that it is not easy to determine its thickness. If we may conclude from the boring at Clinton, it would seem to be in that locality not far from 200 feet. In the numerous borings which have been sunk through this limestone, there is met with nothing distinctive to mark the separation between it and the limestone beds which form the upper part of the Onondaga or Salina formation, and consist of dolomite, alternating with beds of a pure limestone like that of the Corniferous formation. The saliferous and gypsiferous soft magnesian marls, which form the lower part of the Onondaga formation are, however, at once recognized by the borers, and lead to important conclusions regarding this formation in Ontario.

At Tilsonburg, a boring showed the existence of the Corniferous limestone directly beneath about forty feet of clay, while in another boring, about two miles to the south-west, it was overlaid by a few feet of soft shales, probably forming the basis of the Hamilton formation. The first boring at Tilsonburg, as mentioned in the report for 1866, was carried to a depth of 854 feet in the solid rock. Numerous specimens of the borings from the first 196 feet, were of pure non-magnesian limestones, but below that depth similar limestone alternated with dolomite. The marls which occur at the base of the Onondaga formation were not met with in this boring, though the water from 854 feet was said to be strongly saline. I was informed by the proprietors, Messrs. Hebbard & Avery, that the well furnished, by pumping, a brine marking from 35° to 50° of the salometer, but I was not able to get any of the water, and the well was soon after abandoned, although the presence of so strong a brine would seem to show the proximity of a saliferous stratum.

In a boring at London, where the presence of the base of the Hamilton was marked by about twenty feet of gray shales, including a band of black pyroschist, overlying the Corniferous, 600 feet of hard rock were passed through before reaching soft magnesian marls, which were penetrated to the depth of seventy-five feet. Specimens of the borings from this well, and from another near by, carried 300 feet from the top of the Corniferous, show that pure limestones are interstratified with the dolomites to a depth of 400 feet. At Tilsonburg a pure limestone was met with at 524 feet from the top.

At St. Mary's, 700 feet, and at Oil Springs in Enniskillen, 595 feet of limestone and dolomite were penetrated, without encountering shales; while in another well, near the last, soft shaly strata were met with at about 600 feet from the top of the Corniferous limestone, there overlaid by the Hamilton shales. It thus appears that the united thickness of the Corniferous formation and the solid limestones and dolomites which compose the upper part of the Onondaga formation, is about 600 feet in London and Enniskillen, and farther eastward, in Tilsonburg and St. Mary's, considerably greater; exceeding by an unknown amount in these localities, 854 and 700 feet.

As the few observations which we as yet possess of the thickness of the Corniferous limestone in this region, do not warrant us in assigning to it a thickness of over 200 feet, it is evident that at London and in Enniskillen the hard strata which form the upper portion of the Onondaga formation, and have at Goderich a thickness of not less than 775 feet, are greatly reduced in thickness, since the volume of the two united is only 600 feet. To the south-eastward, however, the augmented thickness of the Onondaga would appear, from the results of the borings at St. Mary's and Tilsonburg, to be maintained. The thickness of this formation is, however, known to be very variable; while at the Niagara river it is reduced to 300 feet, and is apparently destitute of salt, it augments to the eastward, in central New York, where it again attains a volume of from 700 to 1000 feet, being equal to that observed at Goderich, and becomes once more salt-bearing. The increased thickness of the formation, in these two regions, connected with accumulations of salt at its base, would seem to point to ancient basins or geographical depressions in the surface of the underlying formation, in which were deposited these thicker portions.

Most of the details here given with regard to the thickness and character of the rocks of this region are condensed from the observations collected in my Report for 1866, pp. 241-250. They are embodied in a paper by me entitled *Notes on the Geology of South-western Ontario*, and published in the *American Journal of Science* for November, 1868; parts of which have been reprinted, with some few changes, in the last three pages.

It is a curious fact that the numerous and productive salt wells of Syracuse, New York, although occurring upon the outcrop of the Onondaga formation, do not penetrate into it, but are sunk in a deposit of stratified sand and gravel, which fills up a valley of erosion on the shores of Onondaga Lake. The limits of this valley are nearly four miles from north to south, by two miles from east to west. The shales belonging to the base of the formation crop out to the northward, and are found in the various borings beneath the ancient gravel deposit, which is itself covered by thirty or forty feet of a more recent deposit of loam or sand. The bottom of the basin is very irregular, the shales being met with at depths of from 90 to 180 feet in some parts, and at 382 feet in the middle of the valley. According to Mr. Geddes, the greatest depth of this ancient basin is not less than 414 feet below the surface-level of Onondaga Lake, and 50 feet below the sea level.—(Trans. N. Y. State Agricultural Society, 1859.)

Beds of the ancient gravel are occasionally found converted into a hard concrete, the cementing material of which, in some cases at least. is crystalline laminated gypsum. The wells are bored in this gravel to various depths up to 350 feet; brine is met with at about 100 feet, but the brines of the deeper wells are stronger, and less liable to variations in quality with the season of the year."

From the Report on Iron we extract as of much interest the passages referring to Iron Sands:

" The silicious sands of most regions contain a greater or less proportion of heavy black grains, which consist chiefly of some ore of iron. The source of these is easily traced to the crystalline rocks which, by their disintegration, have given rise to the sands, and which, in addition to occasional beds or masses of iron ores, generally hold disseminated grains of magnetite, hematite, titanic iron (menaccanite or ilmenite of mineralogists) and more rarely chromic iron ore. In the process of washing earth and sand for gold, diamonds, or tin ore, considerable quantities of these black iron sands are met with, and, from their high specific gravity, remain when the iighter portions are washed away. The chromic iron ore is comparatively rare, and confined to certain districts; the hematite, with the exception of some crystalline varieties, is generally too soft to resist the abrading forces which have reduced the solid rock to sand, so that the black grains, in most districts, consist chiefly of magnetic and titanic iron ores. In the gold-bearing alluvions of the Chaudière region in Canada, the sands obtained in washing for gold, when purified as much as possible by washing, were found to hold eighteen per cent. of magnetic iron. The non-magnetic portion was soluble in acids and fused bisulphate of potash, with the exception of 4.8 per cent. of silicious residue, and the solutions contained, besides iron, a considerable proportion of chromium, and 23.15 per cent. of titanic acid, derived from the titanic iron ore, which made up a large portion of the sand. (*Geology of Canada*, page 520.)

The proportion of these ores to the whole mass of ordinary silicious sands is, generally, by no means large, but the action of moving water effects a concentration of the mixture, separating the lighter silicious grains more or less completely from the heavier portions, which consist chiefly of the iron ores, generally with a small quantity of grains of garnet. This separation is effected, on a large scale, by the action of the sea, under the influence of the winds and tides, and the result of this action occasionally gives rise to remarkable accumulations of these heavy iron sands, along the present sea-beaches. A similar process in past ages, during the deposition of the stratified sands, which are now found at heights above the sea-level, has sometimes arranged the iron grains in layers, which are seen to alternate with the lighter silicious sands, as in the deposits of to-day.

Accumulations of these iron sands are met with in many countries. They are found on the shores of Great Britain, along the borders of the Baltic and Mediterranean, and abundantly on the coast of New Zealand. In some parts of Hindostan and Madagascar the grains of iron ore are extracted by washing from the sands of the country, and employed by the natives in their primitive furnaces, for the manufacture of iron on a small scale. The iron sands of New Zealand have of late attracted particular attention from their great extent and richness. According to Hochstetter, the shore of the northern island from Kaipara to Taranaki, a distance of 180 miles, is bordered with a thick layer of iron sand, which contains, according to different analyses, from six to eleven per cent. of titanic acid.

In North America, black iron sands abound in many places. They occur in great quantities in the lower St. Lawrence, as will be hereafter described, and are met with, in smaller amounts, at various points to the south-westward, along the valley of the St. Lawrence and the great lakes. Thus, a deposit of black sand at the outlet of Lake Huron, near Sarnia, attracted some attention, a few years ago; while along the north shore of Lake Erie this sand is, in some places, found in such quantity that attempts were, it is said, made, more than twenty-five years since, to collect it and smelt it with an admixture of bog ore, which was then treated in a blast-furnace, at Normandale, Norfolk county, Ontario.

These black sands are likewise met with at various points along the coast of the United States, particularly on the shores of Connecticut, where they early attracted the attention of the colonists, and were successfully worked more than a century since. The following details relating to the history of these early and little-known trials, are so interesting that I may be pardoned for introducing them here. It appears by a letter from Mr. Horne, a steel-maker and cutler of London, addressed to Mr. John Ellicot, F.R.S., and read before the Royal Society of London, March 3, 1763, that, at that time, the Society for the Encouragement of Arts and Manufactures was occupied with the question of the Virginian black sand, as it was called. Already, before 1742, one Dr. Moulen, of the Royal Society, had made some unsuccessful experiments to determine the nature of this magnetic sand, but in that year Mr. Horne, having procured a quantity of it, succeeded, as he tells us, in extracting from it more than one-half of its weight of fine malleable iron. He seems, however, to have published nothing upon the subject until after Mr. Jared Elliot had made known, twenty years later, by a pamphlet and a letter addressed to the Society of Arts, and subsequently by a letter in reply to Mr. Horne's inquiries, that he was then making malleable iron from the black sands, in blooms of fifty pounds and upwards, by direct treatment in a common bloomary fire, a process which seems, from his letters, to have been one familiar to him. He describes the ore as yielding 60 per cent. of malleable iron, and as being very abundant, and so free from impurity as to require the addition of cinder or of bog ore. This manufacture of iron from the sand had evidently been somewhat developed, for, according to Mr. Elliot, his son had already erected a steel-furnace, before the Act of Parliament was passed prohibiting the manufacture of steel in the colonies. Specimens of the steel there produced were examined by Mr. Horne, and found to be of excellent quality, very tough, and not at all red-short.*

* These curious details are extracted from a rare volume entitled *Essays concerning Iron and Steel*, (the first of the three essays being on "The American Sand-Iron,") by Henry Horne, London, 1773. 12mo., pp. 223. A copy of this scarce book is in the possession of W. M. B. Hartley, Esq., of New York.

Throughout the essay of Mr. Horne the sand-ore is spoken of as coming from Virginia, a name which in the reign of Elizabeth was given to the whole American coast from Canada to Florida, although in 1643 the name of New England was applied to the region which still bears that name. It appears, however, that the so-called Virginia sand was from the coast of Connecticut. Mr. Elliott's letter to Mr. Henry Horne was dated Killingworth, Oct. 4, 1762. Killingworth is a town in the state of Connecticut, on the shore of Long Island Sound, twenty-five miles east of New Haven, and was the residence of the Rev. Jared Elliot, D.D., who was not only a divine but a physician, and a naturalist of great repute. It is recorded of him that "some considerations had led him to believe that the black sand, which appears originally on the beach of the sound, might be wrought into iron. He made an experiment upon it in the year 1861, and succeeded. For this discovery he was honored with a medal by the society instituted in London for the Encouragement of Arts, Manufactures and Commerce." *

Notwithstanding this successful result, the iron sands seem to have been neglected for the last century, both in America and in Europe. We read, it is true, that such sands are treated in open hearths (bloomaries) at Avellino, near Naples, and within a few years attempts have been made in England to turn to use the iron sands of New Zealand; but the first successful attempts in this country were on the north shore of the lower St. Lawrence. The great deposits of black iron sand on the beach near the mouth of the Moisie River, having attracted attention, various attempts to reduce it were made. In January, 1867, Mr. W. M. Molson of Montreal, had the ore successfully treated by the bloomary process, in northern New York, and the result proving satisfactory, several bloomary furnaces were, in 1867, constructed by him at Moisie, and have since been in successful operation.

It will here be well to notice the nature and the composition of the iron sand at Moisie, as observed by myself in the summer of 1868. The stratified sands at Moisie, lying about ten feet above high-water mark, penetrated by the roots of small shrubs, and

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* Barber's *Historical Collections of Connecticut*, page 531. The Rev. Jared Elliot, who was a grandson of the celebrated John Elliot of Massachusetts, the "Apostle of the Indians," died in 1763, aged seventy-eight years.

holding marine shells, were observed to be banded by irregular dark colored layers, in which the iron ore predominated. The same thing was afterwards remarked by me in stratified sands at much higher levels in the vicinity. Where these sands form the beach, they are exposed to the action of the waves, which effect a process of concentration, on a grand scale, so that, it is said, after a prevalence of certain winds, great belts of nearly pure black sand are exposed along the shore. At the time of my visit trenches were being sunk to a depth of five feet, on the shelving beach, about half-way between high and low-water mark. The sections presented alternations of nearly pure silicious sand and of black iron sand, the latter in layers of from half an inch to six inches in thickness, often with a small admixture of grains of red garnet, which sometimes formed very thin coatings upon the surface of the black layers. One of these latter, six inches in thickness, was taken up by myself, and found to be very pure, as will be seen from my analysis, farther on. It was easy, from these trenches, by means of shovels, to remove, without much admixture, the thicker layers of the moist black sand, which would measure from one and a-half to two feet out of the five feet excavated. This material was piled upon the beach, and afterwards carried to the washing-table. The supplies of sand-ore have hitherto been obtained from the deposits of wet sand below high-water level. Those at the surface, on the beach, have doubtless been recently moved by the waves, but from the inspection of the layers in the trenches, I was led to the opinion that they were lower strata, similar to those seen above the high-water mark, and, like them, of considerable antiquity. They were found to contain marine shells in a crumbling and decayed condition. It is said that these mixed sands of the higher levels yield, on an average, by washing, about fifteen per cent. of black iron sand. When this poor sand is spread upon the shore, and exposed to the action of the waves and the tide, it is found to become concentrated through the washing away of the silicious grains. This process helps us to understand the mode in which the irregular layers of rich iron sand have been formed in the midst of the deposits of silicious sand, in the strata which are now above the sea-level.

The washing of the ore at Moisie, preparatory to smelting, is done upon a shaking-table, about twenty feet long and four feet wide, with a sloping and somewhat concave bottom. Upon this, by the aid of a gentle current of water, a large part of the lighter grains, chiefly of quartz, are washed away.

The specific gravity of the sand, in bulk, was determined by weighing 100 measured cubic centimeters of it, equivalent to 100 grammes of water; and the proportion of grains of magnetic ore was also determined. Of three specimens from Moisie; A was an average sample of several hundred tons gathered in the manner just described, preparatory to washing; B, a portion taken by myself from a layer six inches thick, about three feet below the surface of the beach; and C, the washed ore, as prepared for the bloomary fire. In this connection are given the results of some similar determinations with iron sands from other localities.

| | *Specific gravity.* | *Magnetic.* |
|---|---|---|
| Moisie, A............... | 2·82 | 46·3 per cent. |
| Moisie, B............... | 2·88 | 49·3 |
| Moisie, C............... | 2·97 | 52·0 |
| Mingan.................. | 2·84 | 48·3 |
| Bersimis ............... | 2·81 | 34·3 |
| Natasquan.............. | — | 55·7 |
| Kagashka .............. | — | 24·0 |
| Batiscan ............... | — | 55·0 |

The specific gravity of the silicious sand with which these iron sands are associated, was found, when determined in bulk, as above, to be about 2.00. It consists chiefly of quartz, whose real specific gravity is about 2.65; that of magnetic iron ore being about 5.18, while the titanic iron ore is about 4.70, and the associated garnet not far from 4.0. The amount of material removed in the process of washing at Moisie is not very great, as may be seen by comparing the proportion of magnetic grains in A and C, the Moisie sand before and after washing. The latter was found by analysis to contain about 5.5 p. c. of insoluble matter, chiefly silicious sand, the remainder being almost entirely oxyd of iron and titanic acid.

The sand of Batiscan, mentioned above, had been purified by washing. Considerable deposits near Champlain, contain, according to Dr. Larue, about 10.0 per cent. of magnetic ore, the remainder being chiefly silicious sand. The specimens from Bersimis, Mingan, Natasquan and Kagashka, however, though collected, as I was informed, without washing, compare favorably with those from Moisie, and, with the exception of Bersimis, even surpass it in the proportion of magnetic ore. I am indebted for all of these to Dr. Larue, the professor of chemistry in Laval University, Quebec, who has paid much attention to the iron sands of the lower St. Lawrence, and collected himself the specimen from Bersimis, of which locality he has given me some interesting notes. Besides the considerable accumulations of sand on the beach, he observed, about three feet above high-water mark, two layers of black sand, holding about 30 per cent. of magnetic ore, and separated by a stratum of four inches of a gray sand containing very little iron. The three layers were traced with considerable regularity for 1000 feet along the shore. As we have seen, the sand from the beach at Bersimis contained but 34.3 per cent. of magnetic ore, and had a specific gravity of 2.81; the magnetic portion had, however, a specific gravity of 2.99, and the non-magnetic 2.77. The analyses of both of these will be found farther on.

A deposit of black sand, said to be equal in richness to that of Moisie, is described as stretching along the coast, nearly the whole distance from the Bay of Seven Islands to the mouth of the Moisie River. The sand from Mingan, which is mentioned above, and of which an analysis will be given farther on, is said to be from the west side of the St. John River, at Mingan, but is described as stretching from thence for a distance of three leagues along the coast, and as being very abundant. The deposits of sand at Natasquan and at Kagashka are also stated to be very extensive, and like Mingan, favorably situated for the loading of vessels.

An inspection of the iron sands from the various localities above mentioned, shows that they all contain, besides the ores of iron, a small proportion of red garnet, and more or less of fine silicious sand. The latter of the two substances it is possible to remove almost entirely by careful washing of the crude ore. The use of a magnet enables us to separate the black iron ore grains into a magnetic portion, which is nearly pure magnetic oxyd, and a non-magnetic portion, which is chiefly titanic iron, but, in the specimens submitted to examination, holds a portion of silicious matter, which the imperfectly washed sand still retains. In thus separating the ores into two portions for analysis, the magnetic grains were taken up by a magnet, the poles of which were covered by thin paper, and this process was repeated until the non-magnetic grains were, as far as possible, left behind. The two portions of the ore thus obtained were analyzed separately, the solvent used being, in both cases, hydrochloric acid, which, as is well known, dissolves magnetic oxyd of iron with great facility, and with certain precautions, may be advantageously employed to dissolve titanic iron ore. For this purpose the non-magnetic portion, having been very finely powdered and sifted, is left to digest with about ten times its weight of hydrochloric acid of specific gravity 1.19, or thereabouts, for several hours, or until the undissolved residue is no longer black, but grayish or brownish in color. If the process has been conducted with care, and without over-heating, the whole of the iron, and all of the titanic acid which was combined with it, will be found in solution, and may be separated by the ordinary methods. The residue, apparently, contains little else than grains of quartz, with a small proportion of garnet. The finely pulverized ore may also be fused with bisulphate of soda, a process which is more expeditious, and yields equally good results with the last.

*Moisie.*—A specimen of unwashed black sand from Moisie, holding 49.1 per cent of magnetic grains, was decomposed by digestion with hydrochloric acid, and the residue fused with bisulphate of soda. The titanic acid having been thrown down, by boiling, from the united solutions, the iron was directly determined, the other bases being neglected in this partial analysis, which gave me the following results:

I.

| | | |
|---|---|---|
| Protoxyd of iron............ | 70.10 | = metallic iron 55.23 |
| Titanic acid............... | 16.00 | |
| Insoluble, chiefly quartz..... | 5.92 | |
| | 92.02 | |

A part of the iron in these ores is in a higher state of oxydation than here indicated, but the determination of the degree of oxydation of the iron in titanic ores is difficult, and, as even the magnetic portion of the sands contains some titanic acid, it is thought advisable, in the present analyses, to represent the whole of the iron in these ores as protoxyd, giving, at the same time, the amount of metallic iron, and, in the case of the magnetic portions, the magnetic oxyd corresponding thereto. In the non-magnetic portion of the Berismis sand, however, as will be seen, the proportions of the two oxyds of iron were determined. The magnetic grains having been removed from the above sample of Moisie iron, the non-magnetic portion gave 58.20 of protoxyd of iron, 30.74 of titanic acid, and 6.14 of insoluble residue.

Further and more complete analyses were subsequently made of the washed ore from the Moisie iron-works, which, as already stated, contained 52.0 per cent. of magnetic grains. These were analyzed separately (II), while the non magnetic portion gave me the results under III. Sulphur and phosphorus are present in this sand in very small quantities, the determinations of Mr. Broome giving for the washed mixed ore 0.70 per cent. of sulphu r and .007 of phosphorus.

| | II. | III. | 1 A. |
|---|---|---|---|
| Protoxyd of iron......... | 85.79 | 56.38 | 71.08 |
| Titanic acid............. | 4.15 | 28.95 | 16.55 |
| Oxyd of manganese...... | .40 | 1.10 | .... |
| Lime .................. | .90 | .95 | .... |
| Insoluble ............... | 1.95 | 8.75 | 5.35 |
| | 93.19 | 96.19 | .... |
| Magnetic oxyd of iron... | 92.68 | .... | .... |
| Metallic iron........... | 66.73 | 43.85 | 55.27 |

The sum of the analysis II, if the iron be calculated as magnetic oxyd, is 100.08. The composition of the mixed ore, if we suppose II and III to be mixed in equal proportions, would be as under 1A, which agrees closely with the analysis I, given above.

*Bersimis.*—The iron sand of Bersimis, as already described, contained but 34.7 per cent. of magnetic grains; the analysis of this portion is given under IV.

| | IV. |
|---|---|
| Protoxyd of iron............. | 85.56 |
| Titanic acid................. | 3.40 |
| Oxyd of manganese........... | undet. |
| Lime ...................... | traces. |
| Magnesia .................. | .... |
| Insoluble.................. | 3.85 |
| | 92.81 |
| Magnetic oxyd of iron........ | 92.44 |
| Metallic iron............... | 66.56 |

The sum of the analysis, if the iron be calculated as magnetic oxyd, is 99.67. The non-magnetic portion of the Berismis sand was dissolved in hydrochloric acid, out of contact with oxygen, and the amounts of protoxyd and peroxyd of iron were separately determined. The analysis gave me as follows:

| | V. |
|---|---|
| Protoxyd of iron | 24.66 |
| Peroxyd of iron | 22.24 |
| Titanic acid | 26.95 |
| Oxyd of manganese | 1.10 |
| Lime | 1.12 |
| Magnesia | .72 |
| Insoluble | 23.80 |
| | 100.59 |
| Metallic iron | 34.94 |

*Mingan.*—The iron sand from the south of the St. John river, at Mingan, contained 48.3 per cent. of magnetic grains, whose analysis is given under VI, while that of the non-magnetic portion of the ore is found under VII.

| | VI. | VII. |
|---|---|---|
| Protoxyd of iron | 80.46 | 46.31 |
| Titanic acid | 6.50 | 31.60 |
| Oxyd of manganese | .52 | 1.35 |
| Lime | .75 | 1.06 |
| Magnesia | .70 | .50 |
| Insoluble | 4.20 | 15.50 |
| | 93 13 | 96.32 |
| Magnetic oxyd of iron | 86.92 | .... |
| Metallic iron | 65.58 | 36.00 |

The sum of the analysis VI, if the iron be estimated as magnetic oxyd, is 99.59.

In the above analyses of the iron sands it will be remarked that the magnetic portion retains a little adherent silicious matter, and small amounts of titanium, both of which vary in the sands from different localities, although the separation by means of the magnet was in all cases effected with the same precautions. Observations and experiments on other samples of these sands go to show that different layers from the same locality vary, not only in the proportion of silicious sands, but in the relative proportions of magnetic and titanic ores and of garnet. This might be expected when we consider that the differences in density between each of these constituents of the sand, should, under the influence of moving water, lead to their partial separation from each other.

A specimen of iron sand from Quogue, on the south side of Long Island, near New York, where these sands are about to be employed for the manufacture of steel, closely resembled those of

Bersimis, and contained 31 per cent. of magnetic grains. The unpurified ore, which was mingled with a considerable amount of quartz sand, and some garnet, amounting together to about 17 per cent., gave by analysis about 40 per cent. of iron, and 15 per cent. of titanium, besides a proportion of manganese greater than the iron sands from the lower St. Lawrence."

We have not space to make extracts from the other reports, which are chiefly filled with local details of great value as contributions to the Geology of Canada, but affording few points of popular interest.

If any fault can be found with this Report, it is in the small amount of Palæontology which it contains; but this, it may be supposed, is to appear in the separate reports or decades of the Palæontologist of the Survey. The present Report, it will be observed, belongs to what may be called the transition period of the Survey: the work done having been in great part under the directorship of Sir William Logan, but the issue of the Report being under that of Mr. Selwyn; who will, no doubt, in the large field now presented by the Dominion, prosecute the great work of the Survey with renewed energy and success, and render it even more creditable, if possible, to Canadian science.

J. W. D.

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## ON THE SURFACE GEOLOGY OF NEW BRUNSWICK.

BY G. F. MATTHEW, ESQ.

(Read before the Natural History Society of New Brunswick, April, 1871.)

### PART I.—THE GLACIAL EPOCH.

At the end of Prof. L. W. Bailey's Report on the Geology of the Southern part of New Brunswick (Fredericton, 1865,), will be found a few pages giving a very brief outline of its superficial geology. I now propose to consider the subject at greater length, and to record such observations as have been made in this region since the date of that report.

The Unmodified Drift being the most widely distributed of the superficial deposits in this Province, and that from which the materials of the later ones have been derived, a description of it and of the related phenomena of striation, will naturally form the subject of this paper.

Of the Triassic period some few monuments still remain in Southern New Brunswick. Scattered patches of red sandstone, resting unconformably upon the Coal Measures in the eastern part of Saint John County bear witness to the former existence of an extensive basin of these rocks, which once occupied the Bay of Fundy depression and extended eastward into the area occupied by the waters of the Gulf of St. Lawrence. These soft red rocks are monuments also of the enormous amount of denudation which the region underwent in subsequent ages; for it is only where they have been protected by ridges of hard metamorphic strata, or by the capping of basalt with which they are covered at a number of places, that any vestiges of these soft sandstones remain, around the Bay above named. Between the epoch of the Trias and the glacial period long ages elapsed which, except in the wearing away of the older formations, are not known to have left in Acadia any indications of their passage. During this interval the deposition of the Oölite, Chalk, and Tertiary formations was proceeding in Europe, and extensive accumulations were spread over wide areas in North America. They are to be found on both slopes of the Alleghanies and the Rocky Mountains.

The fossil fruits of Brandon, Vt., and the remains buried in the crumbling cliffs of Martha's Vineyard off the Southern coast of Massachusetts prove that a subtropical climate prevailed in this part of America during a part of the Tertiary Age. That such climatic conditions existed here at a period geologically so recent, would, to one who considers only the present range of temperature, seem highly improbable; but that this was the case is abundantly shown by the geological discoveries in the western part of the continent and in Iceland, where the remains of plants and animals of these intervening ages have been found. Not only does the fauna indicate the prevalence of a mild temperature in high latitudes during this period, but the character of the vegetation, in a great part of British America, was such as is now to be met with only in subtropical and warm temperate regions. Palms, cinnamon trees, and magnolias are known to have grown on the Upper Missouri and in British Columbia, and the genus *Sequoia*, to which belong the giant trees of California, with many species of hardwood (deciduous) trees as far north as Iceland.

The remarkable Miocine flora of this island has been studied by Prof. Heer, who concludes that at this period, evergreen forests must have extended to the pole. In Europe there are indications of a gradual refrigeration of the globe throughout the time of the Pliocene, but in Acadia, where this formation is wanting, we find the earlier tertiaries succeeded by the Boulder-Clay, a formation indicating climatic conditions of extreme vigour. As far south as New Jersey this deposit is of purely glacial origin, according to Prof. Dana and other New England geologists, but in the Middle and Southern States the evidence of ice-action is not so marked.

Much attention has been given to the study of glacial phenomena over large areas in America, but geologists are not yet agreed as to the causes of some of them. Prof. J. S. Newberry, in an able article read before the New York Lyceum of Natural History,* contends for the former existence of a great continental glacier over all the region included in the hydrographic basin of the St. Lawrence and Red rivers. To this cause he ascribes the excavation of the basins of the Great Lakes (except Lake Superior) skirting the Laurentian hills from the State of New York to the valley of the McKenzie River in British America. He conceives that toward the close of the glacial epoch a great fresh-water sea filled the central part of the area, extending eastward as far as the Adirondac mountains in the State of New York; and that it was bounded on the south by the water-shed between the streams which flow to the lakes, and those which seek the Mississippi, and northward by an extensive glacier resting upon the Laurentide hills. He supposes that the Erie clays spread over this area, were deposited in an immense lake during a long period of slow subsidence. At a subsequent time, as the land rose again and the waters of the lake gradually drained away, the Orange sand and other surface deposits were produced by the erosion of the clay beds, as different parts of the lacustrine area were brought under the influence of the waves.

The Orange sand of the Mississippi basin, however, appears to have had a different origin, for Prof. E. Hilgard, who had made extensive explorations in Louisiana and Texas, states that it was swept down the valley of this river by powerful southerly currents.

Both Sir W. E. Logan and Dr. Newberry assert the cotemporaneous origin of the Erie clay of the west and the Champlain (or

* Published in The American Naturalist, June, 1870.

Leda) clay of eastern Canada; and Dr. Dawson has identified these with the Marine clays of Maine. The latter are found in all the valleys near the sea level both in that State and New Brunswick, but have not been traced to any considerable height above the sea. All these clays in New England and the eastern Provinces of Canada are of marine origin, but the Erie clays were probably deposited in fresh-water. In New England as well as Acadia there are masses of superficial materials which underlie these marine clays, and should therefore be older than the Erie clay. Dr. Newberry does not appear to recognize them in the region underlaid by this deposit. These older masses of loose materials present in New Brunswick all the features of unmodified drift, and reach to the tops of the highest hills in the southern counties of that Province. While all the other surface deposits in their arrangement betray to a greater or less degree the sorting power of water, this alone, so far as has been ascertained, is unstratified throughout. It consists of clay and sand promiscuously mingled. These finer materials enclose numberless striated stones and angular fragments having no definite arrangement in the mass, but irregularly distributed throughout it. For a height of two hundred feet above the sea, the Boulder clay has been greatly modified by the action of waves and currents during a period of slow subsidence, and in the valleys it is covered with beds of fine clay.

The Continental Glacier.—Two theories have been advanced to explain the phenomena of drift, namely that which attributes them to the action of icebergs and ocean currents, and that wherein glacier action plays an important part. If the latter be ignored, it would seem no easy matter to account for some of the characteristics of the Drift in this region, such as the smoothing and furrowing of low-lying ledges under the lee of continuous hill ranges; the striation of the undersides of ledges; the transverse grooving of narrow valleys, etc. Since the topography of the region is not favourable to the formation of local glaciers, there being no high mountains in or near it, if the Acadian drift resulted from glacier erosion, the glacier would have been a widespread sheet of ice, covering the whole surface of the country, similar to those of the Antarctic continent, or of Greenland. Rivers of ice flow down to the sea-side from the wide fields of compacted snow which covers a large part of the country last named; large masses of these frozen streams are detached at the coast, and floating southward on the Arctic current along the Atlantic coast, add the distributing power of bergs to that of glaciers.

The degree of cold necessary to bring such an icy covering down to the latitude of St. John (N.B.) does not seem more improbable than the contrary amount of heat which in the preceding age enabled palms to flourish in New England and perhaps in Acadia also.

In an article on the Arctic and western plants of this region, which I had the honour to read before you two years ago, it was shewn that the mean annual summer temperature of this city was nearly two degrees lower than that of Thunder Bay on the north shore of Lake Superior. Undoubted indications of the former existence of glaciers on the north shore of that lake were seen by Prof. L. Agassiz; and Sir. W. E. Logan also alludes to similar instances observed by him. He considers glaciers to have been one of the chief agents in excavating the great lake basins.* If, during the glacial period the isothermal lines of the continent moved southward at an equal ratio in the east and west, we might readily admit that glaciers existed here as well as on the great lakes of the St. Lawrence basin.

Rigid as ice under ordinary circumstances appears, it is now well known that it possesses a certain amount of plasticity. Rendu, Agassiz, Forbes and others, who have carefully studied the Alpine glaciers, have clearly demonstrated the existence of this property in glacial ice. It enables the ice to accommodate itself to the inequalities of the surface on which it rests, and to slide down the ravines and narrow valleys of the mountain side, bearing along with it trains of boulders and loose masses of stones and earth. The rate at which glaciers move is very variable, being governed by the slope of their beds and the obstacles met by the moving ice, but it may be roughly set down at from nine inches to a yard daily for the majority of the Swiss glaciers. Glacier motion is analogous to that of rivers. Where the sheet of ice is broad and the slope moderate, the motion is slow, but where the ice passes through narrow gorges the rate of motion is accelerated. Another point of resemblance to rivers is the motion acquired in passing around curves, the strength of the current being thrown—both in the case of glaciers and rivers—on the outside of the curve. The momentum of ice in motion causes it

* Report of Progress, Canadian Survey, 1863, page 889.

to press heavily on projecting ledges of rock and exposed shoulders of hills. Hence the rocks along the sides of glaciers are striated and smoothed in a manner similar to that of the rock surfaces in New England and Canada.

Extensive as Alpine glaciers are now, they are insignificant compared with what they are shown to have been in former times, by the moraines and boulders which they have left in the low lands, both north and south of the Alps. They are known to have extended fifty miles or more downward from the mountain tops into the valley of the Po. On the north side of the Alps existed a great glacier filling the valley of the Rhone, and extending in the direction of Neufchatel. This great sheet of ice is asserted to have been from 4000 to 5000 feet in thickness, and to have had a slope from the summit of Mont Blanc to the Juras of very nearly one degree. It is also at a height of about 5000 feet that the limit of glacial striation is reached in the New England hills. Mountains which have an elevation of 4000 feet have striæ across the summit, but neither the tops of the White Hill nor (according to Prof. C. H. Hitchcock) that of Mount K'tahdin, in Maine—5300 feet high—are striated. Assuming that Acadia was, during the drift period, covered by a great glacial sheet, such as now exists in Greenland, and formerly filled the valleys of Switzerland, let us endeavour to get some idea of its probable form and depth. In doing so we should bear its physical features in mind. New Brunswick, as a whole, is a country of plains, rolling uplands, and low hill ranges. It has a group of eminences near its northern border, of which only one is known to be more than 2500 feet above the sea. Another knot of hills exist near the Chepetrieticook Lakes, on the western border; and a series of overlapping ridges, none of which much exceed 1000 feet in elevation, along the southern coast. There is not such a slope in the surface of the land as that which in New England may have given momentum to the glacial mass. The general course of the drift striæ on the higher elevations in the central and northern part of New Brunswick, is said to vary from south to two degrees east of south. This is also the course of the grooves observed at the higher levels in the Southern Hills, and it may be regarded as the probable course of the glacier in the eastern part of New Brunswick at the time of its fullest development. Such being the form and motion of this continental mass of ice, a portion would have crossed the Bay Chaleur at Gaspé, traversed the plain of eastern New Brunswick, and surmounted the more easterly ridges along the north shore of the Bay of Fundy, there being meridinal grooves on these ridges to the height of 1000 feet. Hills of this altitude must have been surmounted by a continental glacier such as we have supposed, else its motion would have been arrested at their base. But as an extensive plain stretches away to the north from the base of these hills and passes beneath the Gulf of St. Lawrence, a slope like that of the great Swiss glacier above mentioned, could not have carried the ice over the summit of this range, unless the mass of ice were two and a-half miles thick on the depression now occupied by the Bay Chaleur.

It is evident, however, from several considerations that such a mass of ice could not have existed in Acadia. A glacier of this depth would have been double the height of Mount Washington, the highest peak in Eastern North America, upon which there are no striæ at a greater height than 5000 feet. And the existing continental glacier of Greenland to which the supposed Acadian glacier has been compared, averages only about 2000 feet in thickness. The non-existence of a glacial mass exceeding this thickness may also be inferred upon physical grounds—the internal heat of the globe alone, would prevent it from attaining great thickness. From the comparison of observations carefully made in different parts of Europe it was inferred some years since that terrestrial heat increased in descending toward the centre of the earth at the rate of one degree Fahr. for every sixty feet of descent; but it was suspected that the observed rate of increase in temperature was materially effected in the case of mines (where the observations were chiefly made) by heat evolved during the decomposition of sulphurets of the metals, and in the case of artesian well, by warm waters rising from great depths through fissures in the earth's crust. A means of correcting these observations has been afforded by the Mount Cenis tunnel beneath the Alps. This artificial passage connecting Italy and Savoy is between seven and eight miles long and at one point more than a mile beneath the crest of the Alps; it therefore gives peculiar facilities for testing the heat of the earth at a point twice as far beneath the surface as any of those upon which the sixty feet ratio was based. Moreover, the rock of Mount Frejus, under which the tunnel runs, is singularly homogenous and almost entirely devoid of sulphurets; nor were any thermal springs detected, during the process of boring. The ratio of increase in temperature obtained by observations in this tunnel was one degree for every one hundred feet of descent—a rate which is probably nearer the truth than that first named. Prof. Tyndall found the winter temperature of a glacier in the Alps examined by him, at its surface, to be 5° Cent. (23° Fahr.) If we assume that the temperature of our supposed Acadian glacier at its surface was fifteen degrees lower, and the conductive power of ice only one-half that of solid rock, the heat communicated from the interior of the earth, even at the low rate observed at Mount Cenis, would if the glacier were 5000 feet thick, raise the temperature at its base above the freezing point. It may readily be perceived that this agency would exert a momentous influence on deeply buried glacial iee, converting it into that spongy mass of intimately mingled ice and water which helps to give the glacier its river-like flow. It may also be inferred, if the relative elevation of the land in different parts of New Brunswick was the same in glacial times as now, that as the glacier did not exceed 5000 feet in thickness the slope of its surface from the Bay Chaleur to the Quaco Hills, could not have been more than one-third of a degree and gravitation could have exerted very little force in pushing it on to the south over this part of its path. Unless the Laurentide Hills stood at much greater elevation then than now, and of this we have no evidence, this part of the glacial sheet (if such existed) must have been a great lake of ice, having no perceptible motion.

Glacial Erosion.—A great amount of erosive power has been attributed to glaciers, more perhaps than their known action in Alpine regions will warrant. From an address of Sir R. S. Murchison (this Journal, Feb. 1864), it may be inferred that the glaciers observed by him in the Alps have not the power of pushing out before them even the beds of sand and gravel which lie in their paths, and in some cases scarcely of disturbing the surface of the ground. He cites an instance observed by Mr. Von Der Linth, in which a glacier actually forms a bridge over a narrow gorge in the valley through which it moves. These features in the Alpine glaciers may pethaps be explained upon the grounds taken by Prof. Tyndall in discussing the influence of pressure in reducting the melting point of ice in the glaciers. He very justly infers that the *thrust* of a glacier is very materially reduced by the obstacles which it encounters in its progress down the mountain side, and by the sinuosities of its channel. The Alpine glaciers, therefore, being supported by the shoulders of the rocky ridges along their sides, may be said (if one may be allowed the expression) to *hang down* from the gorges through which they flow, into the valleys beneath; and as their weight is thus materially reduced, their erosive power is lessened; and they do not afford a fair criterion of the amount of pressure which a continental mass of ice, thousands of feet in thickness, would exercise upon the rocky ledges of the region over which it might pass. Prof. Tyndall's estimate of the weight of column of ice, would make this pressure more than 7000 lbs. to the square inch beneath a glacier 2000 feet thick. Nevertheless the glacier which may once have covered Acadia, has accomplished little in moulding the general features of the surface. At many points around the New Brunswick coal-fields, in the valleys among the Southern hills and on the coast, tongues and islands of Carboniferous sediment, yet remaining, shew that the more prominent ridges and depressions ante-date the glacial epoch. Prof. Bailey draws attention to an instance of this in the walls of a rather narrow depression through which the river St. John flows near Indian village, a few miles above Fredericton. Patches of Lower Carboniferous conglomerate may there be seen, plastered against the walls of slate, out of which the gorge was originally cut. Similar instances occur in the southern counties. Nor can the fiord-like bays of the southern coast of New Brunswick be adduced as instances of glacial erosion. Both the St. Croix and Digdeguash estuaries are Pre-Carboniferous. That of the Magaguadavic is crossed by the drift striæ at a wide angle, and the same may be said of other indentations along the coast as far east as Beaver harbour. Lepreau harbour and Basin, and Dipper harbour, are all transverse to the glacial furrows, and Musquash and St. John harbours are too wide and open to be regarded as fiords. Glaciers of the drift period may have enlarged, but they certainly did not excavate the rocky beds of these indentations to any appreciable extent. Their form though partly due to faults and folds of the older (Pre-Carboniferous) formations, is chiefly the result of erosion accomplished in early Palæozoic times. Although these larger indentations of the coast line cannot be attributed to glaciers, the Boulder-clay betrays the action of ice on the softer rocks of the country, as will be hereafter shown. It is probable that ice assisted in enlarging and deepening the small lakes and ponds, so numerous in tracts where metamorphic and granitic rocks occur. These sheets of water are usually to be found along the course of limestone bands, or at the junction of gneissic and granitic rocks with the softer Palæozoic strata. The rapidity with which hard limestone beds will waste away, even when covered by soil, is well exemplified at the manganese mine at Markhamville, King's County, N.B. At this place beds of gravelly earth, varying from three to eight feet in depth, have been removed from the limestone ledges in which the ore occurs, in the process of mining. The rock thus exposed slopes to the northward, and in its rounded outlines gives evidences of glacial erosion. In places it is filled with pockets of the ore, which being softer than the enclosing rock, must have been planed off to a level with the limestone during the glacial period; yet they now stand out above the surface of the ledge to a height of from eight to ten inches. From this it would appear that the surface of the limestone bed has wasted away to a depth equal to the height of these bosses of manganese, since the drift epoch.

Drift Striæ.—In common with New England, Quebec and Ontario, the rock surfaces in New Brunswick are in most places covered with numerous parallel grooves. In the valley of the St. Lawrence these furrows have a general south-westerly course, and in New England tend to the south-east. The latter course is maintained along the Maine border in New Brunswick, but in the central and eastern part of the Province the striæ run nearly due south. The easterly tendency of the glacial grooves along the Atlantic coast seems to be owing to the general slope of the country from the summit of the Appalachian chain to the deep-water margin of the continent. The Gulf of St. Lawrence and the New Brunswick coal-field forming an extensive plain at the eastern end of this slope, appear to have governed the course of the striæ in the central and eastern part of the province named, giving them a more direct southerly course. As far east as the river Magaguadavic the descent from the table-land of northern Maine towards the Bay of Fundy is comparatively regular, being interrupted only by a group of hills around the Chepetneticook Lakes on the river St. Croix, but eastward of this stream, in the southern part of the province, inequalities of the surface cause great variations in the course of the striæ. These variations seem to have been influenced by the contour of three districts in the Southern counties. 1st. The tract occupied by the group of granite hills extending from the Magaguadavic river to the Nerepis river. These hills vary from 700 to 1000 feet in height, and are without longitudinal valleys, but have transverse valleys of no great depth. 2nd. The area occupied by the valley of the St. John and its tributaries. This tract is characterized by a number of longitudinal ridges and valleys having a S. W. course. The ridges are broken by several transverse valleys, many of which are eroded nearly to the sea level. The third tract is the broad unbroken ridge of the Quaco hills and the slope to the Bay of Fundy on its southern side. It extends from Black river (twelve miles east of St. John) to Shepody mountain in Albert County, and rises to a height of from 900 to 1200 feet above the sea. The wide Carboniferous plain to which allusion has already been made, lying to the north of these districts, is in most parts not more than two hundred feet above the sea-level.

The table of striae given below relates chiefly to Charlotte County and the western parts of St. John and King's counties. In it the scattered observations of several years are combined, and although brief and imperfect, it will, I think, serve to show, to how great an extent the peculiarities of the several tracts above named have influenced the direction of the glacial grooves. Numbers 1 to 14 give an average of S. 45° E., and pertain to the district west of the Magaguadavic. The course of the rivers in this part of the Province mark its south-easterly slope. Numbers 15 to 21, which gives an average of S. 10° E., were taken in the granite hills and in the low country north and south of them. They probably exhibit the normal course of the glacier (?) in the middle and eastern part of New Brunswick. Numbers 22 to 33 give the course of the striæ on the eastern side of these hills as far as the St. John river. Here the average is S. 35° E. Eastward of this the influence of the ridges and intervening valleys descending south-westwardly to the St. John River, is clearly seen in the average of S. 25° W., yielded by numbers 34 to 36, 40 to 44, and 51. Numbers 46 and 47, which are on a low S.W. prolongation of the Quaco hills, by their average of S. 10° W., exhibit an approximation to the next set of striæ, which are on the ridge overlooking the Bay of Fundy and on the slope towards it. Here there is no obstacle to a direct descent to the depression, occupied by the Bay, and numbers 45, 48 to 50, and 52, in the average of S. 35° E., show a tendency to return to the strong easterly set of the striations in the western part of Charlotte county.

## Table of Drift Striæ in Southern New Brunswick.

[These notes are arranged according to the longitude of the places mentioned, from west to east. In general those described as "other striæ," are older than the grooves recorded in the margin. I am indebted to Prof. Bailey for permission to include those marked with an asterisk.]

| No. | Description of the Locality. | Exposure. | Direction. |
|---|---|---|---|
| * 1 | St. David's, on St. Stephen's Branch R.R. at Medow's station. Clay slate. | | S. 40° E. |
| 2 | Pembroke, Maine. Red slate. | N. | S. 40° E. |
| * 3 | St. Stephen, 1½ miles from Dennis stream. | | S. 50° E. |
| * 4 | St. Andrew's, opposite Doucett's Id., St. Croix River. | | S. |
| * 5 | Deer Island. Other striæ, S. 65° E. | | S. 50° E. |
| * 6 | St. Patrick's, Bocabec River, west side of St. Andrew's road. Other striæ, S. 45° E. | E. | S. 55° E. |
| * 7 | " Bocabec Bridge. " S. 30° E. | N.W. | S. 70° E. |
| * 8 | " Bocabec Bay. " S. 30° E. | | S. 45° E. |
| 9 | St. George, Mill Cove Brook, at La Tête. | N.W. | S. 60° E. |
| * 10 | " mouth of Magaguadavic river, N. side, on a ledge sloping S.W. 40°. | S.S.W. | S. 80° E. |
| * 11 | " same place. Other striæ, S. 60° E. | | S. 55° E. |
| 12 | " Magaguadavic R. Falls of " S. 80° E. | S.W. | S. 60° E. |
| * 13 | " Bliss Island. On sandstone. | N.E. | S. 30° E. |
| * 14 | " Lake Utopia, west side. | | S. 20° E. |
| 15 | Pennfield, point between Deadman's and Beaver Harbour. | | S. 10° E. |
| 16 | Clarendon, Bear Brook (broad valley). | N. | S. |
| 17 | " Sand Brook (narrow valley). | N. | S. 10° E. |
| 18 | " McLeod Road, 1½ miles from Douglas Valley. | N.W. (flat) | S. 10° E. |
| 19 | " Falls Brook (an open valley). | N. | S. 20° E. |
| 20 | Lepreau Harbour, north side. | S. | S. 10° E. |
| * 21 | Lepreau Basin, Black Duck Hole. | W. | S. 20° E. |
| 22 | Lancaster, West Branch Musquash River, at Mill, course of valley east. | N.N.W. | S. 50° E. |
| 23 | " Musquash Village, McGowan Inn. | S.E. | S. 20° E. |
| 24 | " Musquash Harb. west side of Narrows. | E. | S. 40° E. |
| 25 | " do. Connor's Cove, east side. | N.W. | S. 30° E. |
| 26 | " do. Frenchman's Creek, at bridge in narrow valley. Other striæ, S. 5° E. | N. | S. 20° E. |
| * 27 | " Spruce Lake, near the outlet. | N.W. | S. 40° E. |
| 28 | " Pisarinco Cove, Mill Creek. Other striæ, S. 50° E. | N.W. | S. 40° E. |
| 29 | " do. north side. | " (flat) | S. 35° E. |
| * 30 | Westfield on R.R. 8 miles from Fairville. | | S. 40° E. |
| * 31 | Lancaster on R.R. 4 miles from Fairville. Also on a ledge sloping 70° striæ N. 70° E. curving to | N.N.W. | S. 40° E.<br>S. 65° E. |
| * 32 | Lancaster, on R.R. 3 miles from Fairville. | N.N.E. | S. 30° E. |
| * 33 | " South Bay Mills. Other striæ, S. 40° E. | N.E. | S. 15° E. |
| 34 | Westfield, Kennebeckasis Island, N. side of, south of a ridge running N. E. | N.W. (flat) | S. 30° W |

| No. | Description of the Locality. | Exposure. | Direction. |
|---|---|---|---|
| 35 | Westfield, Kennebeckasis Island, N.E. end, hills to N.W. and E. enclosing valley opening S.S.W. | S.E. (flat.) | S. 20°W. |
| * 36 | Lancaster, west end of Suspension Bridge. | N.N.E. | S. 25°W. |
| 37 | " Sand Cove road, striæ on a steep ledge deflected to S. 80° E. from | N.W. | S. 40° E. |
| 38 | Carleton, Queen's Square, on ledge sloping to N. and N.W. Other striæ S. 4° E. | N.E. | S. 2° W. |
| 39 | " Belltower, under precipitous ledge facing........................ | N. | S. 15°W. |
| | Same place on top of ridge. | S. | S. 4° E. |
| 40 | Portland, summit of valley at Lawlor's L., course S.W. Other striæ, S. 20° W. | N.E. | S. 35°W. |
| | Fainter striæ on same ledges S. 30° W. | " | S. 45°W. |
| 41 | Simond's Black River road, 3 miles east of St John. | W. | S. 2° W. |
| 42 | " Mispec Mills, in valley south of ridge running N.NE. | S. | S. 15°W. |
| 43 | " Next stream southward (course of valley S. W.) on a hillside facing | N. | S. 40°W. |
| 44 | " Black River Road, at Brandy Brook, in shallow valley running S.W. | | S. 20°W. |
| 45 | " Beveridge Cove cross road, on ridge overlooking Bay of Fundy. Other striæ S. 35° E. | S.E. | S. 50° E. |
| 46 | " Same road, 1 mile N. of last. | | S. 5° W. |
| 47 | " Same road further N. Other striæ S. | | S. 15°W. |
| 48 | " Black River Road, east of Grassy L. | flat. | S. 30° E. |
| 50 | " Thompson's Cove cross road, at West Beach road, on slope to Bay of Fundy | S.E. | S. 40° E. |
| 49 | " Thompson's Cove cross road. | | S. 30° E. |
| 51 | " Black River Road, 1 mile N. E. of Mispec Bridge. | | S. 35°W. |
| 52 | " Mountain Road to Black River settlement, on flank of Bloomsbury Mt. | S.W. | S. 25° E. |

It is not easy to account for the strong tendency of these grooves to run down the southerly slopes of the land in this systematic way, upon the theory that they are due to icebergs alone; nor does it seem possible that ocean currents could urge the bergs onward with sufficient force to lift them over hills 700 to 1000 feet in height, and drop them down the southern slopes to groove ledges only a few feet above the sea. If the table be examined in detail, objections to the iceberg theory as the sole means of explaining surface striation, quite as weighty as those already spoken of, will be found. Others of a different kind may be adduced; as for instance the striæ on the over-hanging, as well as the exposed side, of a narrow cleft in hard felspar-porphyry rock at the head of Chamcook lake on the St. Andrew railroad.

Glacial grooves may also be seen crossing a narrow valley at the head of Mill Cove, Pisarinco, at a wide angle. Such instances might be multiplied. On the whole the phenomena of striation in this region seem more readily explicable upon Prof. Dana's theory of local glaciers under a general continental glacier, than any other.

Boulder Clay.—To the grinding power of ice and the disintegrating effects of frost during the long ages of the glacial period, are generally attributed the masses of clay and sand with imbedded stones and fragments of rock which compose the Boulder-clay. This formation is always found in countries where the surfaces of the rocks are extensively striated, and is *not stratified.* In general the stones of the Boulder-clay in New Brunswick have not been moved far from the spot where they occur *in situ.*

The following are some of the most erratic movements of surface blocks noticed by Prof. Bailey. A striated pebble of the Woodstock iron ore found near the University buildings, Fredericton: at Bradford's Cove on the St. Croix river (and also on Grand Manan island in the Bay of Fundy, G. F. M.) stones containing large coarse spirifers and other fossils of Devonian age; these are probably from the belt of Oriskany sandstone in Northern Maine, as the rock has not been met with in New Brunswick: a few miles north of St. Stephens, Prof. Bailey and Dr. Sterry Hunt met with a large boulder of labradorite similar to the rocks of this nature which occur in large masses on the north shore of the St. Lawrence in Quebec.—I may add that in the drift covering the granite hills of the Nerepis range comparatively few boulders derived from a distant source are to be seen, the debris of the Boulder-clay in this region having been swept across a low undulating country of slate, shale and sandstone. Great numbers of fragments of these rocks have been pushed up from the low-lying valley of the South Branch Oromocto river to the summit of these hills, where they are mingled with numberless boulders of granite derived from the surrounding ledges. Here there are a few well rounded masses of grey granite mingled with fragments of the red and tawny granite of which the hills are composed. At the western end of the range the grey granite blocks are quite abundant and closely resemble the coarsely porphyritic granite on the north side of the coal field at Pokioc river and elsewhere. Along the southern side of the Nerepis granite hills there is a belt of land a few miles in width covered with immense numbers of boulders, many of them of large size. So numerous are these blocks on the upper waters of the Lepreau and New rivers, that it is often possible to walk across them for several furlongs without setting foot upon the ground. They consist entirely of the red and tawny granite of these hills. In the narrow transverse valleys among the hills there are also strips of land paved with boulders and angular masses of granite. These are frequently arranged horizontally along the sides of the valleys or behind projecting spurs of the hills, and appear to have been thurst into their present positions by glacial masses pressing through the narrow openings in the hill-range. In departing southward from the foot of these eminences, boulders of this rock diminish in numbers, being gradually replaced by fragments of slate, diorite, gneiss, etc. Great numbers are, however, still to be seen along the beaches of the Bay of Fundy, ten to fifteeu miles distant from the hills.

There is one feature of the Boulder-clay in Southern New Brunswick which seems worthy of especial notice, viz. its colour, and here I include also the overlying Champlain clays which have been derived from it.* Over the district west of the Magaguadavic river, to which I have alluded in connection with the table of striæ, these clays are of various shades of gray, from ash-gray to a dark mouse colour. Similar gray tints are common to the Champlain clays of Maine and the St. Lawrence valleys. Around Passamaquoddy Bay they are often in strong contrast with the bright red rocks which underlie them. But when they are traced northward across the low granite hills of St. Patrick to the parishes of Dumbarton and St. David's, the tint of the clays gives evidence that they are derived chiefly from the rocks of these districts. Two bands of argillites cross this part of Charlotte county, of which the more southerly—of a dark grey color—has given a similar tinge to the clays resting upon and lying to the southward of it. So also the clay beds and slate debris covering the more northerly band of (calcareous) argillites and sandstone are pale gray, buff weathering beds. No sooner, however, does one pass from the country west of the Magaguadavic river to the tract occupied by the granite hills in the Eastern part of Charlotte county, then a marked change in the

* In all the cases referred to here the colour of the clay is that which it possesses when in a moist state.

colour of the clays is observable. They here vary from a pale fox-colour to a warm reddish brown tint. The colour is not derived from the red granite of these hills, for this rock is too hard to have yielded much to the grinding action of glaciers; moreover, the red tint is more pronounced to the east and north of the granite-hills than to the south of them. We must look then to some other cause for the red colour of the surface clays in Acadia. So far as New Brunswick is concerned I believe it is due to the destruction of red and chocolate-coloured shales of the Carboniferous System. Such soft rocks as these would yield readily to the erosive action of glaciers, and so might be expected to impart their colour to the detritus swept along with the ice. Strong ocean currents following the direction of the striæ could scarcely have hollowed out the low valleys which these shales are now seen to occupy, without sweeping the detritus out to the west as well as to the east of the granite hills. But as I have already stated the western clays are all of a grey colour. Much less will such currents account for the presence of these clays on the tops of the hills in question. If the aid of ice-bergs be invoked to push the debris of a sinking continent up the hill sides, we do not seem nearer a solution of the difficulty, than if the distribution of the clays were attributed to current alone. Bergs, no doubt, may have carried erratics from the northern hills across the Coal-field to this point, but such an agency seems inadequate to explain the presence of the red clays—replete as they are with countless fragments of slate and sandstone, swept up from valleys 800 or 900 feet below—on the summit of these hills. Had ice-bergs, driven southward by the polar current, forced these stones up the northern slopes of the hills during a period when the land was slowly sinking, one would expect to find the accompanying clays sorted out and carried down to lower levels. Such a current, too, must have been powerful enough to drive across these summits bergs, which, on sliding down their southern declivities would score the ledges on that side down to the sea level. Indications of southward drift are encountered at Bald Mountain,* the highest eminence in the central part of the Southern counties.

* Gesner in his first report on the Geology of N. B. (1839), page 76, gives 1120 feet as the height of this hill. It is at the eastern extremity of a spur of the intrusive granite of Charlotte County, which extends along the dividing line between King's and Queen's Counties.

On its top are numerous fragments of coarse gray diorite and hypersthenite mingled with the red granite of the mountain, which must have been carried up a steep slope from ledges 500 feet below the summit. Westward of the hill there is a broad gap in the range, to which the descent from the mountain top is nearly as steep as it is on the north. Through this opening icebergs would have found an easy passage to the low-lands south of the hills without being compelled to ascend the mountain.

The influence of the soft carboniferous shales upon the colour of the Boulder and Champlain clays of the district to which the fourth group of striæ belongs, is even more noticeable than their effect upon that of the granite country. The four longitudinal valleys which here terminate in the valley of the St. John river, like the harbours to which I have alluded, ante-date the Carboniferous age, and are occupied to a greater or less extent by Carboniferous strata. This is more especially the case at the upper ends of the valleys, for at the lower ends, where they connect with the valley of the St. John, denudation has swept away the greater part of these deposits. In this way beds of soft slates of the St. John group (Primordial) are usually revealed in the valleys, the dividing ridges being in most cases hard rocks of the Huronian and Laurentian systems. The slates of the St. John group lying in these narrow valleys, while they have evidently contributed to the formation of the surface clays, do not appear to have deepened their colour materially, or caused them to approximate in tint to the gray clays of western Charlotte County. In the large areas of red, gray and chocolate-coloured shales of the Lower Carboniferous formation, about the upper ends of these valleys, a continental glacier would find ample scope for extensive erosion; hence it is not surprising that dark reddish-brown and liver-brown shades should be found to prevail in the Leda or Champlain clays about the city of St. John.

Moraines.—The region over which the Unmodified Drift in southern New Brunswick is spread, is to a great extent forest-clad, and its surface features concealed from view. In the lower districts which are cleared and settled, the drift has been greatly disturbed by the play of strong ocean currents over the surface of the land at the opening of the Champlain epoch. Hence it will be difficult to determine how far the ridges of coarse materials, often many miles in length (denominated Horsebacks) are old moraines, or to what extent they consist of accumulations in the slack-water of the polar current which swept over the land in Post-pliocene times. All the ridges near the coast which I have examined have been worked over to a considerable depth, and some are stratified throughout. On the northern side of the gravel ridge, known as Pennfield Ridge, which lies on the eastern margin of the gray clay district in Charlotte County, there is said to be a tract covered by heavy beds of granite boulders without any admixture of soil.

Conclusions.—The observations upon which this paper is founded are too few and imperfect to form the basis of positive conclusions, but I will here summarize the results to which they appear to point.

1st. The present summer climate of a large part of Acadia is such as to compare with that of the region around Lake Superior, where, according to Prof. L. Agassiz and Sir W. E. Logan, glaciers existed during the Drift period. The resemblance in the climatic conditions of the two regions is shown both by their mean summer temperatures and by the distribution of indigenous plants, (this Journal, June, 1869). The authority of Messrs. L. Agassiz and J. D. Dana may be quoted in favour of the former existence of glaciers in southern New England, which enjoys a summer temperature considerably higher than Acadia.

2nd. Some of the phenomena of the drift epoch, such as the direction and position of the glacial striæ, and the distribution of the Boulder-clay, do not appear susceptible of explanation on the hypothesis that icebergs and ocean-currents alone produced them. And it seems reasonable to suppose that a great sheet of ice similar to the continental glaciers of Greenland and the Antarctic regions, which will explain these phenomena, covered the Lower Provinces during the glacial epoch; and that while the general course of this mass was southward toward the then existing ocean, the motion of the deeply buried ice in the bottom of the glacier was partly governed by the configuration of the land beneath it.

3rd. That while the western portion of this icy mass was steadily moving down the Atlantic slope from the table land of northern Maine, and the eastern pushing across the low swell of land which separates the Gulf of St. Lawrence from the Bay of Fundy, the motion of the central portion of the ice-sheet, which could have had but a slight inclination, would have been impeded or nearly arrested by the southern hills of New Brunswick.

4th. That such portions of the glacier as were pushed over the tops of these hills, or through the narrow valleys between them, conformed in some degree to the slope of the surfaces over which they moved.

5th. The erosion effected by the glacier was chiefly in the softer rocks of the country; the harder ones resisting the attritive power of the ice, and preserving with comparatively little change their Pre-glacial outline.

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## ON THE FOOD AND HABITS OF SOME OF OUR MARINE FISHES.

BY PROFESSOR A. E. VERRILL.

When we consider the great importance and extent of our fisheries, it seems very remarkable that so little reliable information has been recorded concerning the habits, even of our most common and important species of fishes. It is certainly true that the habits of fishes, and especially of marine fishes, are more difficult to observe than those of birds and beasts, but this ought not to be a sufficient excuse at the present day, for the marked neglect of this department of Natural History. The nature of the food of the more abundant species, even including those that are most commonly sold as food, is still very imperfectly known. Observations must be made in great numbers in various localities and at all seasons of the year before we can obtain adequate knowledge of this subject.

During several years past I have improved such opportunities as have occurred to make observations of this kind, and although they are very incomplete, and often isolated, I am induced to present some of the facts thus ascertained, hoping that the attention of others may be directed to the same subject.

While spending a few days at Great Egg Harbor, on the coast of New Jersey, in April of this year, I dissected the stomachs of many specimens of the common fishes, which were at that time being taken in seines in the shallow water of the bay near Beesley's Point. The following were the principal results, in regard to their food. The Striped-bass, or 'Rock' (*Roccus lineatus* Gill) had its stomach filled with large quantities of shrimp (*Cran-*

*gon vulgaris*) unmixed with any other food. This shrimp is very abundant on all sandy bottoms in shallow water along the whole coast, from Labrador to Cape Hatteras, and seems to contribute very largely to the food of many of our most valuable fishes.

The White Perch (*Merone Americana*) contained the same shrimp in abundance.

The Weak-fish (*Cynoscion regalis* Gill), called 'Blue-fish' at that locality, had its stomach filled with the same Crangon.

The King-fish (*Umbrina regalis*) called 'Hake' on the New Jersey coast, contained nothing but *Crangon vulgaris*.

The Toad- or Oyster-fish (*Batrachus tau*) is almost omnivorous. The stomach is large and usually distended with a great variety of food. Young edible crabs (*Callinectes hastatus* Ordw.) up to two inches across, *Crangon vulgaris*, and the common prawn (*Palæmoa vulgaris* Say) were its principal articles of diet at that locality; but pipe-fishes (*Syngnathus Peckianus*) six inches long, and the common black Nassa (*Ilyanassa obsoleta*) were often found in their stomachs, as well as various young fishes of other species, among which were specimens of the Anchovy (*Engraulis vittata*). The toad-fish is, therefore, a fish that should not be encouraged.

The Shad (*Alosa tyrannus* Gill) contained large quantities of fragments of small crustacea, chiefly a small shrimp-like species (*Mysis Americanus* Smith) which was also captured alive in tide-pools on the salt marsh. Shad from the mouth of the Connecticut River, taken in May, contained the same, or another allied species of Mysis. Some of the shad had also fragments of eel-grass (perhaps accidental) mixed with the crustacean fragments.

The 'Hickory Shad' (*Meletta Mattawocca*), the young called 'Herring' at the locality, were also filled with comminuted crustacea, among which the common shrimp (*Crangon vulgaris*) could be recognized most frequent.

The Moss-bunker or Menhaden (*Brevoortia Menhaden* Gill), invariably had its stomach and voluminous intestine filled with the soft, oozy mud—containing a large proportion of organic matter—which abounds in the quiet part of this and all similar bays along the coast. This fish appears, therefore, to obtain its nutriment by swallowing the mud and digesting the organic particles contained in it,—a mode of feeding for which its complex digestive apparatus and toothless mouth are specially adapted. Many marine worms, bivalve mollusks, and echinoderms feed upon the same kind of food, which is everywhere abundant. The Mossbunker is often infested by a large parasitic Lernean (*Lernocera radiata* Les.) which buries its star-shaped head deeply in the flesh.

The Summer Flounder (*Chœnopsetta ocellaris*) contained an abundance of shrimps (*Crangon vulgaris* and *Mysis Americanus*). In one specimen we found a full-grown *Gebia affinis* Say.

The Spotted Flounder (*Lophopsetta maculata* Gill) feeds largely upon crustacea of various kinds. Many specimens contained large quantities of shrimps and prawns (*Crangon vulgaris*, *Palœmon vulgaris* and *Mysis Americanus*), the latter often making up the bulk of the contents of the stomach. In addition to these, *Gammarus mucronatus* Say, and *Gebia affinis* Say, were sometimes found. The Gebia we obtained in considerable numbers by digging them out of their long, crooked burrows at low-water mark, near Mr. Peacock's hotel at Beesley's Point. The burrows, which are made in a tenacious clay soil, often with decaying sea-weed beneath, are from half an inch to nearly an inch in diameter, with smooth walls. They are several feet in depth and very long and tortuous. The Gebia has a distant resemblance to a young lobster about two or three inches long. The real lobster was not found on the New Jersey coast. The species of crustacea found in the fishes above named, are all common in the shallow waters of the bay among eel-grass, with the exception of the *Crangon vulgaris*, which frequents open sandy bottoms, living half buried in the sand, with which its colour exactly accords, furnishing an excellent illustration of imitative adaptation for protection.*

*Ophidium marginatum* DeKay. This species appears to be

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* Many other crustacea of our coast afford similar instances. *Palæmon vulgaris* by its transparency and peculiar tints is scarcely distinguishable among eel-grass; *Idotœa irrorata* imitates in all its varied patterns of colour the eel-grass and sea-weeds on which it lives; *I. cæca* imitates the color of sand; two species allied to *Sphæroma* imitate the colours of the rocks and white barnacles among which they live; *Crangon boreas* of the northern coast, imitates the colours of the red Nullipores among which it seeks concealment, as do also several species of *Hippolyte*, *Chiton ruber*, *C. marmoreus*, *Ophiopholis aculeata* and *Ophioglypha robusta*. Numerous other instances might be given.

very rare and its habits little known. We dug two specimens out of the sand near low-water mark, where they burrowed to the depth of a foot or more. When placed upon moist sand they burrowed into it, tail foremost, with surprising rapidity, disappearing in an instant.

At Fire Island on the southern side of Long Island, Mr. S. I. Smith observed last August a species of worm (*Heteronereis*) of a reddish colour and two or three inches long, swimming in large numbers at and near the surface. These were at that time the favourite food of the Blue-fish (*Temnodon saltator*).

At Eastport in Maine, and at Grand Menan, during several years past, I have made many observations on this subject, but mostly relating to fishes of which the habits are better known, like the cod, hake, haddock, etc.

The Wolf-fish (*Anarrhicas vomerinus*) is not at all particular as to its food. At Eastport I took from the stomach of a large one at least four quarts of the common round sea-urchin (*Euryechinus Dröbachiensis*,), most of them with the spines on, and many of them quite entire. From another I took an equal quantity of a mixture of the same sea-urchin and the large whelk (*Buccinum undulatum*). Many of the latter were entire or but slightly cracked.

The Sculpins not unfrequently swallow entire, large specimens of several crabs (*Cancer irroratus*, *Hyas coarctatus*, etc.)

The Haddock is addicted to the same habit, but is a general feeder, swallowing all sorts of mollusca, worms, fishes. etc.

The Herring (*Clupea elongata*) in the Bay of Fundy feeds very extensively, at least during all the months when I have observed them (June to November), upon several species of *Mysis* and of *Thysanopoda*, called 'shrimp' by the fishermen, which swim free, at and near the surface, in extensive 'schools,' and are persistently pursued by the herring. The commonest species, apparently a Thysanopoda, is about an inch and a half long, of a pale reddish colour. The species of Mysis are smaller and paler; the two genera often occur together. Young Pollock or Coal-fish, four to ten inches long, pursue the same species in large schools, often coming around the wharves of Eastport in great numbers in eager pursuit of their prey, and by leaping out after them, produce a great commotion in the water. When thus pursued the Thysanopoda will leap out of the water to the height of a foot or more. The common Sebastes, or Red Perch, at Eastport, feeds upon the same species when they come around the wharves, but probably does not pursue them to the same extent as the herring and pollock.—*The American Naturalist.*

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NOTE ON THE FOOD OF THE SALMON.—The salmon is a greedy feeder while in the salt-water. Having examined large numbers of these fish just taken from the nets at several of the fisheries on the north shore of the St. Lawrence, I have uniformly found them to be gorged with food,—as heavily gorged and with the same food as were the cod-fish and other ground-feeders taken in the same neighbourhood at the same time. Large shoals of small fish visit these coasts during the summer and autumn; sometimes of sand-launce (*Ammodytes* sp.), sometimes of smelts (*Osmerus mordax* Gill), more frequently of capelin (*Mallotus villosus* Rich.), and these form the staple food of all the larger fish. I have taken as many as twenty-five capelins from the stomach of a salmon, besides a quantity of half-digested matter. The spawn of the echinoids is said to be largely eaten by the salmon, and to account for the colour of his muscle; be that as it may, doubtless nothing juicy and palatable comes amiss to him, and his condition shews that he feeds to good purpose. On the other hand, I have never found any food whatever in the intestines of a salmon taken in the fresh-water; one or two small flies occasionally, or a winged bug, probably taken in sport, and more frequently intestinal worms, formed the sole contents of the collapsed stomach and intestinal canal. From lack of food or otherwise, his stay in our Lower Canada rivers is evidently a prolonged fast, during which he lives on his tissues, consuming them sometimes even to dissolution.

D. A. WATT.

## GEOLOGY AND MINERALOGY.

Prof. Newberry on the Ancient Lakes of Western America.—The following extracts from an article by Dr. Newberry, contributed to the American Naturalist, and intended to form a part of Dr. Hayden's forthcoming work,— Sun Pictures of the Rocky Mountains —will be read with interest.
extract relates to the topography of the region referred to:—

Without going into details or citing the facts or authorities on which our conclusions rest, I will, in a few words, give the generalities of the geological and topographical structure of that portion of our continent which includes the peculiar featnres that are to be more specially the subject of this paper.

It is known to most persons that the general character of the topography of the region west of the Mississippi has been given by three great lines of elevation which traverse our territory from north to south; the Rocky Mountain Belt, the Sierra Nevada and the Coast Ranges. Of these, the last is the most modern, and is composed, in great part, of Miocene Tertiary rocks. It forms a raised margin along the western edge of the continent, and has produced that "iron bound coast" described by all those who have navigated that portion of the Pacific which washes our shores.

Parallel with the Coast Mountains lies a narrow trough which, in California, is traversed by the Sacramento and San Joachin Rivers, and portions of it have received their names. Further north, this trough is partially filled, and for some distance, nearly obliterated by the encroachment of the neighboring mountain ranges, but in Oregon and Washington it reappears essentially the same in structure as further south, and is here traversed by the Williamette and Cowlitz Rivers.

These two sections of this great valley have now free drainage to the Pacific, through the Golden Gate and the trough of the Columbia, both of which are channels cut by the drainage water through mountain barriers that formerly obstructed its flow, and produced an accumulation behind them that made these valleys inland lakes; the first of the series I am to describe of extensive fresh-water basins that formerly gave character to the surface of our Western Territory, and that have now almost all been drained away and have disappeared.

East of the California Valley lies the Sierra Nevada; a lofty mountain chain reaching all the way from our northern to our southern boundary. The crest of the Sierra Nevada is so high and continuous that for a thousand miles it shows no passes less than five thousand feet above the sea, and yet, at three points there are gate-ways opened in this wall, by which it may be passed but little above the sea-level. These are the canons of the Sacramento (Pit River), the Klamath, and the Columbia. All these are gorges cut through this great dam by the drainage of the interior of the continent. In the lapse of ages the cutting down of this barrier has progressed to such an extent as almost completely to empty the great water basins that once existed behind it, and leave the interior the arid waste that it is—the only real desert on the North American Continent.

The Sierra Nevada is older than the Coast Mountains, and was projected above the ocean, though not to its present altitude, previous to the Tertiary and even Cretaceous ages. This we learn from the fact, that strata belonging to these formations cover its base, but reach only a few hundred feet up its flanks. The mass of the Sierra Nevada is composed of granitic rocks, associated with which are metamorphic slates, proved by the California Survey to be of Triassic and Jurassic age. These slates are traversed in many localities by veins of quartz, which are the repositories of the gold that has made California so famous among the mining districts of the world.

East of the Sierra Nevada we find a high and broad plateau, five hundred miles in width, and from four thousand to eight thousand feet in altitude, which stretches eastward to the base of the Rocky Mountains and reaches southward far into Mexico. Of this interior elevated area the Sierra Nevada forms the western margin, on which it rises like a wall. It is evident that this mountain belt once formed the Pacific coast; and it would seem that then this lofty wall was raised upon the edge of the continent to defend it from the action of the ocean waves. In tracing the sinuous outline of the Sierra Nevada, it will be seen that its crest is crowned by a series of lofty volcanic cones, and that one of these is placed at each conspicuous angle in its line of bearing, so that it has the appearance of a gigantic fortification of which each salient and re-entering angle is defended by a massive and lofty tower.

The central portion of the high table lands, to which I have referred, was called by Fremont the Great Basin, from the fact that it is a hydrographic basin, its waters having no outlet to the ocean. The northern part of this area is drained by the Columbia, the southern by the Colorado. Of these the Columbia makes its way into the ocean by the gorge it has cut in the Cascade Mountains, through which it flows nearly at the sea level; while the Colorado reaches the Gulf of California through a series of canons, of which the most important is nearly one thousand miles in length, and from three thousand to six thousand feet in depth. In Volume vi. of the Pacific Railroad Reports, I have described a portion of the country drained by the Columbia, and have given the facts which led me to assert that the gorge through which it passes the Cascade Mountains has been excavated by its waters; and that previous to the cutting down of this barrier these waters accumulated to form fresh-water lakes, which left deposits at an elevation of more than two thousand feet above the present bed of the Columbia. Similar facts were observed in the country drained by the Klamath and Pit Rivers, and all pointed to the same conclusion.

In all this region I observed certain peculiarities of geological structure that have been remarked by most of those who have traversed the interval between the Sierra Nevada and the Rocky Mountains. In the northern and middle portions of the great table lands the general surface is somewhat thickly set by short and isolated mountain ranges, which have been denominated The Lost Mountains. These rise like islands above the level of the plain, and are composed of volcanic or metamorphic rocks. The spaces between those mountains are nearly level, desert surfaces, of which the underlying geological structure is often not easily observed. Toward the north and west, however, wherever we come upon the tributaries of the Columbia, the Klamath or Pit Rivers, we find the plateaus more or less cut by these streams and their substructure revealed.

Here the underlying rocks are nearly horizontal, and consist of a variety of deposits varying much in color and consistence. Some are coarse volcanic ash with fragments of pumice and scoria. Others I have in my notes denominated 'concrete,' as they precisely resemble the old Roman cement and are composed of the same materials. In many localities these strata are as fine and white as chalk, and, though containing little or no carbonate of lime, they have been referred to as "chalk beds" by most travellers who have visited this region. Specimens of this chalk-like material gave me my first hint of the true history of these deposits. These, collected on the head waters of Pit River, the Klamath, Des Chutes, Columbia and elsewhere, were transmitted for examination to Professor Bailey, then our most skilled microscopist. Almost the last work he did before his untimely death was to report to me the results of his observation on them. This report was as harmonious as it was unexpected. In every one of the chalk-like deposits to which I have referred he found fresh-water diatomaceæ.

From the stratification and horizontality of these deposits, I had been fully assured that they were thrown down from great bodies of water that filled the spaces separating the more elevated portions of the interior basin, and here I had evidence that this water was fresh. Since that time a vast amount of evidence has accumulated to confirm the general view then taken of the changes through which the surface of this portion of our continent has passed. From South-western Idaho and Eastern Oregon I have now received large collections of animal and vegetable fossils of great variety and interest. Of these the plants have been, for the most part, collected by Rev. Thomas Condon, of the Dahll, Oregon, who has exposed himself to great hardship and danger by his several expeditions to the localities in Eastern Oregon, where these fossils are found. The plants obtained by Mr. Condon are apparently of Miocene age, forming twenty or thirty species, nearly all new and such as represent a forest growth as varied and luxuriant as can be now found on any portion of our continent.

The animal remains contained in these fresh-water deposits have come mostly from the banks of Castle Creek in the Owyhes district, Idaho. The specimens I have received were sent me by Mr. J. M. Adams, of Ruby City. They consist of the bones of the mastodon, rhinoceros, horse, elk, and other large mammals, of which the species are probably in some cases new, in others identical with those obtained from the fresh-water Tertiaries of the 'Bad Lands' by Dr. Hayden. With these mammalian remains are a few bones of birds and great numbers of the bones and teeth of fishes. These last are Cyprinoids allied to *Mylopharodon*, *Milochsilus*, etc., and some of the species attained a length of three feet or more. There are also in this collection large numbers of fresh-water shells of the genera *Unio*, *Corbicula*, *Melania* and *Planorbis*.* All these fossils show that at one

* One of the most common is a species of Tiara closely resembling an East Indian one, while the genus no longer exists in this continent.

period in the history of our continent, and that geologically speaking quite recent, the region under consideration was thickly set with lakes, some of which were of larger size and greater depth than the great fresh-water lakes which now lie upon our northern frontier. Between these lakes were areas of dry land covered with a luxuriant and beautiful vegetation, and inhabited by herds of elephants and other great mammals, such as could only inhabit a well-watered and fertile country. In the streams flowing into these lakes, and in the lakes themselves, were great numbers of fishes and molusks, of species, which like the others I have enumerated, have now dissappeared. At that time, as now, the great lakes formed evaporating surfaces, which produced showers that vivified all their shores. Every year, however, saw something removed from the barriers over which their surplus water flowed to the sea, and, in the lapse of time, they were drained to the dregs. In the Klamath lakes, and in San Francisco, San Pablo and Suisun bays, we have the last remnants of these great bodies of water; while the drainage of the Columbia lakes has been so complete, that in some instances, the streams which traverse their old basins have cut two thousand feet into the sediments which accumulated beneath their waters.

The history of this old lake country, as it is recorded in the alternations of strata which accumulated at the bottoms of its water basins will be found full of interest. For while these strata furnish evidence that there were long intervals when peace and quiet prevailed over this region, and animal and vegetable life flourished as they now do nowhere on the continent, they also prove that this quiet was at times disturbed by the most violent volcanic eruptions, from a number of distinct centres or action, but especially from the great craters which crowned the summit of the Sierra Nevada. From these came showers of ashes which must have covered the land and filled the water so as to destroy immense numbers of the inhabitants of both. These ashes formed strata which were, in some instances ten or twenty feet in thickness. At other times the volcanic action was still more intense, and floods of lava were poured out which formed continuous sheets, hundreds of miles in extent, penetrating far into the lake basins, and giving to their bottoms floors of solid basalt. When these cataclysms had passed, quiet was again restored, forests again covered the land, herds dotted its pastures, fishes peopled the waters, and fine sediments, abounding in forms of life, accumulated in new sheets above the strata of cooled lava. The banks of the Des Chutes River and Columbia afford splendid sections of these lake deposits, where the history I have so hastily sketched may be read as from an open book.

But, it will be said that there are portions of the great central plateau which have not been drained in the manner I have described. For here are basins which have no outlets, and which still hold sheets of water of greater or less area, such as those of Pyramid Lake, Salt Lake, etc. The history of these basins is very different from that of those already mentioned, but not less interesting nor easily read. By the complete drainage of the northern and southern thirds of the plateau through the channels of the Columbia and Colorado, the water surface of this great area was reduced to the tenth or one-hundredth part of the space it previously occupied. Hence, the moisture suspended in the atmosphere was diminished in like degree, and the dry hot air, sweeping over the plains, licked up the water from the undrained lakes until they were reduced to their present dimensions. Now, as formerly, they receive the constant flow of the streams that drain into them from the mountains on the east and west, but the evaporation is so rapid that their dimensions are not only not increased thereby, but are steadily diminishing from year to year. Around many of these lakes, as Salt Lake for example, just as around the margins of the old drained lakes, we can trace former shore lines and measure the depression of the water level. Many of these lakes of the Great Basin have been completely dried up by evaporation, and now their places are marked by alkaline plains or "salt flats." Others exist as lakes only during a portion of the year, and in the dry season are represented by sheets of glittering salt. Even those that remain as lakes are necessarily salt, as they are but great evaporating pans, where the drainage from the mountains, which always contains a portion of saline matter, is concentrated by the sun and wind until it becomes a saturated solution, and deposits its surplus salt upon the bottom. * * * * *

The pictures which geology holds up to our view, of North America during the Tertiary ages, are, in all respects but one, more attractive and interesting than could be drawn from its present aspects. Then a warm and genial climate prevailed from the Gulf to the Arctic Sea; the Canadian highlands were higher, but the Rocky Mountains lower and less broad. Most of the continent exhibited an undulating surface; rounded hills and broad valleys covered with forests grander than any of the present day, or wide expanses of rich savannah over which roamed countless herds of animals, many of gigantic size, of which our present meagre fauna retains but a few dwarfed representatives. Noble rivers flowed through plains and valleys, and sea-like lakes broader and more numerous than those the continent now bears diversified the scenery. Through unnumbered ages the seasons ran their ceaseless course, the sun rose and set, moons waxed and waned over this fair land, but no human eye was there to mark its beauty, or human intellect to control and use its exuberant fertility. Flowers opened their many colored petals on meadow and hill-side, and filled the air with their fragrance, but only for the delectation of the wandering bee. Fruits ripened in the sun, but there was no hand there to pluck, nor any speaking tongue to taste. Birds sang in the trees, but for no ears but their own. The surface of lake or river was whitened by no sail, nor furrowed by any prow but the breast of the water-fowl; and the far-reaching shores echoed no sound but the dash of the waves, and the lowing of the herds that slaked their thirst in the crystal waters.

Life and beauty were everywhere; and man, the great destroyer, had not yet come, but not all was peace and harmony in this Arcadia. The forces of nature are always at war, and redundant life compels abundant death. The innumerable species of animals and plants had each its hereditary enemy, and the struggle of life was so sharp and bitter that in the lapse of ages many genera and species were blotted out forever.

The herds of herbivores—which included nearly all the genera now living on the earth's surface, with many strange forms long since extinct—formed the prey of carnivores commensurate to these in power and numbers. The coo of the dove and the whistle of the quail were answered by the scream of the eagle; and the lowing of herds and the bleating of flocks come to the ear of the imagination, mingled with the roar of the lion, the howl of the wolf, and the despairing cry of the victim. Yielding to the slow-acting but irresistible forces of nature, each in succession of these various animal forms has disappeared till all have passed away or been changed to their modern representatives, while the country they inhabited, by the upheaval of its mountains, the deepening of its valleys, the filling and draining of its great lakes, has become what it is.

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# OBITUARY NOTICE.

Mr. Edward Hartley, who died in Pictou, Nova Scotia, on the 10th November last, was the eldest son of Mr. William M. B. Hartley, of New York, and grandson of Mr. Philos Blake, of New Haven, U.S. He was born in Montreal on the 8th of November, 1847, and was consequently little over twenty-three years of age. Educated in the schools of Messrs. French & Russell, of New Haven, he early showed a great aptitude for the study of the natural and physical sciences, and for mechanics, tastes which he inherited from both of his parents. At the age of fifteen he became a student in the Sheffield Scientific School of Yale College, where he completed the course of study with much credit to himself. Though still very young, he was, on leaving the school, at once charged with the examination and surveying of mineral lands in Maryland and Pennsylvania, and subsequently with the erection of machinery for washing gold, in North Carolina. His abilities attracted the attention of the officers of the geological survey of Canada, under Sir William Logan, and in July, 1868, he joined the survey as a geological assistant; the following year he was appointed Mining Engineer to the geological survey. His duties from this time confined him to the Coal Fields of Nova Scotia, where, in 1868, he worked conjointly with Sir William Logan and in 1869, alone, completing a careful and detailed survey of the Pictou Coal basin, of which an elaborate report by Sir William and another by himself, was printed and privately distributed before his death. It will be published with a map in the forthcoming volume of the geological survey.

The Appendix to this report contains a large number of coal analyses made by Mr. Hartley in the laboratory of the survey, and also numerous experiments on the heating power of the various steam coals as compared with each other and with wood. These practical trials were made in trips of several hour each on steamers and locomotives, and occupied several weeks. They were conducted in such a manner as to command the full confidence both of the railway officials and the coal owners, and cannot fail to be of great public value.

During 1870, Mr. Hartley was engaged with an assistant, in the survey of the Cumberland coal-basin in Nova Scotia, and of the Cape Breton collieries, and had nearly completed his labours for the season, when he died of an inflammation of the bowels, of only six days duration, brought on, it is to be feared, by labour beyond his physical strength.

Mr. Hartley had rare qualities, and remarkable acquirements. His acquaintance with chemistry and mineralogy, as well as with geology, mining and mechanics, was singularly acurate and extended for one of his years, but his habits of study and intense application explained his remarkable attainments. Added to this his moral and social qualities had made for him, wherever known, a great number of friends. He was a Fellow of the Geological Societies of London and France; a member of the institute of Engineers of Scotland; of the institute of Mining and Engineering of the North of England, and of various local societies.

T. S. H.

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Geographical Science.—The question of higher Geographical education, mooted a few days since, through a contemporary by a distinguished Fellow of the Royal Geographical Society, is of so much importance to the educational world, and of such absorbing interest to myself personally, as to lead me to solicit a brief space in your columns. It is not now for the first time that the necessity of obtaining the recognition of geographical science on the part of the leading educational bodies—*i. e.*, the Universities—has been indicated as the absolutely indispensable condition to its culture in our higher schools and colleges. Reference to your own columns will show that this was pointed out by myself long since (*The Athenœum*, No. 2100), and that I urged the Royal Geographical Society to a course of action which might help to bring about a consummation so eargerly desired by workers who, like myself, have employed years of active exertion in promoting the pursuit of a study which, in regard to its higher aims, is less recognized—even, I will go so far as to say, less understood—in the schools of Britain than in those of any other country of Europe. Educated foreigners regard with astonishment the fact that, amongst a nation which forms the central point of commerce and of colonial enterprise to the modern world—whose merchants have dealings with every land, and whose statesmen require to take cognizance of the climatic and other geographical conditions of dependencies that lie under the most widely-separated meridians—the culture of Geography, in its higher sense, passes without recognition on the part of those who of necessity give the tone to actual workers in the education of the youth of Britain, and brings its devotees none of the honours or more substantial rewards which may fall to the lot of students in other walks of science. No endowment gives encouragement to the cultivator of geographical science—no university even recognizes his labours. Students in schools and colleges must of necessity concentrate their more advanced efforts upon subjects for which they can obtain the coveted reward, and the only Geography they learn is that which belongs to the most rudimentary stage of education—is not, indeed, Geography at all in its higher acceptance and aim. All this, and more than this, has been pointed out long since; and there belongs to myself at least the consciousness of having laboured during many years to give a better direction to the culture of Geography, so as to realize for it something at least of that comprehensiveness of meaning which German men of science recognize as embodied in the expressive word "Erdkunde." But knowing this, and acting, to the best of my opportunities, on the knowledge, the results indicated by Mr. Galton—in reference to the recent offer of medals, to be competed for amongst certain schools, on the part of the Royal Geographicial Society—in no degree surprise me; nor can I apprehend that they will occasion any suprise on the part either of the heads of schools or of practical workers in the class-room. They are precisely such as might have been anticipated, and such as (I can vouch from personal knowledge) *were* anticipated by some at least among the soundest and most advanced of educators. However high may be the estimate placed on proficiency in geographical knowledge—and I, at least, shall not be suspected of undervaluing its claims—it is manifest that the conditions under which its rewards can be sought must (if they are to bear any practical issue) be in harmony with other, and in no degree less important, objects claiming the teacher's attention. In other words, the Geography which, in common wish many fellow-workers, I earnestly wish to see introduced into the curriculum of our higher-class schools and colleges, must take its proper place in the well-considered and matured scheme of education as a whole. To claim for it an undue and all-absorbing regard—or what, in the working of the class-room, such as the practical education alone can know it, amidst the multiplied claims on the attention of the learner at the present day, may prove to be such—is to incur the risk of frustating the entire aim and of doing injury rather than service to a good cause. WM. HUGHES.

King's College, London, June 15, 1871.

Dr. Keith Johnston.—The death of Alexander Keith Johnston, LL.D., is an event which will be sincerely deplored by the whole scientific world; but although he was a man of varied accomplishments, and a member of many learned and scientific societies, his eminence as a geographer will be his chief title to future remembrance. His devotion to geographical science was profound, and for nearly half a century he earnestly strove to promote and disseminate what the Germans happily term 'earth knowledge.' Only seven weeks before his death he received from the Royal Geographical Society the Patron's Gold Medal—a distinction which every true geographer must honourably covet, but which few can ever hope to receive. "His distinguished services in the promotion of physical geography" were thus fitly recognized, although the intense devotion which won him the honour cut short his life soon after the reward was given. Dr. Johnston was born at Kirkhill, near Edinburgh, in December, 1804, and was educated at the Edinburgh High School. He was intended for the medical profession, but after a time he gave up the course of study which he was pursuing for this purpose, and learned the art of engraving, which was subsequently turned to such good account. But his early predilection for geographical studies having increased with his years, and being animated with a strong desire to accomplish something better than had hitherto been attempted in his own country, he determined to make geography his profession, and to devote his whole energies to the prosecution of the absorbing pursuit on which he resolved to enter. Dr. Johnston's first great work was his 'National Atlas,' in folio, which was published, after five years' incessant labour, in 1843. Most of the maps were projected and drawn by himself, and nearly all the names written with his own hand. This work went through many editions, and secured for the author the appointment of Geographer-Royal for Scotland. Humboldt having expressed a wish for an English Physical Atlas, Dr. Johnston resolved to construct one on the scale required. He visited Germany in 1842, for the purpose of collecting materials and making other necessary arrangements, and on his return he laid his plans before the Secretary of the Royal Geographical Society. At that period physical geography was scarcely taught in any of our schools; hence there was but little prospect of any early pecuniary return for the immense labour which would have to be bestowed on such a work as that in contemplation. But these were precisely the circumstances under which Dr. Johnston would be likely to distinguish himself. His own passionate devotion to geographical science induced the determination to make the study take its place among the necessary branches of a liberal education. He received the warmest encouragement from the Royal Geographical Society, from Karl Ritter, and from Humboldt,—a special interview with the latter having taken place in Paris in Paris in 1845, on the subject of the Physical Atlas; while the former geographer explained the original merits of the work at a meeting of the Geographical Society of Paris. This Atlas was at first intended to be founded mainly on the great work of Berghaus: but, as its construction proceeded, the number of additions and improvements that were found necessary caused the abandonment of this intention, and Dr. Johnston's Atlas became essentially an original work. It was published in 1848, and was welcomed by all competent authorities, not only because it was a valuable contribution to the study of physical geography, but because it embodied within convenient limits the results which had been secured by the observations of numerous scientific travellers on the geology, meteorology, climatology, and hydrography of the globe. The Geographical Society of Berlin having awarded its Honorary Diploma to Dr. Johnston, Karl Ritter, the President, took the opportunity of once more acknowledging the merits of the Atlas. Berlin was not alone in determining to do honour to the great geographer. The Royal Society of Edinburgh spontaneously conferred on him the honours and privileges of Fellowship; while the leading Geographical Societies of Europe, America, and India, elected him to Honorary and Corresponding Fellowships. The University of Edinburgh also, after the lapse of years, gave him, in 1865, the honorary degree of Doctor of Laws—the highest honour of the kind that the University could bestow. In 1855 he commenced his 'Royal Atlas of Modern Geography,' in which he may be said to have embodied the results of the arduous studies which he had prosecuted for a quarter of a century. The late Prince Consort took a deep interest in this splendid work, the progress of which he carefully watched, and every sheet of which he criticised as it came out. During recent years Dr. Johnston devoted himself mainly to the publication of maps and other works for educational purposes, and to bringing the results of his previous labours before the public in comparatively cheap forms.—*Condensed from The Athenæum.*

## NATURAL HISTORY SOCIETY.

The annual meeting of the Society was held at its rooms on May 19th, the President, Principal Dawson, LL.D., F.R.S., in the chair. Mr. J. F. Whiteaves, the Recording Secretary, read the minutes, after which the President delivered the annual address.

The Chairman of the Council, Mr. G. L. Marler, then read his report, of which the following is an abstract:—

The Council in making its report for the past year, does so with feelings both of pleasure and regret; with pleasure in having to acknowledge the many valuable scientific contributions which have been placed on the Society's records, to which the President has already alluded; and with regret that the Society has lost many of its members, the number of which is becoming less every year. This decrease is to be attributed to various causes, chiefly, however, to the fact, that the Committee whose special duty it is to solicit and canvas for new members, has ceased its exertions, and that the work of the Society and its valuable contributions to science are not so generally known as they should be. During the last year the Society has lost by death, resignation, or removal, nineteeen members. Eight new ones have been added; the net loss on the year is thus eleven. An appeal should therefore be made to the present subscribers to induce their friends to join the Society.

Your Council begs leave to suggest one means whereby its sphere of usefulness would be enlarged, to wit, by affiliating other Societies, and by bringing into one place the different Libraries now existing in this city. The Society should especially urge upon the Trustees of the Fraser Institute the advantages that would accrue to both parties by such an affiliation. Not only is the position of your building most excellent, but the vacant ground adjoining, belonging to the McGill College, also makes the idea very practicable; and although affiliated the institutions would be distinct.

The annual Conversazione again failed to draw as many persons as we could have wished, notwithstanding the exertions of the Committee in whose hands the matter had been left. Yet your Council cannot but think that such reunions have a beneficial tendency, that much valuable knowledge is derived from them, and that even though there be a loss in a pecuniary point of view, we must regard them as affording valuable knowledge of things and objects which would be otherwise unknown. Your Council, therefore, recommend that they be continued.

The Council desires to draw the attention of members to the collection of shells belonging to Mr. Whiteaves, your industrious Curator, which he is now engaged in classifying; they are so admirably arranged that their inspection will be useful and interesting to members of the Society and to students. Thanks are due Mr. Whiteaves for the duplicates of the collection which he has kindly presented to the Museum.

Your Council have to report that the post of Taxidermist and Janitor, left open by the resignation of the late Mr. Hunter, whom the Society had some difficulty in replacing, has been well and efficiently filled by Mr. Passmore.

Mr. Whiteaves also read his report as Scientific Curator, of which the following is an abstract:—

Owing to the protracted ill health of our late deeply regretted taxidermist, it was found that moths were making havoc among the birds and mammals. The case being urgent, Mr. Craig was called in, and we did our best to remedy the evil. On Mr. Passmore's arrival, I called his attention to this circumstance, and he lost no time in making a searching examination into all the cases, and did all that could be done in the way of applying the necessary remedies. Mr. Passmore and myself have also studied closely our series of Canadian birds, have weeded out several specimens which we have good reason to suppose are not American examples at all, and have rectified some errors in the previous nomenclature. The series is now in good order, and none but authentic specimens are included in that part of the collection.

In the department of mammalia but one new species has been added, namely, a noble example of the grizzly bear of the Rocky Mountains.

In ornithology, however, we have made much more progress. Mr. A. Jowitt has given us thirty-nine specimens of English birds, Major G. E. Bulger seven rare exotic species, but we have only added twelve specimens to our collection of Canadian birds. We have not to go far for a reason for this. When Mr. Passmore arrived, ornithologists here thought that we now had another active and able naturalist resident on the premises, our collection of birds and mammals would rapidly increase. A special application was made to the Minister of Agriculture of the Province of Quebec for a license to enable Mr. Passmore to procure birds, for the museum, which was not granted, probably owing to a misapprehension.

From the Smithsonian Institute at Washington we have received a large and valuable series of North American birds' eggs, consisting of ninety-one species, many of them of considerable rarity. Among the more interesting of these are the eggs of the Golden eagle, American pelican, King eider and Pacific eider duck, Velvet duck and Surf Scoter, Canvas-backed and Red-headed ducks, Gambel's and Hutchins' geese, Pacific diver, Western grebe, American oyster catcher, California gull, and other rare eggs from Arctic America and the Pacific coast. We have also added Canadian examples of the eggs of the Red-shouldered buzzard (*Buteo lineatus*), and of the Long-eared owl (*Otus Wilsonianus*) to our collection. A description of the nidification of each of these species, and a list of all the rare birds that have been recently obtained in the Province (at least of all those of which I could get any definite information) has been published in The Naturalist. The birds' eggs received during the past year have been labelled and arranged in drawers in the museum.

Major Bulger has presented a miscellaneous collection of objects of interest, mostly from the East Indies; a detailed catalogue of some of which has been published in the Society's Journal. Thirty-six species of fossils, several corals, and an example of the Glass-rope sponge (*Hyalonema Sieboldii*), have been also added to the Museum. Many of these were received in exchange for shells dredged in the Gulf of St. Lawrence.

I have steadily worked at the preparation of my own private collection of shells and fossils for exhibition in the Museum, with the following general results: about 3000 species have been partially grouped, of which about 1000 have been attached to proper tablets. Where a name has been ascertained with tolerable certainty, a pen and ink label on white paper has been permanently attached, but where the identification is doubtful, the name and locality of the species is only written in pencil on the blue tablet. Of those mounted permanently 411 species are marine gasteropods (univalve), 300 species and upwards are land or fresh-water gasteropods, 324 species are lamellibranchiate bivalves;—I estimate those remaining unmounted at about 2500 species. With regard to the scientific arrangement to be ultimately adopted, there are some difficulties in the way. Dr. Woodward's manual, though excellent as far as it goes, represents only the state of our knowledge of the subject some fifteen or twenty years ago. On the other hand the Messrs. Adams and Dr. Gray in their elaborate treatises unfortunately disregard the well-known and well-estab. lished laws of zoological nomenclature. In the meantime, until the whole collection is mounted, the arrangement is one of mere convenience. When mounting my own shells, all the duplicates were put into the Society's collection, and in this way over fifty species have been added to it.

The work of editing the Society's Journal has led this year to a much larger amount of general correspondence than last, which has taken up time that would otherwise have been devoted to work in the Museum. Under many disadvantages and difficulties, and with many deficiencies and shortcomings to regret, it is yet hoped that the work done during the past session has not been altogether barren of results but that it may have tended in some small degree to help to popularize the study of the natural sciences in the city.

The various reports were ordered to be printed, the usual votes of thanks to the retiring officers duly passed, and the meeting proceeded to elect officers for the current year with the following result:

OFFICERS FOR THE YEAR 1871–72.

*President.*—Mr. Principal Dawson (re-elected).

*Vice-Presidents.*—Dr. Hunt, Rev. Dr. De Sola, Sir W. Logan, Dr. Carpenter, Messrs. Billings, Selwyn, Leeming and Barnston, Dr. Smallwood.

*Treasurer.*—Mr. J. Ferrier, jun. (re-elected).

*Cor. Secretary.*—Prof. Darey (re-elected).

*Rec. Secretary.*—Mr. Whiteaves (re-elected).

*Council.*—Messrs. Marler, Watt, McCord, R. Bell, Shelton, Edwards, Drummond, Murphy and Joseph.

After naming the sub-committees, the meeting adjourned.

**Dr.** THE NATURAL HISTORY SOCIETY OF MONTREAL IN ACCOUNT WITH JAMES FERRIER, JR., TREASURER. **Cr.**

| | | | |
|---|---|---|---|
| 1870–'71. | | 1870, May 1. | |
| To Cash paid J. F. Whiteaves, salary | $400.00 | By Balance in Treasurer's hands | $886.15 |
| " " W. Hunter, " | 100.00 | | |
| " " H. Passmore, " | 100.00 | 1870–'71. | |
| " " J. E. Pell, Commissions on Collections | 29.20 | By Government Grant | 750.00 |
| " " Interest | 120.00 | " Members Yearly Subscriptions | 595.00 |
| " " Coal | 56.06 | " Donation towards liquidation of Debt, J. F., Jr. | 50.00 |
| " " Gas Bills | 56.03 | " Museum Fees | 35.83 |
| " " Water Tax | 32.75 | " Rent of Lecture Room | 172.06 |
| " " City Tax | 46.40 | " Subscription to "Naturalist" | 2.00 |
| " " Insurance | 39.00 | " Interest from Treasurer one year on $886.15 | 62.03 |
| " " Repairs and Petty Expenses | 530.80 | | |
| " " Books, Printing and Advertising | 125.50 | | |
| 1871, May 1. | | | |
| To Balance in Treasurer's hands | 917.33 | | |
| | $2553.07 | | $2553.07 |

STATEMENT OF LIABILITIES OF THE SOCIETY,
May 1, 1871.

| | |
|---|---|
| Mortgage on Society's Buildings, favour Royal Institution | $2000.00 |
| Dawson Bros. account | 390.92 |
| Craig & Castle, balance account | 64.24 |
| | $2455.16 |

Errors and Omissions excepted.

[Signed] JAMES FERRIER, JR.

Montreal, 1st May, 1871.

THE

# CANADIAN NATURALIST

AND

# Quarterly Journal of Science.

## ABSTRACT OF PROCEEDINGS OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE,

*At its Forty-First Meeting, at Edinburgh, August,* 1871.

The Presidency of the Association was resigned by Prof. Huxley, and assumed by Sir William Thompson, who delivered the usual Presidential Address.

After dwelling on the origin of the Association, and the eminent scientific career of several of its early founders, the President gave a review of the present work of the Association, and suggested, in connection with it, the importance of establishing a British Year Book of Science. He also urged upon the Government the necessity for the foundation of National Colleges of Research, on a scale commensurate with the importance of Scientific Education, and in some degree corresponding with similar institutions on the continent of Europe. He then proceeded to give a general sketch of the recent progress of Physical Science, from which we give the following extracts:—

### 1. SPECTRUM ANALYSIS.

The prismatic analysis of light discovered by Newton was estimated by himself as being "the oddest, if not the most considerable detection, which hath hitherto been made in the operations of nature."

Had he not been deflected from the subject, he could not have failed to obtain a pure spectrum; but this, with the inevitably consequent discovery of the dark lines, was reserved for the nineteenth century. Our fundamental knowledge of the dark lines is due solely to Fraunhofer. Wollaston saw them, but did not discover them. Brewster laboured long and well to perfect the prismatic analysis of sunlight; and his observations on the dark bands produced by the absorption of interposed gases and vapours laid important foundations for the grand superstructure which he scarcely lived to see. Piazzi Smyth, by spectroscopic observation performed on the Peak of Teneriffe, added greatly to our knowledge of the dark lines produced in the solar spectrum by the absorption of our own atmosphere. The prism became an instrument for chemical qualitative analysis in the hands of Fox Talbot and Herschel, who first showed how through it the old "blowpipe test," or generally the estimation of substances from the colours which they give to flames, can be prosecuted with an accuracy and a discriminating power not to be attained when the colour is judged by the unaided eye. But the application of this test to solar and stellar chemistry had never, I believe, been suggested, either directly or indirectly, by any other naturalist, when Stokes taught it to me in Cambridge, at some time prior to the summer of 1852. The observational and experimental foundations on which he built were:—

(1) The discovery by Fraunhofer of a coincidence between his double dark line D of the solar spectrum and a double bright line which he observed in the spectra of ordinary artificial flames.

(2) A very rigorous experimental test of this coincidence by Prof. W. H. Miller, which showed it to be accurate to an astonishing degree of minuteness.

(3) The fact that the yellow light given out when salt is thrown on burning spirit consists almost solely of the two nearly identical qualities which constitute that double bright line.

(4) Observations made by Stokes himself, which showed the bright line D to be absent in a candle-flame when the wick was snuffed clean, so as not to project into the luminous envelope, and from an alcohol flame when the spirit was burned in a watch-glass. And

(5) Foucault's admirable discovery (*L'Institut*, Feb. 7, 1849), that the voltaic arc between charcoal points is "a medium which emits the rays D on its own account, and at the same time absorbs them when they come from another quarter."

The conclusions, theoretical and practical, which Stokes taught me, and which I gave regularly afterwards in my public lectures in the University of Glasgow, were :—

(1) That the double line D, whether bright or dark, is due to vapour of sodium.

(2) That the ultimate atom of sodium is susceptible of regular elastic vibrations, like those of a tuning-fork or of stringed musical instruments; that like an instrument with two strings tuned to approximate unison, or an approximately circular elastic disc, it has two fundamental notes or vibrations of approximately equal pitch; and that the periods of these vibrations are precisely the periods of the two slightly different yellow lights constituting the double bright line D.

(3) That when vapour of sodium is at a high enough temperature to become itself a source of light, each atom executes these two fundamental vibrations simultaneously; and that therefore the light proceeding from it is of the two qualities constituting the double bright line D.

(4) That when vapour of sodium is present in space across which light from another source is propagated, its atoms, according to a well-known general principle of dynamics, are set to vibrate in either or both of those fundamental modes, if some of the incident light is of one or other of their periods, or some of one and some of the other; so that the energy of the waves of those particular qualities of light is converted into thermal vibrations of the medium, and dispersed in all directions, while light of all other qualities, even though very nearly agreeing with them, is transmitted with comparatively no loss.

(5) That Fraunhofer's double dark line D of solar and stellar spectra is due to the presence of vapour of sodium in atmospheres surrounding the sun and those stars in whose spectra it had been observed.

(6) That other vapours than sodium are to be found in the atmospheres of sun and stars by searching for substances producing in the spectra of artificial flames bright lines coinciding with other dark lines of the solar and stellar spectra than the Fraunhofer line D.

The last of these propositions I felt to be confirmed (it was, perhaps, partly suggested) by a striking and beautiful experiment, admirably adapted for lecture illustrations, due to Foucault, which had been shown to me by M. Dubosque Soleil, and the Abbé Moigno, in Paris, in the month of October, 1850. A prism and lenses were arranged to throw upon a screen an approximately pure spectrum of a vertical electric arc between charcoal poles of a powerful battery, the lower one of which was hollowed like a cup. When pieces of copper and pieces of zinc were separately thrown into the cup, the spectrum exhibited, in perfectly definite positions, magnificent well-marked bands of different colours characteristic of the two metals. When a piece of brass, compounded of copper and zinc, was put into the cup, the spectrum showed all the bands, each precisely in the place in which it had been seen when one metal or the other had been used separately.

It is much to be regretted that this great generalization was not published to the world twenty years ago. I say this, not because it is to be regretted that Angström should have the credit of having, in 1853, published independently the statement that "an incandescent gas emits luminous rays of the same refrangibility as those which it can absorb"; or that Balfour Stewart should have been unassisted by it when, coming to the subject from a very different point of view, he made, in his extension of the 'Theory of Exchanges,' (*Edin. Transactions*, 1858-59,) the still wider generalization that the radiating power of every kind of substance is equal to its absorbing power for every kind of ray; or that Kirchoff also should have, in 1859, independently discovered the same proposition, and shown its application to solar and stellar chemistry; but because we might now be in possession of the inconceivable riches of astronomical results which we expect from the next ten years' investigation by spectrum analysis, had Stokes given his theory to the world when it first occurred to him.

### 2. SOLAR AND STELLAR CHEMISTRY.

To Kirchhoff belongs, I believe, solely the great credit of having first actually sought for and found other metals than sodium in the sun by the method of spectrum analysis. His publication of October, 1859, inaugurated the practice of solar and stellar chemistry, and gave spectrum analysis an impulse to which in a great measure is due its splendidly successful cultivation by the labours of many able investigators within the last ten years.

To prodigious and wearing toil of Kirchhoff himself, and of Angström, we owe large-scale maps of the solar spectrum, incomparably superior in minuteness and accuracy of delineation to anything ever attempted previously. These maps now constitute the standards of reference for all workers in the field. Plücker and Hittorf opened ground in advancing the physics of spectrum analysis, and made the important discovery of changes in the spectra of ignited gases produced by changes in the physical condition of the gas. The scientific value of the meetings of the British Association is well illustrated by the fact that it was through conversation with Plücker at the Newcastle meeting that Lockyer was first led into the investigation of the effects of varied pressure on the quality of the light emitted by glowing gas which he and Frankland have prosecuted with such admirable success. Scientific wealth tends to accumulation according to the law of compound interest. Every addition to knowledge of properties of matter supplies the naturalist with new instrumental means for discovering and interpreting phenomena of nature, which in their turn afford foundations for fresh generalizations, bringing gains of permanent value into the great storehouse of philosophy. Thus Frankland, led, from observing the want of brightness of a candle burning in a tent on the summit of Mont Blanc to scrutinize Davy's theory of flame, discovered that brightness without incandescent solid particles is given to a purely gaseous flame by augmented pressure, and that a dense ignited gas gives a spectrum comparable with that of the light from an incandescent solid or liquid. Lockyer joined him; and the two found that every incandescent substance gives a continuous spectrum—that an incandescent gas under varied pressure gives bright bars across the continuous spectrum, some of which, from the sharp, hard and fast lines observed where the gas is in a state of extreme attenuation, broaden out on each side into nebulous bands as the density is increased, and are ultimately lost in the continuous spectrum when the condensation is pushed on till the gas becomes a fluid no longer to be called gaseous. More recently they have examined the influence of temperature, and have obtained results which seem to show that a highly attenuated gas, which at a high temperature gives several bright lines, gives a smaller and smaller number of lines, of sufficient brightness to be visible, when the temperature is lowered, the density being kept unchanged. I cannot refrain here from remarking how admirably this beautiful investigation harmonizes with Andrew's great discovery of continuity between the gaseous and liquid states. Such things make the life-blood of science. In contemplating them we feel as if led out from narrow waters of scholastic dogma to a refreshing excursion on the broad and deep ocean of truth, where we learn from the wonders we see that there are endlessly more and more glorious wonders still unseen.

Stokes's dynamical theory supplies the key to the philosophy of Frankland and Lockyer's discovery. Any atom of gas, when struck and left to itself, vibrates with perfect purity its fundamental note or notes. In a highly attenuated gas each atom is very rarely in collision with other atoms, and therefore is nearly at all times in a state of true vibration. Hence the spectrum of a highly attenuated gas consists of one or more perfectly sharp bright lines, with a scarcely perceptible continuous gradation of prismatic colour. In denser gas each atom is frequently in collision, but still is for much more time free, in intervals between collisions, than engaged in collision; so that not only is the atom itself thrown sensibly out of tune during a sensible proportion of its whole time, but the confused jangle of vibrations in every variety of period during the actual collision becomes more considerable in its influence. Hence bright lines in the spectrum broaden out somewhat, and the continuous spectrum becomes less faint. In still denser gas each atom may be almost as much time in collision as free, and the spectrum then consists of broad nebulous bands crossing a continuous spectrum of considerable brightness. When the medium is so dense that each atom is always in collision, that is to say, never free from influence of its neighbours, the spectrum will generally be continuous, and may present little or no appearance of bands, or even of maxima of brightness. In this condition the fluid can be no longer regarded as a gas, and we must judge of its relation to the vaporous or liquid states according to the critical conditions discovered by Andrews.

While these great investigations of properties of matter were going on, naturalists were not idle with the newly-recognized power of the spectroscope at their service. Chemists soon followed the example of Bunsen in discovering new metals in terrestrial matter by the old blow-pipe and prism test of Fox Talbot and Herschel. Biologists applied spectrum analysis to animal and vegetable chemistry, and to sanitary investigations. But it is in astronomy that spectroscopic research has been carried on with the greatest activity, and been most richly rewarded with results.

The chemist and the astronomer have joined their forces. An astronomical observatory has now appended to it a stock of reagents such as hitherto was only to be found in the chemical laboratory. A devoted corps of volunteers of all nations, whose motto might well be *Ubique*, have directed their artillery to every region of the universe. The sun, the spots on his surface, the corona and the red and yellow prominences seen round him during total eclipses, the moon, the planets, comets, auroras, nebulæ, white stars, yellow stars, red stars, variable and temporary stars, each, tested by the prism, was compelled to show its distinguishing prismatic colours. Rarely before in the history of science has enthusiastic perseverance directed by penetrative genius produced within ten years so brilliant a succession of discoveries. It is not merely the *chemistry* of sun and stars, as first suggested, that is subjected to analysis by the spectroscope. Their whole laws of being are now subjects of direct investigation; and already we have glimpses of their evolutional history through the stupendous power of this most subtle and delicate test. We had only solar and stellar chemistry; we now have solar and stellar physiology.

### 3. MOTION OF THE STARS.

It is an old idea that the colour of a star may be influenced by its motion relatively to the eye of the spectator, so as to be tinged with red if it moves from the earth, or blue if it moves towards the earth. William Allen Miller, Huggins, and Maxwell showed how, by aid of the spectroscope, this idea may be made the foundation of a method of measuring the relative velocity with which a star approaches to or recedes from the earth. The principle is, first to identify, if possible, one or more of the lines in the spectrum of the star, with a line or lines in the spectrum of sodium, or some other terrestrial substance, and then (by observing the star and the artificial light simultaneously by the same spectroscope) to find the difference, if any, between their refrangibilities. From this difference of refrangibility the ratio of the periods of the two lights is calculated, according to data determined by Fraunhofer from comparisons between the positions of the dark lines in the prismatic spectrum and in his own "interference spectrum" (produced by substituting for the prism a fine grating). A first comparatively rough application of the test by Miller and Huggins to a large number of the principal stars of our skies, including Aldebaran, a Orionis, b Pegasi, Sirius, a Lyræ, Capella, Arcturus, Pollux, Castor (which they had observed rather for the chemical purpose than for this), proved that not one of them had so great a velocity as 315 kilomètres per second to or from the earth, which is a *most momentous result in respect to cosmical dynamics.* Afterwards Huggins made special observations of the velocity test, and succeeded in making the measurement in one case, that of Sirius, which he then found to be receding from the earth at the rate of 66 kilomètres per second. This, corrected for the velocity of the earth at the time of the observation, gave a velocity of Sirius, relatively to the sun, amounting to 47 kilomètres per second. The minuteness of the difference to be measured, and the smallness of the amount of light, even when the brightest star is observed, renders the observation extremely difficult. Still, with such great skill as Mr. Huggins has brought to bear on the investigation, it can scarcely be doubted that velocities of many other stars may be measured. What is now wanted is, certainly not greater skill, perhaps not even more powerful instruments, but *more instruments and more observers.* Lockyer's applications of the velocity test to the relative motions of different gases in the Sun's photosphere, spots, chromosphere, and chromospheric prominences, and his observations of the varying spectra presented by the same substance as it moves from one position to another in the Sun's atmosphere, and his interpretations of these observations, according to the laboratory results of Frankland and himself, go far towards confirming the conviction that in a few years all the marvels of the sun will be dynamically explained according to known properties of matter.

### 4. SOURCE OF THE SUN'S HEAT.

During six or eight precious minutes of time, spectroscopes have been applied to the solar atmosphere and to the corona seen round the dark disc of the Moon eclipsing the Sun. Some of the wonderful results of such observations, made in India on the occasion of the eclipse in August, 1868, were described by Prof. Stokes in a previous address. Valuable results have, through the liberal assistance given by the British and American Governments, been obtained also from the total eclipse of last December, notwithstanding a generally unfavourable condition of weather. It seems to have been proved that at least some sensible part of the light of the "corona" is a terrestrial atmospheric halo or dispersive reflexion of the light of the glowing hydrogen and "helium" round the sun. (Frankland and Lockyer find the yellow prominences to give a very decided bright line not far from D, but hitherto not identified with any terrestrial flame. It seems to indicate a new substance, which they propose to call Helium.) I believe I may say, on the present occasion, when preparation must again be made to utilize a total eclipse of the sun, that the British Association confidently trusts to our Government exercising the same wise liberality as heretofore in the interests of science.

The old nebular hypothesis supposes the solar system and other similar systems through the universe which we see at a distance as stars, to have originated in the condensation of fiery nebulous matter. This hypothesis was invented before the discovery of thermo-dynamics, or the nebulæ would not have been supposed to be fiery; and the idea seems never to have occurred to any of its inventors or early supporters that the matter, the condensation of which they supposed to constitute the Sun and stars, could have been other than fiery in the beginning. Mayer first suggested that the heat of the Sun may be due to gravitation; but he supposed meteors falling in to keep always generating the heat which is radiated year by year from the Sun. Helmholtz, on the other hand, adopting the nebular hypothesis, showed in 1854 that it was not necessary to suppose the nebulous matter to have been originally fiery, but that mutual gravitation between its parts may have generated the heat to which the present high temperature of the Sun is due. Further, he made the important observations that the potential energy of gravitation in the Sun is even now far from exhausted; but that with further and further shrinking more and more heat is to be generated, and that thus we can conceive the Sun even now to possess a sufficient store of energy to produce heat and light, almost at present, for several million years of time future. It ought, however, to be added that this condensation can only follow from cooling, and therefore that Helmholtz's gravitational explanation of future Sun-heat amounts really to showing that the Sun's thermal capacity is enormously greater, in virtue of the mutual gravitation between the parts of so enormous a mass, than the sum of the thermal capacities of separate and smaller bodies of the same material and same total mass. Reasons for adopting this theory, and the consequences which follow from it, are discussed in an article 'On the Age of the Sun's Heat,' published in *Macmillan's Magazine* for March, 1862.

For a few years Mayer's theory of solar heat had seemed to me probable; but I had been led to regard it as no longer tenable, because I had been in the first place driven, by consideration of the very approximate constancy of the Earth's period of revolution round the Sun for the last 2,000 years, to conclude that "the principal source, perhaps the sole appreciably effective source of Sun-heat, is in bodies circulating round the Sun at present inside the Earth's orbit"; and because Le Verrier's researches on the motion of the planet Mercury, though giving evidence of a sensible influence attributable to matter circulating as a great number of small planets within his orbit round the Sun, showed that the amount of matter that could possibly be assumed to circulate at any considerable distance from the Sun must be very small; and therefore, "if the meteoric influx taking place at present is enough to produce any appreciable portion of the heat radiated away, it must be supposed to be from matter circulating round the Sun, within very short distances of his surface. The density of this meteoric cloud would have to be supposed so great that comets could scarcely have escaped as comets actually have escaped, showing no discoverable effects of resistance, after passing his surface within a distance equal to one-eighth of his radius. All things considered, there seems little probability in the hypothesis that solar radiation is compensated to any appreciable degree, by heat generated by meteors falling in, at present; and, as it can be shown that no chemical theory is tenable, it must be concluded as most probable that the Sun is at present merely an incandescent liquid mass cooling."

Thus on purely astronomical grounds was I long ago led to abandon as very improbable the hypothesis that the Sun's heat is supplied dynamically from year to year by the influx of meteors. But now spectrum analysis gives proof finally conclusive against it.

Each meteor circulating round the Sun must fall in along a very gradual spiral path, and before reaching the Sun must have been for a long time exposed to an enormous heating effect from his radiation when very near, and must thus have been driven into vapour before actually falling into the Sun. Thus, if Mayer's hypothesis is correct, friction between vortices of meteoric vapours and the Sun's atmosphere must be the immediate cause of solar heat; and the velocity with which these vapours circulate round equatorial parts of the Sun must amount to 435 kilomètres per second. The spectrum test of velocity applied by Lockyer showed but a twentieth part of this amount as the greatest observed relative velocity between different vapours in the Sun's atmosphere.

### 5. NEBULÆ, COMETS, AND METEORS.

At the first Liverpool Meeting of the British Association (1854), in advancing a gravitational theory to account for all the heat, light, and motions of the universe, I urged that the immediately antecedent condition of the matter of which the Sun and Planets were formed, not being fiery, could not have been gaseous; but that it probably was solid, and may have been like the meteoric stones which we still so frequently meet with through space. The discovery of Huggins, that the light of the Nebulæ, so far as hitherto sensible to us, proceeds from incandescent hydrogen and nitrogen gases, and that the heads of comets also give us light of incandescent gas, seems at first sight literally to fulfil that part of the Nebular hypothesis to which I had objected. But a solution, which seems to me in the highest degree probable, has been suggested by Tait. He supposes that it may be by ignited gaseous exhalations proceeding from the collision of meteoric stones that nebulæ and the heads of comets show themselves to us; and he suggested, at a former meeting of the Association, that experiments should be made for the purpose of applying spectrum analysis to the light which has been observed in gunnery trials, such as those at Shoeburyness, when iron strikes against iron at a great velocity, but varied by substituting for the iron various solid materials, metallic or stony. Hitherto this suggestion has not been acted upon; but surely it is one the carrying out of which ought to be promoted by the British Association.

Most important steps have been recently made towards the discovery of the nature of comets; establishing with nothing short of certainty the truth of a hypothesis which had long appeared to me probable,—that they consist of groups of meteoric stones; accounting satisfactorily for the light of the nucleus, and giving a simple and rational explanation of phenomena presented by the tails of comets which had been regarded by the greatest astronomers as almost preternaturally marvellous. The meteoric hypothesis to which I have referred remained a mere hypothesis, (I do not know that it was ever even published,) until, in 1866, Schiaparelli calculated, from observations on the August meteors, an orbit for these bodies which he found to agree almost perfectly with the orbit of the great comet of 1862, as calculated by Oppolzer; and so discovered and demonstrated that a comet consists of a group of meteoric stones. Prof. Newton, of Yale College, United States, by examining ancient records, ascertained that in periods of about thirty-three years, since the year 902, there have been exceptionally brilliant displays of the November meteors. It had long been believed that these interesting visitants came from a train of small detached planets circulating round the Sun, all in nearly the same orbit, and constituting a belt analogous to Saturn's ring; and that the reason for the comparatively large number of meteors which we observe annually about the 14th of November is, that at that time the earth's orbit cuts through the supposed meteoric belt. Prof. Newton concluded from his investigation that there is a denser part of the group of meteors which extends over a portion of the orbit so great as to occupy about one-tenth or one-fifteenth of the periodic time in passing any particular point, and gave a choice of five different periods for the revolution of this meteoric stream round the sun, any one of which would satisfy his statistical result. He further concluded that the line of nodes, that is to say, the line in which the plane of the meteoric belt cuts the plane of the earth's orbit, has a progressive sidereal motion of about 52″·4 per annum. Here, then, was a splendid problem for the physical astronomer; and, happily, one well qualified for the task took it up. Adams, by the application of a beautiful method invented by Gauss, found that of the five periods allowed by Newton, just one permitted the motion of the line of nodes to be explained by the disturbing influence of Jupiter, Saturn, and other planets. The period chosen on these grounds is $33\frac{1}{4}$ years. The investigation showed further that the form of the orbit is a long ellipse, giving for shortest distance from the sun 145 million kilomètres, and for longest distance 2,895 million kilomètres. Adams also worked out the longtitude of the perihelion and the inclination of the orbit's plane to the plane of the elliptic. The orbit which he thus found agreed so closely with that of Temple's Comet I. 1866, that he was able to identify the comet and the meteoric belt.* The same conclusion had been pointed out a few weeks

* Signor Schiaparelli, Director of the Observatory of Milan, who, in a letter dated 31st of December, 1866, pointed out that the elements of the orbit of the *August* Meteors, calculated from the observed posi-

earlier by Schiaparelli, from calculations by himself, on data supplied by direct observations on the meteors, and independently by Peters, from calculations by Leverrier on the same foundation. It is, therefore, thoroughly established that Temple's Comet I. 1866, consists of an elliptic train of minute planets, of which a few thousands or millions fall to the earth annually about the 14th of November, when we cross their track. We have probably not yet passed through the very nucleus or densest part; but thirteen times, in Octobers and Novembers, from October 13, A.D. 902, to November 14, 1866, inclusive (this last time having been correctly predicted by Prof. Newton), we have passed through a part of the belt greatly denser than the average. The densest part of the train, when near enough to us, is visible as the head of the comet. This astounding result, taken along with Huggins's spectroscopic observations on the light of the heads and tails of comets, confirm most strikingly Tait's theory of comets, to which I have already referred; according to which the comet, a group of meteoric stones, is self-luminous in its nucleus, on account of collisions among its constituents, while its "tail" is merely a portion of the less dense part of the train illuminated by sunlight, and visible or invisible to us according to circumstances, not only of

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tion of their radiant point on the supposition of the orbit being a very elongated ellipse, agreed very closely with those of the orbit of Comet II. 1862, calculated by Dr. Oppolzer. In the same letter Schiaparelli gives elements of the orbit of the November meteors, but these were not sufficiently accurate to enable him to identify the orbit with that of any known comet. On the 21st of January, 1867, M. Leverrier gave more accurate elements of the orbit of the November meteors, and in the *Astronomische Nachrichten* of January 9, Mr. C. F. W. Peters, of Altona, pointed out that these elements closely agreed with those of Temple's Comet (I. 1866), calculated by Dr. Oppolzer, and on February 2, Schiaparelli, having re-calculated the elements of the orbit of the meteors, himself noticed the same agreement. Adams arrived quite independently at the conclusion that the orbit of 33¼ years period is the one which *must* be chosen, out of the five indicated by Prof. Newton. His calculations were sufficiently advanced before the letters referred to appeared, to show that the other four orbits offered by Newton were inadmissible. But the calculations to be gone through to find the secular motion of the node in such an elongated orbit as that of the meteors, were necessarily very long, so that they were not completed till about March, 1867. They were communicated in that month to the Cambridge Philosophical Society, and in the month following to the Astronomical Society.

density, degree of illumination, and nearness, but also of tactic arrangement, as of a flock of birds or the edge of a cloud of tobacco smoke! What prodigious difficulties are to be explained, you may judge from two or three sentences which I shall read from Herschel's Astronomy, and from the fact that even Schiaparelli seems still to believe in the repulsion: "There is, beyond question, some profound secret and mystery of nature concerned in the phenomena of their tails. Perhaps it is not too much to hope that future observation, borrowing every aid from rational speculation, grounded on the progress of physical science generally (especially those branches of it which relate to the ethereal or imponderable elements), may enable us ere long to penetrate this mystery, and to declare whether it is really *matter* in the ordinary acceptation of the term which is projected from their heads with such extraordinary velocity, and if not *impelled*, at least *directed*, in its course, by reference to the Sun, as its point of avoidance." "In no respect is the question as to the materiality of the tail more forcibly pressed on us for consideration than in that of the enormous sweep which it makes round the Sun *in perihelio* in the manner of a straight and rigid rod, *in defiance of the law of gravitation*, nay, even, *of the received* laws of motion." "The projection of this ray. . . . to so enormous a length, in a single day, conveys an impression of the intensity of the forces acting to produce such a velocity of material transfer through space, such as no other natural phenomenon is capable of exciting. It is clear that *if we have to deal here with matter, such as we conceive it*, viz., *possessing inertia—at all*, it must be under the dominion of forces incomparably more energetic than gravitation, and quite of a different nature."

Think now of the admirable simplicity with which Tait's beautiful "sea-bird analogy," as it has been called, can explain all these phenomena.

## 6. BIOLOGICAL RESEARCH.

The essence of science, as is well illustrated by astronomy and cosmical physics, consists in inferring antecedent conditions, and anticipating future evolutions, from phenomena which have actually come under observation. In biology the difficulties of successfully acting up to this ideal are prodigious. The earnest naturalists of the present day are, however, not appalled or paralyzed by them, and are struggling boldly and laboriously to pass out of the mere "Natural History stage" of their study, and bring zoology within the range of Natural Philosophy. A very ancient speculation, still clung to by many naturalists (so much so that I have a choice of modern terms to quote in expressing it) supposes that, under meteorological conditions very different from the present, dead matter may have run together or crystallized or fermented into "germs of life," or "organic cells," or "protoplasm." But science brings a vast mass of inductive evidence against this hypothesis of spontaneous generation, as you have heard from my predecessor in the Presidential chair. Careful enough scrutiny has, in every case up to the present day, discovered life as antecedent to life. Dead matter cannot become living without coming under the influence of matter previously alive. This seems to me as sure a teaching of science as the law of gravitation. I utterly repudiate, as opposed to all philosophical uniformitarianism, the assumption of "different meteorological conditions"—that is to say, somewhat different vicissitudes of temperature, pressure, moisture, gaseous atmosphere—to produce or to permit that to take place by force or motion of dead matter alone, which is a direct contravention of what seems to us biological law. I am prepared for the answer, "our code of biological law is an expression of our ignorance as well as of our knowledge." And I say, yes; search for spontaneous generation out of inorganic materials; let any one not satisfied with the purely negative testimony of which we have now so much against it, throw himself into the inquiry. Such investigations as those of Pasteur, Pouchet, and Bastian are among the most interesting and momentous in the whole range of Natural History, and their results, whether positive or negative, must richly reward the most careful and laborious experimenting. I confess to being deeply impressed by the evidence put before us by Prof. Huxley, and I am ready to adopt, as an article of scientific faith, true through all space and through all time, that life proceeds from life, and from nothing but life.

### 7. ORIGIN OF LIFE.

How, then, did life originate on the earth? Tracing the physical history of the earth backwards, on strict dynamical principles, we are brought to a red-hot melted globe, on which no life could exist. Hence when the earth was first fit for life, there was no living thing on it. There were rocks solid and disintegrated, water, air all round, warmed and illuminated by a brilliant sun, ready to become a garden. Did grass and trees and flowers spring into existence, in all the fulness of ripe beauty, by a fiat of Creative Power? or did vegetation, growing up from seed sown, spread and multiply over the whole earth? Science is bound, by the everlasting law of honour, to face fearlessly every problem which can fairly be presented to it. If a probable solution, consistent with the ordinary course of nature, can be found, we must not invoke an abnormal act of Creative Power. When a lava stream flows down the sides of Vesuvius or Etna it quickly cools and becomes solid; and after a few weeks or years it teems with vegetable and animal life, which for it originated by the transport of seed and ova and by the migration of individual living creatures. When a volcanic island springs up from the sea, and after a few years is found clothed with vegetation, we do not hesitate to assume that seed has been wafted to it through the air, or floated to it on rafts. Is it not possible, and if possible, is it not probable, that the beginning of vegetable life on the earth is to be similarly explained? Every year thousands, probably millions, of fragments of solid matter fall upon the earth —whence came these fragments? What is the previous history of any one of them? Was it created in the beginning of time an amorphous mass? This idea is so unacceptable that, tacitly or explicitly, all men discard it. It is often assumed that all, and it is certain that some, meteoric stones are fragments which had been broken off from greater masses and launched free into space. It is as sure that collisions must occur between great masses moving through space as it is that ships, steered without intelligence directed to prevent collision, could not cross and recross the Atlantic for thousands of years with immunity from collisions. When two great masses come into collision in space it is certain that a large part of each is melted; but it seems also quite certain that in many cases a large quantity of *débris* must be shot forth in all directions, much of which may have experienced no greater violence than individual pieces of rock experience in a land-slip or in blasting by gunpowder. Should the time when this earth comes into collision with any other body, comparable in dimensions to itself, be when it is still clothed as at present with vegetation, many great and small fragments carrying seed and living plants and animals would undoubtedly be scattered through space. Hence and because we all confidently believe that there are at present, and have been from time immemorial, many worlds of life besides our own, we must regard it as probable in the highest degree that there are countless seed-bearing meteoric stones moving about through space. If at the present instant no life existed upon this earth, one such stone falling upon it might, by what we blindly call *natural* causes, lead to its becoming covered with vegetation. I am fully conscious of the many scientific objections which may be urged against this hypothesis, but I believe them to be all answerable. I have already taxed your patience too severely to allow me to think of discussing any of them on the present occasion. The hypothesis that life originated on this earth through moss-grown fragments from the ruins of another world may seem wild and visionary; all I maintain is that this is not unscientific.

## 8. THE DARWINIAN THEORY.

From the Earth stocked with such vegetation as it could receive meteorically, to the Earth teeming with all the endless variety of plants and animals which now inhabit it, the step is prodigious; yet, according to the doctrine of continuity, most ably laid before the Association by a predecessor in this chair (Mr. Grove), all creatures now living on earth have proceeded by orderly evolution from some such origin. Darwin concludes his great work on 'The Origin of Species' with the following words:—"It is interesting to contemplate an entangled bank clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us." . . . "There is grandeur in this view of life with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning, endless forms, most beautiful and most wonderful, have been and are being evolved." With the feeling expressed in these two sentences I most cordially sympathize. I have omitted two sentences which come between them, describing briefly the hypothesis of "the origin of species by natural selection," because I have always felt that this hypothesis does not contain the true theory of evolution, if evolution there has been, in biology. Sir John Herschel, in expressing a favourable judgment on the hypothesis of zoological evolution, with, however, some reservation in respect to the origin of man, objected to the doctrine of natural selection, that it was too like the Laputan method of making books, and that it did not sufficiently take into account a continually guiding and controlling intelligence. This seems to me a most valuable and instructive criticism. I feel profoundly convinced that the argument of design has been greatly too much lost sight of in recent zoological speculations. Reaction against the frivolities of teleology, such as are to be found, not rarely, in the notes of the learned commentators on Paley's 'Natural Theology,' has, I believe, had a temporary effect in turning attention from the solid and irrefragable argument so well put forward in that excellent old book. But overpoweringly strong proofs of intelligent and benevolent design lie all round us, and if ever perplexities, whether metaphysical or scientific, turn us away from them for a time, they come back upon us with irresistible force, showing to us through nature the influence of a free will, and teaching us that all living beings depend on one ever-acting Creator and Ruler.

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The Biological Section was presided over by Prof. Allan Thompson, who delivered the following address:—

I must content myself with endeavouring to express to you some of the ideas which arise in my mind in looking back from the present upon the state of Biological science at the time, forty years since, when the meetings of the British Association commenced—a period which I am tempted to particularise from its happening to coincide very nearly with the time at which I began my career as a public teacher in one of the departments of biology in this city. In the few remarks which I shall make, it will be my object to show the prodigious advance which has taken place not only in the knowledge of our subject as a whole, but also in the ascertained relation of its parts to each other, and in the place which this kind of knowledge has gained in the estimation of the educated part of the community, and the consequent increase in the freedom with which the search after truth is now asserted in this as in other departments of science. And first, in connection with the distribution of the various subjects which are included under this section, I may remark that the general title under which the whole section D has met since 1866, viz, Biology, seems to be advantageous both from its convenience, and as tending to promote the great consolidation of our science, and a juster appreciation of the relation of its several parts. It may be that looking merely to the derivation of the term, it is strictly more nearly synonymous with physiology in the sense in which that word has been for a long time employed, and therefore designating the science of life, rather than the description of the living beings in which it is manifested. But until a better or more comprehensive term be found we may accept that of biology under the general definition of "the science of life and of living beings," or as comprehending the history of the whole range of organic nature—vegetable as well as animal. The propriety of the adoption of such a general term is further shown by a glance at the changes which the title and distribution of the subordinate departments of this section have undergone during the period of the existence of the Association.

## HISTORY OF THE SECTION.

During the first four years of this period the Section met under the combined designation of Zoology and Botany, Physiology and Anatomy—words sufficiently clearly indicating the scope of its subjects of investigation. In the next ten years a connection with Medicine was recognised by the establishment of a sub-section or department of Medical Science, in which, however, scientific anatomy and physiology formed the most prominent topics, though not to the exclusion of more strictly medical and surgical or professional subjects. During the next decade, or from the year 1845, we find along with Zoology and Botany a sub-section of physiology, and in several years of the same time along with the latter a separate department of Ethnology. But in the eleven years which extended from 1855 to 1865, the branch of Ethnology was associated with Geography in Section F. And more recently, or since the arrangement which was commenced in 1866, the section Biology has included, with some slight variation, the whole of its subjects in three departments. Under one of these are brought all investigations in Anatomy and Physiology of a general kind, thus embracing the whole range of these sciences when without special application. A second of these sub-sections has been occupied with the extensive subjects of Botany and Zoology; while the third has been devoted to the subject of Anthropology, in which all researches having a special reference to the structure and functions or life history of man have been received and discussed. Such I understand to be the arrangement under which we shall meet on this occasion. At the conclusion of my remarks, therefore, the sub-section for Anatomy and Physiology will remain with me in this room; while the sub-section of Zoology and Botany, on the one hand, and of Anthropology on the other, will adjourn to the apartments which have been provided for them respectively.

### ANTHROPOLOGY.

With regard to the position of Anthropology. as including Ethnology, and comprehending the whole natural history of man, there may be still some differences of opinion, according to the point of view from which its phenomena are regarded: as by some they may be viewed chiefly in relation to the bodily stucture and function of individuals or numbers of men; or as by others they may be considered more directly with reference to their national character and history, and the affinities of languages and customs; or by a third set of inquirers, who are inclined to devote their principal attention to the facts and views bearing upon the origin of man and his relation to animals. As the first and third of these sets of topics entirely belong to Biology, and as those parts of the second set which do not properly fall under that branch may with propriety find a place under Geography or Statistics, I feel inclined to adhere to the distinct recognition of a sub-section—Anthropology, in its present form; and I think that the suitableness of this arrangement is apparent, from the nature and number of the communications properly falling under such a sub-section which have been received under the last distribution of the subjects.

### CONDITION OF BIOLOGICAL RESEARCH.

The beneficial influence of the British Association in promoting biological research is made apparent by the number and importance of the reports on various subjects, as well as of the communications to the sections. Of the latter, the number received annually has been nearly doubled in the course of the last twenty years. Nor can it be doubted that this influence has been materially assisted by the contributions in money made by the Association in aid of various biological investigations; for it appears that out of the whole sum of nearly £34,500 contributed by the Association to the promotion of scientific research, about

£2800 has been devoted to biological purposes, to which it would be fair to add a part at least of the grants for Palæontological researches, many of which must be acknowledged to stand in close relation to Biology. The enormous extent of knowledge and research in the various departments of Biology has become a serious impediment to its more complete study, and leads to the danger of confined views on the part of those whose attention, from necessity or taste, is too exclusively directed to the details of one department, or even, as often happens, to a subdivision of it. It would seem, indeed, as if our predecessors in the last generations, possessed this superior advantage in the then existing narrower boundaries of knowledge, that they were able more easily to overtake the contemplation of a wider field, and to follow out researches in more than one of the sciences. To such combination of varied knowledge, united with their transcendent powers of sound generalization and accurate observation, must be ascribed the wide-spread and enduring influence of the works of such men as Haller, Linnæus, and Cuvier, Von Baer and Joannes Müller. There are doubtless brilliant instances in our own time of men endowed with similar powers; but the difficulty of bringing these powers into effectual operation in a wide range is now so great, that while the amount of research in special biological subjects is enormous, it must be reserved for comparatively few to be the authors of great systems, or of enduring broad and general views which embrace the whole range of biological science. It is incumbent on all those, therefore, who are desirous of promoting the advance of biological knowledge to combat the confined views which are apt to be engendered by the too great restriction of study to one department. However much subdivision of labour may now be necessary in the origin, investigation, and elaboration of new facts in our science (and the necessity for such subdivision will necessarily increase as knowledge extends), there must be secured at first, by a wider study of the general principles and some of the details of collateral branches of knowledge, that power of justly comparing and correlating facts which will mature the judgment and exclude partial views. To refer only to one bright example, I may say that it can scarcely be doubted that it is the unequalled variety and extent of knowledge, combined with the faculty of bringing the most varied facts together in new combination, which has enabled Dr. Darwin (whatever may be thought otherwise of his system) to give the greatest impulse which has been felt in our own times to the progress of biological views and thought; and it is most satisfactory to observe the effect which this influence is already producing on the scientific mind of this country, in opposing the tendency perceptible in recent times to the too restricted study of special departments of natural history. I need scarcely remind you that for the proper investigation and judgment of problems in physiology, a full knowledge of anatomy in general, and much of comparative anatomy, of histology and embryology, of organic chemistry, and of physics, is indispensable as a preliminary to all successful physiological observation and experiment. The anatomist again, who would profess to describe rationally and correctly the structure of the human body, must have acquired a knowledge of the principles of morphology derived from the study of comparative anatomy and development, and he must have mastered the intricacies of histological research. The comparative anatomist must be an accomplished embryologist in the whole range of the animal kingdom, or in any single division of it which he professes to cultivate. The zoologist and the botanist must equally found their descriptions and systematic distinctions on morphological, histological, and embryological data. And thus the whole of these departments of biological science are so interwoven and united that the scientific investigation of no one can now be regarded as altogether separate from that of the others. It has been the work of the last forty years to bring that intimate connection of the biological sciences more and more fully into prominent view, and to infuse its spirit into all scientific investigation. But while in all the departments of biology prodigious advances have been made, there are two more especially which merit particular attention as having almost taken their origin within the period I now refer to, and as having made the most rapid progress in themselves, and have influenced most powerfully and widely the progress of discovery, and the views of biologists in other departments—I mean histology and embryology.

### HISTOLOGY.

I need scarcely remind those present that it was only within a few years before the foundation of the British Association that the suggestions of Lister in regard to the construction of achromatic lenses brought the compound microscope into such a state of improvement as caused it to be restored, as I might say, to the place which the more imperfect instrument had lost in the previous century. The result of this restoration became apparent in the foundation of a new era in the knowledge of the minute characters of textureal structure, under the joint guidance of R. Brown and Ehrenberg, so as at last to have entitled this branch of inquiry, to its designation, by Mr. Huxley, of the exhaustive investigation of structural elements. All who hear me are fully aware of the influence which, from 1838 onwards, the researches of Schwann and Schleiden exerted on the progress of Histology and the views of anatomists and physiologists as to the structure and development of the textures, and the prodigious increase which followed in varied microscopic observations. It is not for me here even to allude to the steps of that rapid progress by which a new branch of anatomical science has been created; nor can I venture to enter upon any of the interesting questions presented by this department of the microscopic anatomy; nor attempt to discuss any of those possessing so much interest at the present moment, such as the nature of the organised cell or the properties of protoplasm. I would only remark that it is now very generally admitted that the cell wall (as Schwann indeed himself pointed out) is not a source of new production, though still capable of considerable structural change after the time of its first formation. The nucleus has also lost some of the importance attached to it by Schwann and his earlier followers, as an essential constituent of the cell, while the protoplasm of the cell remains in undisputed possession of the field as the more immediate seat of the phenomena of growth and organisation, and of the contractile property which forms so remarkable a feature of their substance. I cordially agree with much of what Mr. Huxley has written on this subject in 1853 and 1869. The term physical basis of life may perhaps be in some trifling respect objectionable, but I look upon the recognition of protoplasm, as a general term indicating that part of the tissue of plants and animals which is the constant seat of the growing and moving powers as a most important step in the recent progress of histology. To Maechel the fuller history of this in lowest forms is due. To Dr. Beale we owe the fullest investigation of these properties by the use of magnifying powers beyond any that had previously been known, and the successful employment of re-agents which appear to mark out distinction from the other elements of the textures. I may remark, however, in passing, that I am inclined to regard contractile protoplasm, whether vegetable or animal, as in no instance entirely amorphous or homogeneous, but rather as always presenting some minute molecular structure which distinguishes it from parts of glassy clearness. Admitting that the form it assumes is not necessarily that of a regular cell, and may be various and irregular in a few exceptional instances, I am not on that account disposed to give up definite structure as one of the universal characteristics of organisation in living bodies. I would also suggest that the term formative and nonformative, or some others, should be substituted for those of living and dead, employed by Dr. Beale to distinguish the protoplasm from the cell-wall or its derivation, as those terms are liable to introduce confusion.

## EMBRYOLOGY.

To the discoveries in embryology and development I might have been tempted to refer more at large, as being those which have had, of all modern research, the greatest effect in extending and modifying biological views, but I am warned from entering upon a subject in which I might trespass too much on your patience. The merits of Wolff as the great first pioneer in the accurate observation of the phenomena of development were clearly pointed out by Mr. Huxley in his presidential address of last year. Under the influence of Dollinger's teaching, Pander, and afterwards Von Baer and Rathke established the foundations of the modern history of embryology. It was only in the year 1827 that the ovum of mammals was discovered by Von Baer; the segmentation of the yolk, first observed by Prevost and Dumas in the frog's ovum in 1824, was ascertained to be general in succeeding years; so that the whole of the interesting and important additions which have followed, and have made embryological development a complete science, have been included within the eventful period of the life of this Association. I need not say how distinguished the Germans have been by their contributions to the history of animal development. The names of Bischoff, Reichart, Kolliker, and Remak are sufficient to indicate the most important of the steps in recent progress, without attempting to enumerate a host of others who have assisted in the great work thus founded. I am aware that the mere name of development suggests to some ideas of painful nature as associated with the theory of evolution recently promulgated. To one accustomed during the whole of his career to trace the steps by which every living being, including man himself, passes from the condition of an almost imperceptible germ, through a long series of changes of form and structure into their perfect state, the name of development is rather suggestive of that which seems to be the common history of all living beings; and it is not wonderful therefore that such a one should regard with approval the more extended view which supposes a process of development to belong to the whole of nature. How far that principle may be carried, to what point the origin of man or any animal can by history, facts or reasoning be traced in the long unchronicled history of the world, and whether living beings may arise independently of parents or germs of previously existing organisms, or may spring from the direct combination of the elements of dead matter, are questions upon which we may expect this section may endeavour to guide the hesitating opinion of the time. I cannot better express the state of opinion in which I find myself than by quoting the words of Professor Huxley from his address of last year, p. lxxxiii.:—"But though I cannot express this conviction of mine too strongly (viz., the occurrence of abiogenesis), I must carefully guard myself against the supposition that I intend to suggest that no such thing as abiogenesis ever has taken place in the past, or ever will take place in the future. With organic chemistry, molecular physics, and physiology yet in their infancy, and every day making prodigious strides, I think it would be the height of presumption for any man to say that the conditions under which matter assumes the properties we call 'vital,' may not some day be artificially brought together. And again, if it were given me to look beyond the abyss of geologically recorded time, to the still more remote period when the earth was passing through physical and chemical conditions, which it can no more see again than a man can recall his infancy, I should expect to be a witness of the evolution of living protoplasm from living matter." I will quote further a few wise words from the discourse to which many of you must have listened last evening with admiration. Sir Wm. Thomson said—" The essence of science, as is well illustrated by astronomy and cosmical physics, consists in inferring antecedent conditions, and anticipating future evolutions, from phenomena which have actually come under observation. In biology, the difficulty of successfully acting up to this ideal are prodigious. Our code of biological law is an expression of our ignorance as as well as of our knowledge. Search for spontaneous generation out of inorganic materials; let any one not satisfied with the purely negative testimony, of which we have now so much against it, throw himself into the inquiry. Such investigations as those of Pasteur, Pouchet and Bastian are among the most interesting and momentous in the whole range of natural history; and their results, whether positive or negative, must richly reward the most careful and laborious experimenting." The consideration of the finest discoverable structures of the organised parts of living bodies is intimately bound up with that of their chemical composition and properties. The progress which has been made in organic chemistry belongs not only to the knowledge of the composition of the constituents of organised bodies, but also in the manner in which that composition is chemically viewed. Its peculiar feature, especially as related to biological investigation, consists in the results of the introduction of the synthetic method of research, which has enabled the chemist to imitate or to form artifi cially a greater and greater number of the organic compounds. In 1828 the first of these substances was formed by Wohler, by a synthetic process, as cyanate of ammonia; and still, though some no doubt entertained juster views, the opinion prevailed among chemists and physiologists that there was some great and fundamental difference in the chemical phenomena and laws of organic and inorganic nature. But now this supposed barrier has been in a great measure broken down and removed, and chemists, with almost one accord, regard the laws of combination of the elements as essentially the same in both classes of bodies, whatever differences may exist in actual composition, or in the reaction of organic bodies in the more complex and often obscure conditions vitality, as compared with the simpler and, on the whole, better known phenomena of a chemical nature observed in the mineral kingdom. Thus, by the synthetic method, there have been formed among the simpler organic compounds a great number of alcohols, hydrocarbons, and fatty acids. But the most remarkable example of the synthetic formation of an organic compound is that of the alkaloid conia, as recently obtained by Hugo Schiff by certain reactions from butyric aldehyde, itself an artificial product. This substance, so formed, and its compounds, possess all the properties of the natural conia—chemical, physical, and physiological—being equally poisonous with it. The colouring-matter of madder, or alizarine, is another organic compound which has been formed by artifical processes. It is true that the organised or containing solid, either of vegetable or animal bodies, has not as yet yielded to the ingenuity of chemical artifice; nor, indeed, is the actual composition of one of the most important of these, albumen and its allies, fully known. But as chemists have only recently began to discover the track by which they may be led to the synthesis of organic compounds, it is warrantable to hope that ere long cellulose and lignine may be found; and, great as the difficulties with regard to the albumenoid compounds may at present appear, the synthetic formation of these is by no means to be despaired of, but, on the contrary, may with confidence be expected to crown their efforts. From all recent research, it appears to result that the general nature of the properties belonging to the products of animal and vegetable life, can no longer be regarded as different from those of minerals, in so far at least as they are the subject of chemical investigation. The union of elements and their separation, whether occurring in an animal, a vegetable or a mineral body, must be looked upon as dependent on innate powers or properties belonging to the elements themselves; and the phenomena of change of composition of organic bodies occurring in the living state are not the less chemical because they are different from those observed in organic nature. All chemical actions are liable to vary according to the conditions in which they occur, and many instances might be adduced of most remarkable variations of this kind, observed in the chemistry of dead bodies from very slight changes of electrical, calorific, mechanical, and other conditions. But because these conditions are infinitely more complex and far less known in living bodies, it is not necessary to look upon the actions as essentially of a different kind, to have recourse to the hypothesis of vital affinities, and still less to shelter ourselves under the slim curtain of ignorance implied in the explanation of the most varied chemical phenomena by the influence of a vital principle.

## EVOLUTION OF SPECIES.

On the subjects of zoological and botanical classification and anthropology, it would be out of place for me now to make any observations at length. I will only remark, in regard to the first, that the period now under review has witnessed a very great modification in the aspect which the affinities of the bodies belonging to these two great kingdoms of nature bear to each other, and the principles on which in each groups of bodies are associated together in classification; for, in the first place, the older view has been abandoned that the complication of structure rises in a continually increasing and continuous gradation from one kingdom to the other, or extends in one line from one group to another in either of the kingdoms separately. Evolution into a gradually increasing complexity of structure and function no doubt exists in both, so that types of formation must be acknowledged to pervade, accompanied by typical resemblance of the plan of formation of a most interesting nature; but it has become more and more apparent in the progress of morphological research that the different groups form rather circles, which touch one another at certain points of greatest resemblance, rather than one continuous line, or even a number of lines, which partially pass each other. Certain simpler bodies of the two kingdoms of nature thus exhibit the increasing resemblance to each other, until at last the differences between them wholly disappear, and we reach a point of contact at which the properties become almost indistinguishable, as in the remarkable Protista of Haeckel and others. I fully agree, however, with the view stated by Professor Wyville Thomson in his introductory lecture, that it is not necessary on this account to recognize with Haeckel a third intermediate kingdom of nature. Each kingdom presents, as it were, a radiating expansion into groups for itself, so that the relations of the two kingdoms might be represented by the divergence of lines spreading in two different directions from a common point. Recent observations on the chorda dorsalis of some Ascidians (or supposed notochord) tend to revive the discussion at one time prevalent, but long in abeyance, as to the possibility of tracing a homology between the vertebrate and invertebrate animals; and, should this correspondence be confirmed and extended, it may be expected to modify greatly our present views of zoological affinities and classification, and be an additional proof of the importance of minute and embryological research in such determinations. The recognition of homological resemblance of animals, to which in this country the researches of Owen and Huxley have contributed so largely, form one of the most interesting subjects of contemplation in the study of comparative anatomy and zoology in our time; but I must refrain from touching on so seductive and difficult a subject.

## NATURAL SCIENCE IN SCHOOLS.

There is another topic to which I can refer with pleasure as connected with the cultivation of biological knowledge in this country, and that is the introduction of instruction in natural science into the system of education of our schools. As to the feasibility of this in the primary schools, I believe most of those who are intimately acquainted with the management of these schools have expressed their decidedly favourable opinion—it being found that a portion of the time now allotted to the three great requisites of a primary education might with advantage be set apart, for the purpose of instructing the pupils in subjects of common interest, calculated to awaken in their minds a desire for knowledge of the various objects presented by the field of nature around them. As to the benefit which may result from this measure to the persons so instructed, it is scarcely necessary for me to say anything in this place. It is so obvious that whatever knowledge, though easily acquired, and even of the most elementary kind, tends to enlarge the range of observation and thought, must have some effect in removing its recipients from grosser influences, and may even give information which may prove useful in social economy and in the occupations of labour. Nor need I point out how much more extended the advantages of such instruction may prove if introduced into the system of our secondary schools, and more freely combined than heretofore with the two exclusively literary and philosophical study which has so long prevailed in the approved British education. Without disparagement to those modes of study as in themselves necessary and useful, and excellent means of disciplining the mind to learning, I cannot but hold it as certain that the mind which is entirely without scientific cultivation is but half prepared for the common purposes of modern life, and is entirely unqualified for forming a judgment on some of the most difficult and yet most common and important questions of the day, affecting the interests of the whole community. I refer with great pleasure to the cogent arguments addressed yesterday by Dr. Bennet to the medical graduates of the University, in favour of the establishment of physiology as a subject of general education in this country with reference to sanitary conditions. It is gratifying, therefore, to perceive that the suggestions made some time ago in regard to this subject by the British Association, through its committee, have already borne good fruit, and that the attention of those who preside over education in this country, as well as of the public themselves, is more earnestly directed to the object of securing for the lowest as well as the highest classes of the community that wholesome combination of knowledge derived from education, which will duly cultivate all the faculties of the mind, and thus fit a greater and greater number for applying themselves with increased ability and knowledge to the purposes of their living and its improved condition. If the law of the survival of the fittest be applicable to the mental as well as to the physical improvement of our race (and who can doubt that it must be so), we are bound by motives of interest and duty to secure for all classes of the people that kind of education which will lead to the development of the highest and most varied mental power. And no one who has been observant of the recent progress of the useful arts and its influence upon the moral, social, and political condition of our population, can doubt that that education must include instruction in the phenomena of external nature, including, more especially, the laws and conditions of life; and be, at the same time, such as will adapt the mind to the ready reception of varied knowledge. It is obvious too, that while this more immediately useful or beneficial effect on the common mind may be produced by the diffusion of natural knowledge among the people, biological science will share in the gain accruing to all branches of natural science, by the greater favour which will be accorded to its cultivators, and the increased freedom from prejudice with which their statements are received and considered by learned as well as by unscientific persons.

### SPIRITUALISM.

I cannot conclude these observations without adverting to one aspect in which it might be thought that biological science has taken a retrograde rather than an advanced position. In this, I do not mean to refer to the special cultivators of biology in its true sense, but to the fact that there appears to have taken place of late a considerable increase in the number of persons who believe, or who imagine that they believe, in the class of phenomena which are now called spiritual, but which have been long known —since the exhibitions of Mesmer, and indeed, long before his time—under the most varied forms, as liable to occur in persons of an imaginative turn of mind and peculiar nervous susceptibility. It is still more to be deplored that many persons devote a large share of their time to the practice—for it does not deserve the name of study or investigation—of the alleged phenomena, and that a few men of acknowledged reputation in some departments of science have lent their names, and surrendered their judgment, to the countenance and attempted authentication of the foolish dreams of the practitioners of spiritualism, and similar chimerical hypotheses. The natural tendency to a belief in the marvellous is sufficient to explain the ready acceptance of such views by the ignorant; and it is not improbable that a higher species of similar credulity may frequently act with persons of greater cultivation, if their scientific information has been of a partial kind. It must be admitted, further, that extremely curious and rare, and to those who are not acquainted with nervous phenomena, apparently marvellous phenomena, present themselves in peculiar states of the nervous system—some of which states may be induced through the mind and may be made more and more liable to recur, and greatly exaggerated by frequent repetition. But making the fullest allowance for all these conditions, it is surprising that persons otherwise appearing to be within the bounds of sanity, should entertain a confirmed belief in the possibility of phenomena, which, while they are at variance with the best established physical laws, have never been brought under proof by the evidences of the senses, and are opposed to the dictates of sound judgment. It is so far satisfactory in the interests of true biological science that no man of note can be named from the long list of thoroughly well-informed anatomists and physiologists, who has not treated the belief in the separate existence of powers of animal magnetism and spiritualism as wild speculations, devoid of all foundation in the carefully tested observation of facts. It has been the habit of the votaries of the systems to which I have referred to assert that scientific men have neglected or declined to investigate the phenomena with attention and candour; but nothing can be farther from the truth than this statement. Not to mention the admirable reports of the early French academicians, giving the account of the negative result of an examination of the earlier mesmeric phenomena by men in every way qualified to pronounce judgment on their nature, I am aware that from time to time men of eminence, and fully competent, by their knowledge of biological phenomena, and their skill and accuracy in conducting scientific investigation, have made the most patient and careful examination of the evidence placed before them by the professed believers and practitioners of so-called magnetic, phreno-magnetic, electro-biological, and spiritualistic phenomena; and the result has been uniformly the same in all cases when they were permitted to secure conditions by which the reality of the phenomena, or the justice of their interpretation, could be tested—viz., either that the experiments signally failed to educe the results professed, or that the experimenters were detected in the most shameless and determined impostures. I have myself been fully convinced of this by repeated examinations. But were any guarantee required for the care, soundness, and efficiency of the judgment of men of science on these phenomena and views, I have only to mention, in the first place the revered name of Faraday, and in the next that of my life-long friend Dr. Sharpley, whose ability and candour none will dispute, and who I am happy to think, is here among us, ready from his past experience of such exhibitions, to bear his weighty testimony against all cases of *levitation*, or the like, which may be the last wonder of the day among the mesmeric or spiritual pseudo-physiologists. The phenomena to which I have at present referred, be they false or real, are in great part dependent upon a natural principle of the human mind, placed, as it would appear, in dangerous alliance with certain tendencies of the nervous system. They ought not to be worked upon without the greatest caution, and they can only be fully understood by the accomplished physiologist who is also conversant with psychology. The experience of the last hundred years tends to show that there will always exist a certain number of minds prone to adopt a belief in the marvellous and striking in preference to that which is easily understood and patent to the senses; but it may be confidently expected that the diffusion of a fuller and more accurate knowledge of vital phenomena among the non-scientific classes of the community may lead to a juster appreciation of the phenomena in question, and a reduction of the number among them who are believers in the impossible. As for men of science who persist in submitting to such strange perversion of judgment, we can only hope that the example of their less instructed fellow-countrymen may lead them to allow them themselves to be guided more directly by the principles of common sense than by the erratic tendencies of a too fervid imagination.

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Extracts from the President's (T. Andrews, F.R.S.) Address in the Chemical Section on the

## PROGRESS OF CHEMICAL RESEARCH.

Proceeding to touch on questions of general chemistry at present attracting attention, the learned Professor spoke first of the relations which subsist between the chemical composition and refractive power of bodies for light. He then proceeded—A happy modification of the ice calorimeter has been made by Bunsen. The principle of the method—to use as a measure of heat the change of volume which ice undergoes in melting—had already occurred to Herschel, and, as it now appears, still earlier to Hermann; but their observations had been entirely overlooked by physicists, and had led to no practical results. Bunsen has, indeed, clearly pointed out that the success of the method depends upon an important condition, which is entirely his own. The ice to be melted must be prepared with water free from air, and must surround the source of heat in the form of a solid cylinder frozen artificially *in situ*. Those who have worked on the subject of heat know how difficult it is to measure absolute quantities with certainty, even where relative results of great accuracy may be obtained. The ice calorimeter of Bunsen will therefore be welcomed as an important addition to our means of research. Roscoe has prosecuted the photo-chemical investigations which Bunsen and he began some years ago. For altitudes above 10 degrees, the relation between the sun's altitude and the chemical intensity of light is represented by a straight line. Till the sun has reached an altitude of about 20 degrees, the chemical action produced by diffused daylight exceeds that of the direct sunlight; the two actions are then balanced, and at higher elevations the direct sunlight is superior to the diffused light. The supposed inferiority of the chemical action of light under a tropical sun to its action in higher latitudes proves to be a mistake. According to Roscoe and Thorpe, the chemical intensity of light at Para, under the equator, in the month of April, is more than three times greater than at Kew in the month of August. Hunter has given a great extension to the earlier experiments of Saussure on the absorptive power of charcoal for gases. Cocoanut charcoal, according to Hunter's experiments, exceeds all other varieties of wood charcoal in absorptive power, taking up at ordinary pressures 170 volumes of ammonia and 69 of carbonic acid. Methylic alcohol is more largely absorbed than any other vapour at temperatures from 90° to 127°, but at 159° the absorption of ordinary alcohol exceeds it. Cocoanut charcoal absorbs 44 times its volume of the vapour of water at 127°. The absorptive power is increased by pressure. Last year two new processes for improving the manufacture of chlorine attracted the attention of the section; one of them has already proved to be a success, and I am glad to be able to state that Mr. Deacon has recently overcome certain difficulties in his method, and has obtained a complete absorption of the chlorine. May we hope to see oxygen prepared by a cheap and continuous process from atmospheric air? With baryta the problem can be solved very perfectly, if not economically. Another process is that of Tessier de Mothay, in which the manganate of potassium is decomposed by a current of superheated steam, and afterwards revived by being heated in a current of air. A company has lately been formed in New York to apply this process to the production of a brilliant house light. A compound Argand burner is used, having a double row of apertures—the inner row is supplied with oxygen, the other with coal gas or other combustible. The applications of pure oxygen, if it could be procured cheaply, would be very numerous, and few discoveries would more amply reward the inventor. Among other uses, it might be applied to the production of ozone, free from nitric acid by the action of the electrical discharge, and to the introduction of that singular body in an efficient form into the arts as a bleaching and oxidising agent. Tessier de Mothay has also proposed to prepare hydrogen gas on the large scale by heating hydrate of lime with anthracite. We learn from the history of metallurgy that the valuable alloy which copper forms with zinc was known and applied long before zinc itself was discovered. Nearly the same remark may be made at present with regard to manganese and its alloys. The metal is difficult to obtain, and has not in the pure state been applied to any useful purpose; but its alloys with copper and other metals have been prepared, and some of them are likely to be of great value. The alloy with zinc and copper is used as a substitute for German silver, and possesses some advantages over it. Not less important is the alloy of iron and manganese prepared according to the process of Henderson, by reducing in a Siemens' furnace a mixture of carbonate of manganese and oxide of iron. It contains from 20 to 30 per cent. of manganese, and will doubtless replace to a large extent the spiegeleism now used in the manufacture of Bessemer steel. The classical researches of Roscoe have made us acquainted for the first time with metallic vanadium. Berzelius obtained brilliant scales which he supposed to be the metal, by heating oxychloride in ammonia, but they have proved to be a nitride. Roscoe prepared the metal by reducing its chloride in a current of hydrogen, as a light gray powder, with a metallic lustre under the microscope. It has a remarkable affinity both for nitrogen and silicon. Like phosphorus, it is a pentad, and the vanadates correspond in composition to the phosphates, but differ in the order of stability at ordinary temperatures, the soluble tribasic salts being less stable than the tetrabasic compounds. Sainte Claire Deville, in continuation of his researches on dissociation, has examined the conditions under which vapour of water is decomposed by metallic iron. The iron, maintained at a constant temperature, but varying in different experiments, from 150° C. to 1600° C., was exposed to the action of the vapour of water of known tension. It was found that for a given temperature the iron continued to oxidise till the tension of the hydrogen formed reached an invariable value. In these experiments, as Deville remarks, the iron behaves as if it emitted a vapour (hydrogen), obeying the laws of hygometry. An interesting set of experiments has been made by Lothian Bell on the power possessed by spongy metallic iron of splitting up carbonic oxide into carbon and carbonic acid, the former being deposited in the iron. A minute quantity of oxide of iron is always formed in this reaction. In organic chemistry, the labours of chemists have been of late largely directed to a group of hydrocarbons, which were first discovered among the products of the destructive distillation of coal or oil. The central body round which these researches have chiefly turned is benzol, whose discovery will always be associated with the name of Faraday. Baeyer has prepared artificially picoline, a base isomeric with aniline, and discovered by Anderson in his very able researches on the Pyridine series. Of the two methods described by Baeyer, one is founded on an experiment of Simpson, in which a new base was obtained by heating tribromallyl with an alcoholic solution of ammonia. By pushing further the action of the heat, Baeyer succeeded in expelling the whole of the bromine from Simpson's base, in the form of hydrobromic acid, and in obtaining picoline. The same chemist has also prepared artificially collidine, another base of the Pyridine series. In this list of remarkable synthetical discoveries, another of the highest interest has lately been added by Schiff—the preparation of artificial coniine. He obtained it by the action of ammonia on butyric aldehyde. The artificial base has the same composition as coniine prepared from hemlock. It is a liquid of an amber-yellow colour, having the characteristic odour and nearly all the usual reactions of ordinary coniine. Its physiological properties, so far as they have been examined, agree with those of coniine from hemlock, but the artificial base has not yet been obtained in large quantity, nor perfectly pure.

Valuable papers on alizarine have been published by Perkin and Schunk. The latter has described a new acid—the anthraflaric—which is formed in the artificial preparation of alizarine. Madder contains another colouring principle, purpurine, which, like alizarine, yields anthracene when acted on by reducing agents, and has also been prepared artificially. These colouring principles may be distinguished from one another, as Stokes has shown, by their absorption bands; and Perkin has lately confirmed by this optical test the interesting observation of Schunk that finished madder prints contain nothing but pure alizarine in combination with the mordaunt employed. Hofmann has achieved another triumph in a department of chemistry which he has made peculiarly his own. In 1857, he showed that alcohol bases, analogous to those derived from ammonia, could be obtained by replacement from phosphuretted hydrogen, but he failed in his attempts to prepare the two lower derivatives. These missing links he has now supplied, and has thus established a complete parallelism between the derivatives of ammonia and of phosphuretted hydrogen. The same able chemist has lately described the aromatic cyanates, of which one only—the phenylic cyanate—was previously known, having been discovered about twenty years ago by Hofmann himself. He now prepares this compound by the action of phosphoric anhydride on phenylurethane, and by a similar method he has obtained the tolylic, xylylic, and napthylic cyanates. Stenhouse had observed many years ago that, when aniline is added to furfurol, the mixture becomes rose-red, and communicates a fugitive red stain to the skin, and also to linen and silk. He has lately resumed the investigation of this subject, and has obtained two new bases—furfuraniline and furfurtolnidine—which like rosaniline, form beautifully coloured salts, although the bases themselves are nearly colourless, or of a pale brown colour. The interesting work of Dewar on the oxidation of picoline must not be passed over without notice. By the action of the permanganate of potassium on that body, he has obtained a new acid, which bears the same relation to pyridine that phthalic acid does to benzol. Thorpe and Young have published a preliminary notice of some results of great promise which they have obtained by exposing paraffin to a high temperature in closed vessels. By this treatment it is almost completely resolved into liquid hydrocarbons whose boiling points range from 18° C. to 300° C. Those boiling under 100° have been examined, and consist chiefly of olefines. In connection with this subject, it may be interesting to recal the experiments of Pelouze and Cahours on the Pennsylvanian oils, which proved to be a mixture of carbolizdrogers belonging to the marsh gas series. An elaborate exposition of Berthelot's method of transforming an organic compound into a hydrocarbon containing a maximum of hydrogen, has appeared in a connected form. The organic body is heated, in a sealed tube with a large excess of a strong solution of hydriodic acid, to the temperature of 275°. The pressure in these experiments Berthelot estimates at 100 atmospheres, but apparently without having made any direct measurements. He has thus prepared ethyl hydride from alcohol, aldehyde, &c., hexyl hydride from benzol. Berthelot has submitted both wood charcoal and coal to the reducing action of hydriodic acid, and among other interesting results, he claims to have obtained in this way oil of petroleum. By the action of chloride of zinc upon codeia, Matthiessen and Burnside have obtained apocodeia, which stands to codeia in the same relation as apomorphia to morphia, an atom of water being abstracted in its formation. Apocodeia is more stable than apomorphia; but the action of reagents upon the two bases is very similar. As regards their physiological action, the hydrochlorate of apocodeia is a mild emetic, while that of apomorphia is an emetic of great activity. Other bases have been obtained by Wright by the action of hydrobromic acid on codeia. In two of these bases, bromotetra-codeia and chlorotetra-codeia, four molecules of codeia are welded together, so that they contain no less than seventy-two atoms of carbon. They have a bitter taste, but little physiological action. The authors of these valuable researches were indebted to Messrs. Macfarlane for the precious material upon which they operated. We are indebted to Crum Brown and Fraser for an important work on a subject of great practical, as well as theoretical, interest—the relation between chemical constitution and physiological action. It has long been known that the ferrocyanide of potassium does not act as a poison on the animal system; and Bunsen has shown that the kakodylic acid, an arsenical compound, is also inert. Crum Brown and Fraser found that the methyl compounds of strychnia-brucia and thebaia are much less active poisons than the alcoloids themselves; and the character of their physiological action is also different. The hypnotic action of the sulphate of methyl-morphium is less than that of morphia. But a reverse result occurs in the case of atropia, whose methyl and ethyl derivatives are much more poisonous than the salts of atropia itself.

# THE POST-PLIOCENE GEOLOGY OF CANADA,

By J. W. DAWSON, LL.D., F.R.S., F.G.S.

## PART II.—LOCAL DETAILS.

Before entering into the special consideration of this Second Part of the subject, I desire to call attention to some additional facts bearing on two of the most remarkable properties of the Post-pliocene deposits of the Northern Hemisphere, namely their general similarity of arrangement, and their local diversities.

In the first part of this memoir, taking the Post-pliocene of the Lower St. Lawrence as a type, I showed that it has its parallel, with but slight general difference, in the wide-spread superficial deposits of the interior of North America surrounding the great lakes, and that the Post-pliocene deposits of Scotland and Scandinavia almost precisely resemble those of Canada in the general sequence of deposits. Since that part was published, additional illustrations have been afforded by papers in the Geological Magazine by Mr. Hull, and Mr. Mackintosh, by papers and discussions on the Eskers of Ireland, at the meeting of the British Association, and by an able monograph on the Estuary of the Forth, by Mr. David Milne Home. Mr. Hull, who is a "Land Glacialist," arranges the deposits of the Drift Period in the British area in the following three groups, in descending order, in accordance with Prof. Ramsay's observations in England, and his own in Ireland.

1. Upper Boulder-clay, which he regards as "generally marine." In Canada, this is represented by the loose boulders and partial boulder deposits of the Upper Saxicava Sand.

2. Shelly marine sands and gravels belonging to the greatest depression of the land, and representing our Saxicava Sand and Leda Clay.

3. Lower Boulder-clay, which represents the true or principal Boulder-clay of Canada. This Mr. Hull attributes "chiefly to land ice."

In Ireland, it would thus seem that the principal sub-divisions of the Post-pliocene can be recognized, and Mr. Kinahan has described the remarkable ridges of gravel called eskers which run across the country in a North-east and South-west direction. Like our Canadian eskers or " Boar's backs," they are now admitted to be of marine origin, and are attributed to current action and to the waves, though floating ice has no doubt, as in Canada, contributed in some cases to their formation.

Mr. Milne Home gives a graphic description of the Post-pliocene deposits in the neighbourhood of the Frith of Forth, and many of his numerous sections might have just as well been taken from Canadian deposits. He thus sums up the causes of the phenomena, assuming that at the beginning of the period the land was submerged.

" The ocean over and around Scotland was full of icebergs and shore ice, which spread fragments of rocks over the sea bottom and often stranded, ploughing through beds of mud, sand, gravel, and blocks of stone, and mingling them together in such a way as to form the 'Boulder-clay.' The land thereafter gradually emerged, during which time the long ridges or embankments of gravel called 'kames' were formed."

Mr. Mackintosh's observations go mainly to show that in England, as in Canada, even the lower drift and rock striation are due to a great extent to floating ice and not to glaciers, and he extends this conclusion even into the lake district of England.

It is also worthy of remark that the long-received doctrine that glaciers are powerful eroding agents, which the author showed in a paper in this journal, in 1866, to be without foundation, is only now beginning to be discredited in England. I shall refer to this in the sequel, and in the meantime may direct attention to an interesting paper on the subject by Mr. Bonney, F.G.S., in the Journal of the Geological Society for August, 1871.

It would further appear that, after the glacial period, in the Post-glacial, the British land rose to a level higher than that which it at present exhibits, then sunk again, and re-emerged in the modern period. Evidences of this later submergence have not been recognized in Canada, but in the inland area they have been detected by Hilgard and by Andrews.

Since the publication of the first part of this memoir, Prof. Hilgard has discussed the subject of the southern drifts of the Mississippi valley at the meeting of the American Association at Indianapolis; and I am indebted to that gentleman and to Prof. Andrews, of Chicago, for much information on these deposits and their relation to those of more northern regions.

It appears that the oldest Post-pliocene deposit in the south is that called by Prof. Hilgard the "Orange Sand." This deposit is spread over the States of Mississippi, Alabama, Tennessee, and parts of Louisiana, Kentucky, and Arkansas, and in some places attains an elevation of 700 feet. It contains water-worn fragments of northern rocks, and is supposed by Prof. Hilgard to have been deposited by rapid currents of water, possibly fresh, as the deposit contains no marine fossils.

Above this, according to Prof. Hilgard, is found in places a swamp, lagoon or estuary formation designated the "Port Hudson group." Succeeding this is the "Bluff or Loess" group, a deposit of fine silt, limited almost or entirely to the Valley of the Missisippi. Its maximum thickness is seventy-five feet.

On this rests a very widely distributed bed, the "Yellow Loam," not more than twenty feet thick, but much more extensively distributed laterally than the former, and reaching an elevation of 700 feet.

Under the names of "Second Bottoms or Hummocks," and "First Bottoms," are known terraced deposits of clay belonging to the present river valleys, but indicating in the case of the Second Bottoms a greater amount of water than at present.

It is obvious that all of the above are aqueous deposits, and there seems to be no evidence whatever in the region referred to, of the action of land ice, though the stones and few boulders in the Orange sand are very probably due to floating ice. There seems reason to believe that the Orange sand is continuous with the Boulder-drift of the north-west; and if this is, as stated by Newberry and others, a later deposit than the Erie clay, then it is probable that no representative of the latter exists to the south-west, or that the Orange sand represents the whole of the northern deposits. In any case it represents northern currents of water, though whether salt water admitted by the depression of the land, or fresh water resulting from the melting of glaciers, it is not easy to decide, as very great difficulties attend either view in the present state of our knowledge of the deposit. Whatever the conditions of deposit of the Orange sand, it would seem to have been succeeded by a land surface, and this by a depression to the extent of 700 feet or more, before the modern elevation of the land. If this last elevation corresponds with that of the terraces of the St. Lawrence, then the former one must have occurred in the St. Lawrence valley in the interval between the deposit of the Leda clay and the close of the Post-pliocene. This question we shall have occasion to consider in the sequel, in connection with the second depression of the European land above referred to.

Since the publication of the first of these papers, Dr. Newberry has kindly sent me a paper of his published as early as 1862, in which he states the remarkable fact, quoted above from his more recent Report on Ohio, that the drainage of the great lake basins, open in the early Post-pliocene period, was obstructed by the glacial deposits, and has been only partially restored. He also desires me to state that he refers the old drainage not exclusively to the action of glaciers, but to the "ice period, or an earlier epoch." I am happy to make these corrections; the latter more especially, as it brings our theoretical views more into harmony. Dr. Newberry, however, for whose conclusions on such subjects I have the highest respect, still, in his latest expressions of opinion, adheres to the action of land ice in producing the glacial striation, which from his descriptions is, I should suppose, quite as definite and strongly marked as that in the St. Lawrence valley.

The grand series of Post-pliocene changes was thus uniform in Europe and America, pointing to great general causes of subsidence and re-elevation; but locally there is the most extreme irregularity in these deposits, giving great uncertainty to their arrangement. Some of these differences we shall have occasion to notice under the following geographical subdivisions.

### 1. *Newfoundland and Labrador.*

In the Journal of the Geological Society of London, for February, 1871, is a communication from Staff-commander Kerr, R. N., of the Coast Survey, in which he gives the directions of twenty-eight examples of grooved and scratched surfaces observed in the southern part of Newfoundland. The course of the majority of these is N.E. and S.W., ranging from N.8° E. to N. 64° E. The remainder are N.W. and S.E., most of them with a predominating Easterly direction. Boulders are mentioned, but no marine beds. The author refers the glaciation to land ice, supposing certain submerged banks across the mouths of the bays to be terminal moraines.

The latest information on the Post-pliocene of Labrador is that given in a paper by Dr. Packard in the memoirs of the Boston Society of Natural History for 1867. The deposits are said to consist of boulders, Leda clay and sand, and raised beaches, which, on the authority of Prof. Hind, are stated to reach an elevation of 1200 feet above the sea. The hills to a height of 2500 feet are rounded as if by ice action. Some higher hills present a frost-shattered surface at their summits. No directions of striæ are given, and they appear to be rare. Mr. Campbell, author of "Frost and Fire," mentions examples with course N. 45° E. in the Strait of Belle Isle. It is remarkable that true Boulder-clay is rare in Labrador, though loose boulders are abundant in the valleys and on the inland table land. Dr. Packard attributes the absence of Boulder-clay to denudation. This may be the cause, but it is to be observed that, on that view of the origin of Boulder-clay which attributes it to ice-laden arctic currents, there must always have been in the course of such currents areas of denudation as well as areas of deposition, and an elevated table-land like that of Labrador, in a high northern latitude, may well have been of the former character.

The Leda clay occurs in several places. In 1860, I published a list of species collected by Capt. Orlebar; and Packard has greatly added to the number, giving a list which will be referred to farther on. Dr. Packard very truly remarks that the fauna of the Labrador clays is very similar to that now found on the coast, and called by him the Syrtensian fauna. In the latter we have a few southern forms, absent in the clay, but this is all. Further, the Labrador Post-pliocene fauna is identical or nearly so with that of similar deposits in South Greenland, described by Möller and Rink. Thus the climatal conditions of the arctic current on the coast of Labrador seem to have in no respect differed in the Post-pliocene from those which obtain at present. The Leda clay with its characteristic fossils is found as high as 500 feet above the level of the sea.

Raised beaches and terraces, whether cut into sand and clay or the hard metamorphic rocks of the coast, are as common in Labrador as along the shores of the River St. Lawrence. Their precise altitudes are not given, but they appear to be very numerous and to rise to a great height above the sea. One feature of some interest is their consisting in some places of large stones and boulders, evidencing very powerful action of coast ice and currents. Packard speaks of many of these beaches as moraines modified by the sea, but he gives no reason for this except the general belief that extensive glaciers existed in Labrador in the Post-pliocene, of which, however, there seems little direct evidence. From the descriptions of Prof. Hind,* however, it would seem that traces of local glaciers in the river valleys, similar to those referred to above in the case of the Saguenay and the Murray River, exist, and these might now be restored by a slight increase of cold and a moderate elevation of the land.

On the island of Anticosti, Messrs. Hyatt, Verrill and Shaler found *Saxicava arctica* in clay at an elevation of fifteen feet above the level of the sea.

Before proceeding up the St. Lawrence Valley into Canada proper, I may cross to the south side of the Gulf of St. Lawrence and notice the drift deposits of Prince Edward Island, Nova Scotia and New Brunswick, and their connection with those of the State of Maine.

### 2. *Prince Edward Island.*

The Triassic and Upper Carboniferous rocks of this island consist almost entirely of red sandstones, and the country is low and undulating, its highest eminences not exceeding 400 feet. The prevalent Post-pliocene deposit is a Boulder-clay, or in some places boulder loam, composed of red sand and clay derived from the waste of the red sandstones. This is filled with boulders of red sandstone derived from the harder beds. They are more or less rounded, often glaciated, with striæ in the direction of their longer axis, and sometimes polished in a remarkable manner, when the softness and coarse character of the rock are considered. This polishing must have been effected by rubbing with the sand and loam in which they are embedded. These boulders are not usually large, though some were seen as much as five feet in length. The boulders in this deposit are almost universally of the native rock, and must have been produced by the grinding of ice on the outcrops of the harder beds. In the eastern and middle portion of the Island, only these native rocks were seen in the clay, with the exception of pebbles of quartzite which may have been derived from the Triassic conglomerates. At Campbellton, in the western part of the Island, I observed a bed of Boulder-clay filled with boulders of metamorphic rocks similar to those of the mainland of New Brunswick.

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* Trans. Geol. Society, 1864.

Striæ were seen only in one place on the North-eastern coast and at another on the South-western. In the former case their direction was nearly S.W. and N.E. In the latter it was S. 70° E.

No marine remains were observed in the Boulder-clay; but at Campbellton, above the Boulder-clay already mentioned, there is a limited area occupied with beds of stratified sand and gravel, at an elevation of about fifty feet above the sea, and in one of the beds there are shells of *Tellina Grœnlandica.*

On the surface of the country, more especially in the western part of the island, there are numerous travelled boulders, sometimes of considerable size. As these do not appear in situ in the Boulder-clay, they may be supposed to belong to a second or newer boulder drift similar to that which we shall find to be connected with the Saxicava sand in Canada. These boulders being of rocks foreign to Prince Edward Island, the question of their source becomes an interesting one. With reference to this, it may be stated in general terms, that the majority are Granite, Syenite, Diorite, Felsite, Porphyry, Quartzite and coarse slates, all identical in mineral character with those which occur in the metamorphic districts of Nova Scotia and New Brunswick, at distances of from 50 to 200 miles to the South and South-west; though some of them may have been derived from Cape Breton on the East. It is further to be observed that these boulders are most abundant and the evidences of denudation of the Trias greatest in that part of the Island which is opposite the deep break between the hills of Nova Scotia and New Brunswick, occupied by the Bay of Fundy, Chiegnecto Bay and the low country extending thence to Northumberland Strait, an evidence that this boulder drift was connected with currents of water passing up this depression from the South or South-west.

Besides these boulders, however, there are others of a different character; such as Gneiss, Hornblende schist, Anorthosite and Labradorite rock, which must have been derived from the Laurentian rocks of Labrador and Canada, distant 250 miles or more, to the Northward. These Laurentian rocks are chiefly found on the North side of the island, as if at the time of their arrival the island formed a shoal, at the North side of which the ice carrying the boulders grounded and melted away. With reference to these boulders, it is to be observed that a depression of four or five hundred feet would open a clear passage for the arctic current entering the Straits of Belle Isle, to-the Bay of Fundy; and that heavy ice carried by this current would then ground on Prince Edward Island, or be carried across it to the Southward. If the Laurentian boulders came in this way, their source is probably 400 miles distant in the Strait of Belle Isle. On the North shore of Prince Edward Island, except where occupied by sand dunes, the beach shows great numbers of pebbles and small boulders of Laurentian rocks. These are said by the inhabitants to be cast up by the sea or pushed up by the ice in spring. Whether they are now being drifted by ice direct from the Labrador coast, or are old drift being washed up from the bottom of the gulf, which north of the island is very shallow, does not appear. They are all much rounded by the waves, differing in this respect from the majority of the boulders found inland.

The older Boulder-clay of Prince Edward Island, with native boulders, must have been produced under circumstances of powerful ice-action, in which comparatively little transport of material from a distance occurred. If we attribute this to a glacier, then as Prince Edward Island is merely a slightly raised portion of the bottom of the Gulf of St. Lawrence, this can have been no other than a gigantic mass of ice filling the whole basin of the gulf, and without any slope to give it movement except toward the centre of this great though shallow depression. On the other hand, if we attribute the Boulder-clay to floating ice, it must have been produced at a time when numerous heavy bergs were disengaged from what of Labrador was above water, and when this was too thoroughly enveloped in snow and ice to afford many travelled stones. Farther, that this Boulder-clay is a submarine and not a subaerial deposit, seems to be rendered probable by the circumstance that many of the boulders of sandstone are so soft that they crumble immediately when exposed to the weather and frost.

The travelled boulders lying on the surface of the Boulder-clay evidently belong to a later period, when the hills of Labrador and Nova Scotia were above water, though lower than at present, and were sufficiently bare to furnish large supplies of stones to coast ice carried by the tidal currents sweeping up the coast, or by the Arctic current from the North, and deposited on the surface of Prince Edward Island, then a shallow sand-bank. The sands with sea-shells probably belonged to this period, or perhaps to the later part of it, when the land was gradually rising. Prince

Edward Island thus appears to have received boulders from both sides of the gulf of St. Lawrence during the later Post-pliocene period; but the greater number from the South side, perhaps because nearer to it. It thus furnishes a remarkable illustration of the transport of travelled stones at this period in different directions, and in the comparative absence of travelled stones in the lower Boulder-clay, it furnishes a similar illustration of the homogeneous and untravelled character of that deposit, in circumstances where the theory of floating ice serves to account for it, at least as well as that of land-ice, and in my judgment greatly better.

### 3. *Nova Scotia and New Brunswick.*

In these Provinces the circumstances are entirely different from those in Prince Edward Island, the country consisting of Carboniferous and Triassic plains, with ranges of older hills, often metamorphic, and attaining elevations of 1200 feet or more. It may, perhaps, be best in the first instance to present a summary of the phenomena, as I have given them in my Acadian Geology, and to add such additional facts and inferences as the present state of the subject may require.

The beds observed may be arranged as follows, in descending order.

1. Gravel and sand beds, and ancient gravel ridges and beaches, indicating the action of shallow water, and strong currents and waves. Travelled boulders occur in connection with these beds.
2. Stratified clay with shells, showing quiet deposition in deeper water.
3. Unstratified Boulder-clay, indicating, probably, the united action of ice and water.
4. Peaty deposits, belonging to a land surface preceding the deposit of the Boulder-clay.

As the third of these formations is the most important and generally diffused in Nova Scotia and New Brunswick, we shall attend to it first, and notice the relation of the others to it.

The Unstratified Drift or Boulder-clay varies from a stiff clay to loose sand, and its composition and colour generally depend upon those of the underlying and neighbouring rocks. Thus, over sandstone it is arenaceous, over shales argillaceous, and over conglomerates and hard slates pebbly or shingly. The greater number of the stones contained in the drift are usually, like the paste containing them, derived from the neighbouring rock formations. These untravelled fragments are often of large size, and are usually angular, except when they are of very soft material, or of rocks whose corners readily weather away. It is easy to observe, that on passing from a granite district to one composed of slate, or from slate to sandstone, the character of the loose stones changes accordingly. It is also a matter of familiar observation, that in proportion to the hardness or softness of the prevailing rocks, the quantity of these loose stones increases or diminishes. In some of the quartzite and granite districts of the Atlantic coast, the surface seems to be heaped with boulders with only a little soil in their interstices, and every little field, cleared with immense labour, is still half-filled with huge white masses popularly known as "elephants." On the other hand, in the districts of soft sandstone and shale, one may travel some distance without seeing a boulder of considerable size. The boulders are as usual often glaciated or marked with ice-striæ.

Though the more abundant fragments are untravelled, it by no means follows that they are undisturbed. They have been lifted from their original beds, heaped upon each other in every variety of position, and intermixed with sand and clay, in a manner which shows convincingly that the sorting action of running water had nothing to do with the matter; and this applies not only to stones of moderate size, but to masses of ten feet or more in diameter. In some of the carboniferous districts where the Boulder-clay is thick, as for example, near Pictou Harbour, it is as if a gigantic harrow had been dragged over the surface, tearing up the outcrops of the beds, and mingling their fragments in a rude and unsorted mass.

Besides the untravelled fragments, the drift always contains boulders derived from distant localities, to which in many cases we can trace them; and I may mention a few instances of this to show how extensive has been this transport of detritus. In the low country of Cumberland there are few boulders, but of the few that appear some belong to the hard rocks of the Cobequid hills to the Southward; others may have been derived from the somewhat similar hills of New Brunswick. On the summits of the Cobequid hills and their Northern slopes, we find angular fragments of the sandstones of the plain below, not only drifted from their original sites, but elevated several hundreds of fee above them. To the Southward and Eastward of the Cobequids, throughout Colchester, Northern Hants, and Pictou, fragments from these hills, usually much rounded, are the most abundant travelled boulders, showing that there has been great driftage from this elevated tract. Near the town of Pictou, where a thick bed of a sandy boulder deposit occurs, this is filled with large masses of sandstone derived from the outcrops of the beds on higher ground to the north; but with these are groups of travelled stones often in the lower part of the mass. Near the steam ferry wharf, in the town of Pictou, I observed one such group, consisting of the following, all large boulders and lying close together—two of red syenite, six of gray granite, one of compact grey felsite, one of hard conglomerate, two of hard grit. The two last were probably Lower Carboniferous, the others derived from the altered Silurian deposits. All may have been drifted by one berg or ice-floe from the flanks of the Cobequid range of hills. In like manner, the long ridge of trap rocks, extending from Cape Blomidon to Briar Island, has sent off great quantities of boulders across the sandstone valley which bounds it on the South and up the slopes of the slate and granite hills to the Southward of this valley. Well characterized fragments of trap from Blomidon may be seen near the town of Windsor; and I have seen unmistakeable fragments of similar rock from Digby neck, on the Tusket River, thirty miles from their original position. On the other hand, numerous boulders of granite have been carried to the Northward from the hills of Annapolis, and deposited on the slopes of the opposite trappean ridge; and some of them have been carried round its Eastern end, and now lie on the shores of Londonderry and Onslow. So also, while immense numbers of boulders have been scattered over the South coast from the granite and quartz rock ridges immediately inland, many have drifted in the opposite direction, and may be found scattered over the counties of Antigonish, Pictou, and Colchester. These facts show that the transport of travelled blocks, though it may here as in other parts of America, have been principally from the Northward, has by no means been exclusively so; boulders having been carried in various directions, and more especially from the more elevated and rocky districts to the lower grounds in their vicinity. Professor Hind has shown the existence of a similar relation between the boulders of New Brunswick and the hilly ranges of that country.

The following are the directions of the diluvial scratches in a number of localities in different parts of Nova Scotia :—

| | |
|---|---|
| Point Pleasant and other places near Halifax, exposure south, very distinct striæ, . . . | S. 20° E. to S. 30° E. |
| Head of the Basin, exposure south, but in a valley, . . . | E. & W. nearly. |
| La Have River, exposure S.E., . | S. 20° W. |
| Petite River, exposure S. . . | S. 20° E. |
| Bear River, exposure N., . | S. 30° E. |
| Rawdon, exposure N., . . | S. 25° E. |
| The Gore Mountain, exposure N., two sets of striæ, respectively, . | S. 65° E. & S. 20° E. |
| Windsor Road, exposure not noted, | S.S.E. |
| Gay's River, exposure N., . | Nearly S. & N. |
| Musquodoboit Harbour, exposure S., | Nearly S. & N. |
| Near Pictou, exposure E., in a valley, | Nearly E. & W. |
| Polson's Lake, summit of a ridge, . | Nearly N. & S. |
| Near Guysboro', exposure not noted, | Nearly S. & N. |
| Sydney Mines, Cape Breton, exposure S | S. 30° W.* |

The above instances show a tendency to a Southerly and South-easterly direction, which accords with the prevailing course in most parts of North-eastern America. Local circumstances have, however, modified this prevailing direction ; and it is interesting to observe that, while S.E. is the prevailing direction in Acadia and New England, it is exceptional in the St. Lawrence valley, where the prevailing direction is S.W. Professor Hind has given a table of similar striation in New Brunswick, showing that the direction ranges from N. 10° W. to N. 30° E., in all except a very few cases. On Blue Mountains, 1650 feet above the sea, it is stated to be N. and S. As in Nova Scotia, N. W. and S. E. seems to be the prevailing course. In a paper published in the Canadian Naturalist, Vol. VI., No. 1, Mr. Matthew gives a table of striation in the southern part of New Brunswick, in which the South-east direction is decidedly predominant, though there are also some in the South west direction. In this paper will also be found many interesting facts as to the Boulder-clay of New Bruns-

* The above courses are *magnetic*, the average variation being about 18° W.

wick, though the agency of a continental glacier is invoked to explain some facts which in the sequel we shall find to admit of a different interpretation.

The travelled and untravelled boulders are usually intermixed in the drift. In some instances, however, the former appear to be most numerous near the surface of the mass, and their horizontal distribution is also very irregular. In examining coast sections of the drift, we may find for some distance a great abundance of angular blocks, with few travelled boulders, or both varieties are equally intermixed, or travelled boulders prevail; and we may often observe particular kinds of these last grouped together, as, for instance, a number of blocks of granite, greenstone, syenite, etc., all lying together, as if they had been removed from their original beds and all deposited together at one operation. On the surface of the country where the woods have been removed, this arrangement is sometimes equally evident; thus hundreds of granite boulders may be seen to cumber one limited spot, while in its neighbourhood they are comparatively rare. It is also well known to the farmers in the more rocky districts, that many spots which appear to be covered with boulders have, when these are removed, a layer of soil comparatively free from stones beneath. These appearances may in some instances result from the action of currents of water, which have in spots carried off the sand or clay, leaving the boulders behind; but in many cases this is manifestly the original arrangement of the material, the superficial layer of boulders belonging to a more recent driftage than that of the underlying mass in which boulders are often much less abundant.

Boulders or travelled stones are often found in places where there is no other drift. For example, on bare granite hills, about 500 feet in height, near St. Mary's River, there are large angular blocks of quartzite, derived from the ridges of that material which abound in the district, but which are separated from the hills on which the fragments lie by deep valleys.

In Nova Scotia I have observed no beds with marine shells, though the Boulder-clay is often covered with beds of stratified sand and gravel; and the only evidence of organic life, during the boulder period, or immediately before it, that I have noticed, is a hardened peaty bed which appears under the Boulder-clay on the North-west arm of the River of Inhabitants in Cape Breton. It rests upon gray clay similar to that which underlies peat bogs, and is overlaid by nearly twenty feet of Boulder-clay. Pressure has rendered it nearly as hard as coal, though it is somewhat tougher and more earthy than good coal. It has a shining streak, burns with considerable flame, and approaches in its characters to the brown coals or more imperfect varieties of bituminous coal. It contains many small roots and branches, apparently of coniferous trees allied to the spruces. The vegetable matter composing this bed must have flourished before the drift was spread over the surface.

In New Brunswick, stratified clays holding marine shells have been found overlying the Boulder-clay, or in connexion with it, especially in the Southern part of the Province, where deposits of this kind occur similar to those found in Canada and in Maine, though apparently on a smaller scale. These deposits, as they occur near St. John, consist of gray and reddish clays, holding fossils which indicate moderately deep water, and are, as to species, identical with those occurring in similar deposits in Canada and in Maine. They would indicate a somewhat lower temperature than that of the waters of the Bay of Fundy at present, or about that of the Northern part of the Gulf of St. Lawrence.

In Bailey's Report on the Geology of Southern New Brunswick, Professor Hartt has given a list of the fossils of these beds, as seen at Lawlor's Lake, Duck Cove, and St. John, which I re-published with some additions in Acadian Geology.

These New Brunswick beds are strictly continuous with, and equivalent to those which extend along the coast of New England, and thence ascend into the Valley of Lake Champlain, while on the other side they may be considered as perfectly representing in character and fossils the Leda clay of Eastern Canada. They are remarkably like both in mineral character and fossils to the Clyde beds of Scotland, which are probably their equivalents. The points of resemblance of the Leda clay of the coast of Maine, and that of the St. Lawrence, and Labrador, were noticed by me in my paper of 1860, already referred to, and have been more fully brought out by Dr. .Packard, who describes the Leda clay as it occurs at several localities from Eastport to Cape Cod. Along this whole coast it retains its Labradoric or Gulf of St. Lawrence aspect, though with the introduction of some more Southern species, and the gradual failure of some more arctic forms. South of Cape Cod, as in the modern sea, the Post-pliocene beds assume a much more Southern aspect in their fossils, the boreal forms altogether disappearing. For a very full exhibition of these facts, I may refer to Dr. Packard's paper.

The stratified sand and gravel of Nova Scotia rests upon and is newer than the Boulder-clay, and is also newer than the stratified marine clays above referred to. Its age is probably that of the Saxicava Sand of the St. Lawrence valley. The former relation may often be seen in coast sections or river banks, and occasionally in road cuttings. I observed some years ago an instructive illustration of this fact, in a bank on the shore a little to the Eastward of Merigomish harbour. At this place the lower part of the bank consists of clay and sand with angular stones, principally sandstones. Upon this rests a bed of fine sand and small rounded gravel with layers of coarser pebbles. The gravel is separated from the drift below by a layer of the same sort of angular stones that appear in the drift, showing that the currents which deposited the upper bed have washed away some of the finer portions of the drift before the sand and gravel were thrown down. In this section, as well as in most others that I have examined, the lower part of the stratified gravel is finer than the upper part, and contains more sand.

In some cases we can trace the pebbles of the gravels to ancient conglomerate rocks which have furnished them by their decay; but in other instances the pebbles may have been rounded by the waters that deposited them in their present place. In places, however, where old pebble rocks do not occur, we sometimes find, instead of gravel, beds of fine laminated sand. A very remarkable instance of the connexion of superficial gravels with ancient pebble rocks occurs in the county of Pictou. In the coal formation of this county there occurs a very thick bed of conglomerate, the outcrop of which, owing to its comparative hardness and great mass, forms a high ridge extending from the hill behind New Glasgow across the East and Middle Rivers, and along the South of the West River, and then, crossing the West River, re-appears in Rogers' Hill. The valleys of these three rivers have been cut through this bed, and the material thus removed has been heaped up in hillocks and beds of gravel, along the banks of the streams, on the side toward which the water now flows, which happens to be the North and North-east. Accordingly, along the course of the Albion Mines Railway and the lower parts of the Middle and West Rivers, these gravel beds are everywhere exposed in the road-cuttings, and may in some places be seen to rest on the Boulder-clay, showing that the cutting of these valleys was completed after the drift was produced. Similar instances of the connexion of gravel with conglomerate occur near Antigonish, and on the sides of the Cobequid mountains, where some of the valleys have at their Southern entrances immense tongues of gravel extending out into the plain, as if currents of enormous volume had swept through them from North to South.

The stratified gravels do not, like the older drift, form a continuous sheet spreading over the surface. They occur in mounds and long ridges, or eskers, sometimes extending for miles over the country. One of the most remarkable of these ridges is the "Boar's Back," which runs along the West side of the Hebert River in Cumberland. It is a narrow ridge, perhaps from ten to twenty feet in height, and cut across in several places by the channels of small brooks. The ground on either side appears low and flat. For eight miles it forms a natural road, rough indeed, but practicable with care to a carriage, the general direction being nearly North and South. What its extent or course may be beyond the points where the road enters on and leaves it, I do not know; but it appears to extend from the base of the Cobequid mountains to a ridge of sandstone that crosses the lower part of the Hebert river. It consists of gravel and sand, whether stratified or not I could not ascertain, with a few large boulders. Another very singular ridge of this kind is that running along the West side of Clyde river in Shelburne county. This ridge is higher than that on Hebert river, but, like it, extends parallel to the river, and forms a natural road, improved by art in such a manner as to be a very tolerable highway. Along a great part of its course it is separated from the river by a low alluvial flat, and on the land side a swamp intervenes between it and the higher ground. Shorter and more interrupted ridges of this kind may also be seen in the country Northward and Eastward of the town of Pictou. In sections they are seen to be stratified, and they generally occur on low or level tracts, and in places where if the country were submerged, the surf or marine currents and tides might be expected to throw up ridges. The presence of boulders shows that ice grounded on these ridges, and it, probably by its pressure, in some instances, modified their forms. These eskers, or "horse-backs," must not, however, be confounded with glacier moraines, to which in structure they bear no resemblance whatever.

It is probably to this more modern part of the Post-pliocene, if not to a more recent period following the elevation of the land, that the bones of the mastodon found in Cape Breton, and described in "Acadian Geology," belong.

For many additional facts relating to the Post-pliocene of New Brunswick, I may refer to the valuable paper by Mr. Matthew, already mentioned.

### 4. *Lower St. Lawrence—North Side.*

Descriptions of the Post-pliocene deposits of this region are contained in several of my papers above cited, but I shall here give a summary of these, with the corrections and additional facts obtained within the past few years.

*Saguenay River.*—I have already, in part first, referred to the glacial striation of this region, and perhaps no better example could be found of those lateral valleys along which ice seems to have been poured into the St. Lawrence from the North. The gorge of the Saguenay is a narrow and deep cut, running nearly N.W. and S.E., or at right angles to the course of the St. Lawrence, and of the Laurentian ridges. It extends inland more than forty-five miles, and then divides into two branches, one of which is occupied by the continuation of the river to Lake St. John, the other by Ha-Ha Bay and a valley at its head. In the lower part of its course, as far as Ha-Ha Bay, this gorge is from 50 to 140 fathoms deep, below the level of the tide in the St. Lawrence, and in some places the cliffs on its banks rise abruptly to 1500 feet above the water level, so that its extreme depth is nearly 2400 feet, while its width varies from about a mile to a mile and a-half. The striated surfaces and the roches moutonnées seen in this gorge and on the hills on its sides, to a height of at least 300 feet, shew that in the glacial period a powerful stream of ice must have flowed down this gorge into the St. Lawrence, though whether it was occupied by a glacier or constituted a fiord leading from one, like many in Greenland, or was a strait traversed by bergs, does not appear. Possibly, with different levels of the land, these conditions may have alternated. I cannot imagine anything more like what the Saguenay may have been at this time, than the view of Franz Joseph Fiord in East Greenland, brought home by the second German expedition to that country, in the present year,* and which, with other discoveries of that

* Copied in the "Leisure Hour" for November, 1871.

expedition soon to be published by Dr. Petermann, will go far to remove the prevailing error as to Greenland being covered with a universal glacier; whereas it seems to be a rocky and mostly snow-clad country, with very large glaciers in its valleys.

The strikes of the gneiss on the opposite sides of the Saguenay indicate that it occupies a line of transverse fracture, constituting a weak portion of the Laurentian ridges, and this has evidently been smoothed and deepened by water and ice under conditions different from the present, in which it is probable that the channel is being gradually filled with mud. Its excavation must have taken place before the deposition of the thick beds of marine clay (Leda clay) which appear near its mouth and in its tributaries, sometimes passing into Boulder-clay below, and capped by sand and gravel. It is indeed not improbable that in the later Post-pliocene it was in great part filled up with such deposits, which have been swept away in the course of the re-elevation of the land.

At Tadoussac, at the mouth of the Saguenay, where the underlying formation is the Laurentian gneiss, the Post-pliocene beds attain to great thickness, but are of simple structure and slightly fossiliferous. The principal part is a stratified sandy clay with few boulders, except in places near the ridges of Laurentian rocks, when it becomes filled with numerous rounded blocks and pebbles of gneiss. This forms high banks eastward of Tadoussac. It contains a few shells of *Tellina Grœnlandica* and *Leda truncata*, and a little inland, at Bergeron River, it also contains *Cardium Islandicum, Astarte elliptica*, and *Rhynchonella psittacea*. It resembles some of the beds seen on the South side of the river St. Lawrence, and has also much of the aspect of the Leda clay, as developed in the valley of the Ottawa. On this clay there rest in places thick beds of yellow sand and gravel.

At Tadoussac these deposits have been cut into a succession of terraces which are well seen near the hotel and old church. The lowest, near the shore, is about ten feet high; the second, on which the hotel stands, is forty feet; the third is 120 to 150 feet in height, and is uneven at top. The highest, which consists of sand and gravel, is about 250 feet in height. Above this the country inland consists of bare Laurentian rocks. These terraces have been cut out of deposits, once more extensive, in the process of elevation of the land; and the present flats off the mouth of the Saguenay, would form a similar terrace as wide as any of the others, if the country were to experience another elevatory movement. On the third terrace I observed a few large Laurentian boulders, and some pieces of red and gray shale of the Quebec group, indicating the action of coast-ice when this terrace was cut. On the highest terrace there were also a few boulders; and both terraces are capped with pebbly sand and well rounded gravel, indicating the long-continued action of the waves at the levels which they represent.

*Murray Bay, &c.*—At Murray Bay, Petit Mal Bay, and Les Eboulements, as noticed above, the system of Post-pliocene terraces is well developed. On the West side of Murray Bay, the Silurian rocks of White Point, immediately within the pier, form a steep cliff, in the middle of which is a terraced step marking an ancient sea level. At the end nearest the pier the sea has again cut back to the old cliff, leaving merely a narrow shelf; but toward the inner side this shelf rapidly expands into the sandy flat along which the main road runs, and which is continuous with the lower plain extending all the way to the head of the bay. In this flat the upper portion of the Post-pliocene deposit seems to consist principally of sand and gravel, resting on stony clay. In the former, which corresponds to the Saxicava sand of Montreal, I found only a few valves of *Tellica Grœnlandica* which is still the most abundant shell on the modern beach. In the latter, corresponding to the Leda clay, which is best seen in some parts of the shore at low tide, I found a number of deep water shells of the following species, all of which, except *Spirorbis spirillum* and *Aphrodite Grœnlandica*, have been found in these deposits at Quebec and Montreal.

*Fusus tornatus.*
*Trophon Scalariforme.*
*Margarita helicina.*
*Cylichna occulta.*
*Pecten Islandicus.*
*Tellina calcarea.*
*Leda truncata.*
*Saxicava rugosa.*
*Aphrodite Grœnlandica.*
*Mytilus edulis.*
*Mya arenaria.*
*Balanus Hameri.*
*Spirorbis spirillum.*
*S. vitrea.*
*Serpula vermicularis.*

Roches Moutonneés — Mouth of the Saguenay
In Gneiss, at Elevation of 300. Feet.

Clay & Sand Terraces - Tadousac

These shells imply a higher beach than that of this lower flat, which is not more than 30 feet above the present sea level. Accordingly above this are several higher terraces, the heights of which on the west side of bay are given in Section I. The second principal terrace, which forms a steep bank of clay some distance behind the main road, is 116 feet in height, and is of considerable breadth, and has on its front in some places an imperfect terrace at the height of 81 feet. It corresponds nearly in height with the shoulder over which the road from the pier passes. Upon it, in the rear of the property of Mr. Du Berger, is a little stream which disappears under ground, probably in a fissure of the underlying limestone, and returns to the surface only on the shore of the bay. Above this is a smaller and less distinct terrace 139 feet high. Beyond this the ground rises in a steep slope, which in many places consists of calcareous beds, worn and abraded by the waves, but showing no distinct terrace; and the highest distinct shore mark which I observed, is a narrow beach of rounded pebbles at the height of more than 300 feet; but above this there is a flat at the height of 448 feet. This beach appears to become a wide terrace further to the North, and also on the opposite side of the bay. It probably corresponds with the highest terrace observed by Sir W. E. Logan, at Bay St. Paul, and estimated by him at the height of 360 feet.

As already stated, three of the principal terraces at Murray Bay correspond nearly with three of the principal shore levels at Montreal; and in various parts of Canada, two principal lines of old sea beaches occur at about 100 to 150 feet, and 300 to 350 feet above the sea, though there are others at different levels.

In the Post-pliocene period the valley of the Murray Bay river has been filled, almost or quite to the level of the highest terrace, with an enormously thick mass of mud and boulders, washed from the land and deposited in the sea bed during the long period of Post-pliocene submergence. Through this mass the deep valley of the river has been cut, and the clay, deprived of support and resting on inclined surfaces, has slipped downward, forming strangely shaped slopes, and outlying masses, that have in some instances been moulded by the receding waves, or by the subsequent action of the weather, into conical mounds, so regular that it is difficult to convince many of the visitors to the bay that they are not artificial. Sir W. E. Logan in his report on the district has in my view given the true explanation of these mounds, which may be seen in all stages of formation on the neighbouring hill sides. Their effect to a geological eye is to give to this beautiful valley an unfinished aspect, as if the time elapsed since its elevation had not been sufficient to allow its slopes to attain to their fully rounded contour. This appearance is no doubt due to the enormous thickness of the deposit of Post-pliocene mud, to the uneven surfaces of the underlying rock, and possibly also in part to the earthquake shocks which have visited this region.

At the mouth of the Murray Bay River, the Boulder-clay, which rests directly on the striated rock surfaces, and which is a true till, filled with the Laurentian stones and boulders of the inland hills, though resting on Silurian limestone, is evidently marine, since it contains shells of *Leda truncata* ; and many of the stones are coated with Bryozoa and *Spirorbes*. It is also observable that on the N.E. sides of the limestone ridges the boulders are more numerous and larger. Above the Boulder-clay may in some places be seen a stratified sandy clay, which further up the river attains to a great thickness. It contains *Saxicava rugosa*, *Tellina Grœnlandica*, and *Tellina calcarea*, as well as *Leda truncata*. The most recent deposit is a sand or gravel, often of considerable thickness, and in some of the beds of gravel the pebbles are more completely rounded than those of the modern beach.

I have already, in Section I, stated my reasons for believing that the upper part of the valley of the Murray Bay River may have been the bed of a glacier flowing down from the inland hills toward the St. Lawrence. N.W. and S.E. striæ attributable to this glacier were seen at an elevation of 800 feet, and the marine beds were traced up to almost the same height, above which, to a height of about 1200 feet, loose boulders were observed and glaciated rock surfaces, but no marine deposits. It is probable, therefore, that at a time when the sea extended up to an elevation of 800 feet, the higher part of the valley may have been filled with land ice. Whether the bergs from this, drifting down toward the St. Lawrence, produced the N.W. striation observed at a lower level, or whether at a previous period, when the land was higher, the ice extended farther down, may admit of doubt. Certainly no land ice has extended to a lower level than about 800 feet, since the deposition of the marine boulder and Leda clay.

Very large boulders occur in this vicinity. One observed on the beach on the east side of the Bay, is an oval mass of lime felspar, thirty feet in circumference, lying like most other large boulders in this region, with its longer axis to the N.E.

*Les Eboulements.*—At this place the Laurentian hills rise to a great height near the shore, and the Post-pliocene beds present the exceptional feature of resting on soft decomposed Silurian shale (Utica shale). This rock might indeed be mistaken for drift, but for its stratification, and it must have been decomposed to a great depth by subaerial action and subsequently submerged and covered by the Post-pliocene beds. Its preservation is the more remarkable that the clay overlying it contains very large Laurentian boulders, which must have been quietly deposited by floating ice. Only a few shells of *Tellina Grœnlandica* were observed in these clays.

The remarkable series of terraces seen at this place, and noticed in part first, rising to 900 feet in height, are all cut out of the Post-pliocene beds and decomposed shale, and even the highest presents large boulders. In examining such terraces it is always necessary to distinguish between the clays out of which the terraces have been cut and the more modern deposits resting on the terraces. Both may contain fossils, but those of the original clay are in this region mostly of deeper water species than those in the overlying superficial beds.

I attribute the preservation of the thick beds of Boulder-clay and the decomposed shale at Les Eboulements, to the fact that no transverse valley exists here, and that a point of high Laurentian land projects to the North-East, so as to shelter this place from forces acting in that direction. I have observed this appearance on the lee or South-west side of other projecting masses of hard rock, and as the decomposed shale must be a monument remaining from the Pliocene elevation of the land, it shews that no powerful eroding force had acted between that time and the period of the N. E. arctic ice-laden currents.

It is perhaps deserving of notice that the thick beds of soft material at Les Eboulements have been cut into many irregular forms by modern subærial causes of denudation, and also by landslips, which last have been in part connected with the earthquake shocks with which this part of the coast has been visited more than any other district of Canada.

Above Les Eboulements, Bay St. Paul presents features similar to those of Murray Bay, and then the Laurentian land of Cape Tourment comes boldly forward to the shore of the River. Above this the conditions are similar to those observed in the neighbourhood of Quebec.

(*To be continued.*)

# ON THE "COLONIES" OF M. BARRANDE.

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The doctrine of "Colonies," propounded by M. Barrande, has been long before the palæontological world, and is known, at any rate by name, to all students of geology. It is doubtful, however, if there is as clear a comprehension of this subject as its importance would render desirable; and it may, therefore, be of interest to discuss briefly the leading facts upon which this theory is based. In so doing, I shall take the necessary details from M. Barrande's "Défense des Colonies," published in 1870, one of the most valuable of the many palæontological works of this distinguished observer, and I shall confine myself chiefly to a *resumé* of the facts therein recorded and the deductions drawn therefrom.

## I. Sub-divisions of the Silurian Rocks of Bohemia.

The Silurian Rocks of Bohemia are described by M. Barrande as occupying an elliptical basin, the long axis of which has a N.E., and S.W. direction, and a length of 148 kilometres. The breadth of the basin increases gradually in passing from the N.E. to the S.W., its minimum breadth being about 30 kilometres, and its maximum about 74 kilometres. The Silurians of this basin repose upon granitic and gneissic rocks, and dip inwards towards a central line. The fossiliferous beds of the entire basin occupy a far from considerable superficial area; and their extent —supposing them not to have been much denuded—would assign to the Silurian sea of Bohemia an area not exceeding 1–60 of the superficies of the Adriatic.

The Silurian rocks of the entire basin admit of separation into two primary divisions, an *Inferior* and a *Superior* division, corresponding respectively to the Lower and Upper Silurian Rocks of Sir Roderick Murchison. The Inferior Division is composed principally of schists and quartzites; or, as we should say, slates and grits or graywackes, and is wholly destitute of calcareous matter, except occasional concretions of carbonate of lime. The Superior Division is composed almost entirely of calcareous matter, with merely subordinate bands of schists and quartzites. Each division can be satisfactorily broken up into four sub-divisions (étages), grounded solely upon the characters of their contained fossils, and lettered in ascending order:—

The étages of the Inferior Division are A., B., C., D. The étages of the Superior Division are E., F., G., H. Each of the fossiliferous sub-divisions can be further broken up into minor groups or "bands," distinguished by the smaller letters of the alphabet, as shown in the annexed table.

Etages A. & B., the lowest of the Inferior Division, are composed of semi-crystalline rocks and conglomerates, and are unfossiliferous. They are termed by Barrande the "Azoic Etages," and are considered by him as forming the base of the Silurian Series. It is, however, more probable that they should be regarded as being truly of Lower Cambrian age.

Etages C. D. E. F. G. & H. are fossiliferous. Etage C. is the well-known "Primordial Zone" of Bohemia, corresponding with the Menevian beds of Britain, and characterized by primordial trilobites of the genera *Paradoxides*, *Olenus*, *Conocoryphe*, *Elliptocephalus*, &c. It should probably be regarded as Upper Cambrian.

Etage D. contains Barrande's so-called "faune second" or second fauna, and must correspond with the Llandeilo and Caradoc beds of Britain. Etages E. F. G. & H. are characterized by a single fauna termed by Barrande the "faune troisième" or third fauna; and they correspond collectively to the Upper Silurian Rocks of Britain.

The precursors ("avanteureurs") of this "third fauna" in the last portions of the period of the "second fauna" are termed by Barrande the "colonies." They are in the form of bands which are enclosed in the mass of étage D towards its higher part, and which are thus *stratigraphically* Lower Silurian, but which, nevertheless, contain a predominance of fossils characteristic of the "third fauna," and thus come *palæontologically* to belong to the Upper Silurian series. They abound especially in the band *d* 5, occurring also in *d* 4, and about twenty of them are known in all. The subjoined table shows in a summary form the general subdivisions and lithology of the rocks of the Bohemian basin, with the principal characteristic fossils:—

## TABLE OF THE SUBDIVISIONS OF THE SILURIAN ROCKS OF BOHEMIA.

| | | | |
|---|---|---|---|
| Etage A. | | Different crystalline rocks. | Destitute of fossils. |
| Etage B. | | | These are the "etages azoiques" of Barrande. Probably Lower Cambrian. |
| Etage C. "Primordial Zone." | | Compact argillaceous schists, rarely metamorphic. | "Primordial fauna," comprising 27 trilobites, 5 pteropods, 2 brachiopods, 1 polyzoön (?), and 5 echinoderms. |
| Etage D. (containing the "second fauna.") | *d* 1. | Black, fissile, argillaceous schists, sometimes with fossiliferous siliceous nodules. | 47 trilobites, 25 cephalopods, 14 pteropods, few gasteropods, brachiopods, and lamellibranchs; very few graptolites. |
| | *d* 2. | Beds of "quartzite" (*i. e.* greywacke), sometimes with thin beds of schist. | 19 trilobites, 1 cephalopod, 8 pteropods; other fossils very rare. |
| | *d* 3. | Black, argillaceous, and micaceous schists. | 18 trilobites, 1 cephalopod, 10 pteropods. |
| | *d* 4. | A lenticular mass of limestone forming the "Colony Zippe." | 8 trilobites and 9 brachiopods. |
| | | Impure, very micaceous schists of different tints, with beds of impure quartzites, and few calcareous concretions. | 26 trilobites, 6 cephalopods, 18 pteropods; rare, gasteropods, brachiopods and bivalves; frequent, cystideans. |
| | *d* 5. | *Colonies*, composed of graptolitic schists, with calcareous spheroids, associated with beds of trap. | 4 trilobites, 36 cephalopods; few brachiopods; many graptolites. |
| | | Fissile argillaceous schists, gray, yellowish, or bluish, alternating with beds of quartzite. | 54 trilobites, 12 cephalopods; few gasteropods, brachiopods, and bivalves; graptolites very rare. |
| Etage E. | *e* 1. | Graptolitic schists containing calcareous spheroids, and alternating with beds of trap. | 15 trilobites, 149 cephalopods, 5 pteropods; few gasteropods, brachiopods and bivalves; many graptolites. |
| | *e* 2. | Compact, often fetid limestone in continuous beds, frequently blackish, but in certain localities whiteish. | 81 trilobites, 665 cephalopods, 11 pteropods; very many gasteropods, brachiopods, bivalves and corals; few graptolites. |
| Etage F. | *f* 1. | Compact limestone, black or dark gray, not fetid. | 11 trilobites, 31 cephalopods, 2 pteropods (first *Tentaculites*); few gasteropods, brachiopods and bivalves; last graptolites. |
| | *f* 2. | Compact limestone, often white or red. | Fish (first? in Bohemia); 84 trilobites, 60 cephalopods (first *Goniatites*), 15 pteropods; very many gasteropods and brachiopods; few bivalves, many corals. |
| Etage G. | *g* 1. | Nodular limestone, very like *g* 3, but much thicker. | 4 fishes, 56 trilobites, 55 cephalopods, 10 pteropods; few gasteropods, bivalves, and brachiopods. |
| | *g* 2. | Fissile argillaceous schists, *without calcareous spheroids*, and without quartzites. A few beds of trap. | 6 trilobites, 12 cephalopods, 3 pteropods (*Tentaculites* common); few bivalves and brachiopods. |
| | *g* 3. | Nodular limestone, very like *g* 1, with cherty concretions. | 3 trilobites, 86 cephalopods (14 *Goniatites*), 2 pteropods; few gasteropods, bivalves and brachiopods. |
| Etage H. | *h* 1. | Fissile, argillaceous schists, without quartzites or calcareous concretions. | 2 trilobites, 13 cephalopods (3 *Goniatites*), 3 pteropods (*Tentaculites* common); *Cardiola retrostriata*, &c. |
| | *h* 2. | Fissile argillaceous schists, alternating in thin beds with quartzites, but with no calcareous concretions. | Without fossils. |
| | *h* 3. | Fissile argillaceous schists, without calcareous concretions. | Without fossils. |

## II. Distribution of the Colonies.

The colonial zone occupies a great part of the superficial area and vertical thickness of the band *d* 5, forming an elliptical zone or belt concentric with the calcareous rocks of the Upper Silurian basin. From this basin the colonial zone is generally separated by schists and quartzites, which form the summit of *d* 5, and which contain no fossils of an animal nature. On the surface of this zone the colonies are distributed in concentric but discontinuous lines, with irregular intervals between. Each colony is in the form of a lenticular mass, of which the length enormously exceeds the breadth and thickness; and the phenomena of their distribution and their relations to the surrounding rocks prove plainly that they cannot be explained by invoking the agency of mechanical disturbance or faults.

Several interbedded traps are found in the colonial zone, regularly interstratified with the colonies, and similar beds are found in band *e* 1 at the base of Etage E. They all have the form of elongated lenticular masses thinning out at both extremities. As the Silurian rocks of Bohemia form a basin, the colonies are, as a matter of course, found on both sides of the central group of calcareous rocks (Upper Silurian). With the exception of the "Colony Zippe," which is found in *d* 4, all the colonies are found in the lower portion of *d* 5; and, like the rocks amongst which they are situated, they dip inwards towards the axis of the basin.

## III.—Lithology of the Colonies compared with that of bands *e* 1, *e* 2, *d* 4, & *d* 5:

*A. Band, e* 2.—This band is the second subdivision of Etage E., and is composed mainly of continuous beds of limestone, often fetid, almost black in colour, and chiefly composed of the debris of Crinoids. The beds of limestone are separated by thin courses of impure shales containing a few graptolites. Lithologically *e* 2 differs most markedly both from band *e* 1 and from the colonies; but nevertheless the palæontological relationships of the colonial zone are far stronger with *e* 2 than with *e* 1, though the mineral characters of *e* 1 are identical with those of the colonies.

*B. Band e* 1:—Band *e* 1 constitutes the stratigraphical base of Etage E. or of the Upper Silurian Series of Bohemia. It consists wholly of Graptolitic Schists, enclosing calcareous spheroids or "anthracolites" and having intercalated beds of trap. Its thickness is very variable, sometimes exceeding 600 metres, and it is always much thicker than band *e* 2.

Lithologically, therefore, as well as in possessing interbedded traps, *e* 1 differs greatly from *e* 2. In the same way, the palæontological differences between the two are sufficiently well marked, though they are united by many specific connexions. Each, however, has its own fauna, and the richness of the two is very unequal. Thus, *e* 1 possesses but 15 Trilobites, whilst *e* 2 has 81 species; *e* 1 has yielded no more than 149 Cephalopods, whilst *e* 2 has yielded the extraordinary number of 665 species; and similar differences are found in the Gasteropods, Bivalves, and Brachiopods. Still, the propriety of retaining *e* 1 and *e* 2 on the same stratigraphical horizon is shown by numerous palæontological relationships, amongst which may be mentioned the fact that 68 Cephalopods are common to the two divisions.

*C. Band d* 5:—Band *d* 5 underlies band *e* 1, and forms the summit of Etage D., or the highest division of the Lower Silurian Series of Bohemia. Its upper portion has a thickness of 100 metres and is composed of alternating thin beds of gray schist and quartzite (graywacke). It is remarkable in being wholly destitute of fossils of an animal nature, having yielded nothing more than a few "Fucoids". This thick deposit, therefore, corresponds with a prolonged and total intermission of the Silurian fauna of the Bohemia area.

The thickness of this unfossiliferous formation might serve as an approximate measure of the time which elapsed between the last appearance of the colonial fauna and the definitive appearance of the "third fauna" (Upper Silurian fauna). In certain localities, however, this unfossiliferous mass *appears to have undergone partial denudation, prior to the deposition of e* 1.

It may be remarked here that the above observation of M. Barrande would seem to indicate *a want of conformity* between Etage D. and Etage E., such as is found in many other countries between the Lower and Upper Silurian rocks. If this be so, the interval between the colonial fauna and the introduction of the third fauna may have been indefinitely long, and cannot even be approximately measured by the thickness of the upper part of *d* 5.

Below this unfossiliferous series, band *d* 5 is composed of masses of argillaceous schist of different tints, sometimes with subordinate beds of quartzite. In all cases, with the exception of the colony Zippe, the colonies are intercalated in this portion of *d* 5; and there are also numerous beds ("coulées") of trap at various horizons. As will be seen immediately, this portion of *d* 5 is chiefly distinguished from the beds of the colonies by the fact that the schists are almost wholly destitute of graptolites.

*D. The Colonies.*—The colonies, as just remarked, are situated in the schistose lower portion of *d* 5, and they are lithologically absolutely undistinguishable from band *e* 1, consisting of graptolitic schists with calcareous concretions and interbedded traps. The following distinctions, however, may be noted as compared with *e* 1:—

1. The thickness of the colonies is always much less than that of band *e* 1; and there are fewer alternations of the graptolitic schists with the traps.

2. Certain colonies are composed entirely of schists without traps.

3. In some colonies (*e. g.* Colony Haidinger and Colony Cotta) there are bands of gray schists and quartzites like those of *d* 5.

4. The calcareous concretions are generally rarer in the colonies than in the band *e* 1, and they even appear to be wanting in some colonies, especially in the deepest (*e. g.* in the Colony Haidinger.)

*E. Band d,* 4:—This band is composed of impure schists, which are always highly micaceous and deeply coloured, brown, gray or black. Though fissile, they are much less homogeneous and papery ("feuillétes") than those which constitute the superior band *d* 5. Sometimes there are intercalated beds of quartzite, and occasionally there are interbedded sheets of trap. There is only one colony in *d* 4, namely the Colony Zippe, situated within the ramparts of Prague. This colony differs from all the rest by its being entirely composed of a lenticular mass of limestone, about 25 centimetres thick, intercalated in the midst of regular alternations of schist and quartzite.

## IV. Palæontological Relations of the Colonies.

From what has preceded, it is evident that stratigraphically the colonies belong to the Lower Silurian series, and we have now to enquire what relationships can be shown to subsist between the colonial fauna and the second and third fauna respectively. The specific connexions of the colonial fauna, when examined in detail, will then be found to be most close and intimate with the first phases of the *third* fauna (Upper Silurian), so that palæontologically the colonies must be regarded as truly Upper Silurian. This result will be brought out by a comparison of the fauna of the colonies with that of the Lower and Upper Silurian periods respectively :—

*A. Specific connexions between the Colonies and the Second Fauna.*—As yet only two colonies are known in which there is any intermixture of the characteristic forms of the second fauna (Lower Silurian) with those of the colonial fauna, *i. e.* with those of the third fauna (Upper Silurian). Thus, out of seventeen species in the colony Zippe, there are four species representing the *second* fauna, with twelve species belonging to the *third* fauna. On the other hand, in the colony d'Archiac there are only two species of the third fauna (viz. *Cardiola interrupta* and *Graptolites priodon ?*). It is quite clear, therefore, that the colonial fauna, as a whole, has very slight connexion with the second or Lower Silurian fauna.

*B. Specific connexions between the Colonies and the Thîrd Fauna.*—In showing the specific connexions between the colonies and the third or Upper Silurian fauna, it will be advisable to review briefly the different orders of fossils represented in the Silurian basin of Bohemia.

*a. Fishes.*—No traces of fishes have been detected in the colonies or in the whole of the Lower Silurian series, and their only indubitable remains occur in Etages F and G, which have hardly any connexion with the colonies. (Altogether five fishes have been discovered in the Upper Silurians of Bohemia, viz. *Coccosteus primus*, *C. Agassizi*, *Asterolepis Bohemicus*, *Gompholepis Panderi*, and *Ctenacanthus Bohemicus.*)

*b. Crustaceans.*—These are principally trilobites. The trilobites of the colonies, not taking into account the four species of the second fauna, are referable to eight species and seven genera, all belonging to the third fauna. The trilobites are, therefore, very limited in number, and their paucity agrees perfectly with the small number of these crustaceans in the first phase of the third fauna, *i. e.* in *e* 1, in which only fifteen species are known. On the other hand *d* 5 and *d* 4 have together furnished about eighty trilobites peculiar to the last phases of the second fauna. The remaining Crustaceans of the colonial fauna are *Pterygotus Bohemicus*, *Ceratiocaris inœqualis*, *Entomis migrans*, and *Apty-*

*chopsis* (*Peltocaris*) *primus*, all of which reappear in the third fauna. *Ceratiocaris*, however, occurs in *d* 5. *Aptychopsis* (or *Peltocaris*, Salter, as it more probably is) occurs in the Scotch Upper Llandeilos, whereas in Bohemia it is confined to the base of the Upper Silurians (*e* 1 and *e* 2) and to the colonies. A similar, if not identical form, however, has recently been discovered by Mr. Lapworth in the Scotch Silurians, high up in the series, and I have found another closely similar form in the sandstone of the Coniston series (Caradoc) of the north of England.

*c. Cephalopoda.*—This class of fossils, as is well known, has been an object of M. Barrande's especial study, and his results are, therefore, of the highest value and interest. The *Cephalopoda* are represented in the colonial fauna by thirty-six species, of which all except species of *Cyrtocera* are referable to the genus *Orthoceras.* The Cephalopods, therefore, abounded in the colonial fauna, and this again agrees with the state of things in the earlier portion of the third fauna. On the other hand, bands *d* 5 and *d* 4, though much thicker than the colonies, have only yielded altogether eighteen species of *Cephalopoda*, the paucity of these fossils thus contrasting strongly with the abundance of trilobites. It should also be remarked that the small representation of the genus *Cyrtoceras* in the colonies (only two species being known) contrasts very strongly with the total absence of the genus in the second fauna, and its great abundance in the earlier phases of the third fauna, twenty-six species occurring in *e* 1, and no less than 201 species in *e* 2. Lastly, of the thirty-six species of Cephalopoda in the colonies, not one is specifically identical with any form known in the second fauna. On the contrary, thirty-one species reappear on different horizons in the third fauna, the remaining five species being peculiar to the colonies.

*d. Pteropoda.*—Only two species of *Hyolithes* occur in the colonies, and both reappear in the first phase of the third fauna. Neither occur in *d* 5, though various other Pteropods occur in this band.

*e. Gasteropoda.*—Only ten species, belonging to eight genera, have hitherto been found in the colonies (almost all in the Colony d'Archiac). No species is common to the colonies and the second fauna, but the genus *Pleurotomaria* occurs in both. All the colonial species, however, reappear in the third fauna; and their rarity in the colonies agrees fully with their comparative scarcity in *e* 1.

*f. Brachiopoda.*—Only fifteen species of Brachiopods are known in the colonial fauna, and these occur in three colonies only. The brachiopods are, therefore, poorly represented; but the following conclusions may be drawn from such as are present: Firstly, five genera and eight species suddenly occur in the Colony Zippe, in *d* 4, which band hardly contains anything else but *Orthides*. Secondly, the colonies contain the genus *Spirifer*, which is not known at all in the second fauna of Bohemia, and is equally very rare in the Lower Silurian of other countries. The genus, however, is abundantly represented in the first phases of the third fauna. Thirdly, we meet in the colonies with *Atrypa reticularis*, which is equally unknown in the second fauna of Bohemia, and is comparatively rare in the Lower Silurian series elsewhere. On the other hand, it is a characteristic species of the Upper Silurian series from its base almost to its summit. Fourthly, of the total number of fifteen species, only one is exclusively colonial, and that doubtfully so. Fourteen species, therefore, establish the connexion with the third fauna.

*g. Lamellibranchiata.*—The most remarkable forms of this class in the colonies belong to the genus *Cardiola*, the most important species being *C. fibrosa*, Sow, *C. interrupta*, Sow, *C. gibbosa*, Barr., and *C. nigrans*, Barr. Not one of these species is found in any formation belonging to the second fauna, but all reappear at different horizons in the third fauna.

*h. Graptolites.*—These are very abundant in the colonies, and show many points of affinity with those of the third fauna, whilst "they have only few affinities with those of the contemporary phases of the second fauna." Twenty-one species of Graptolites occur altogether in the colonies, and they give rise to the following conclusions:—Firstly, not one species of the colonial fauna can be positively asserted to occur in the second fauna (Lower Silurian). Secondly, fourteen species of the twenty-one reappear in band *e* 1, and of these six pass on into *e* 2. There remains seven forms which are peculiar to the colonial zone, and these are found exclusively in the Colony Archiac.

The Graptolites, therefore, contribute largely to establish the connexion between the faunæ of the colonies and of the Upper Silurian rocks of Bohemia, no single form being certainly known to be identical in the colonies and the contemporary phases of the second fauna. It is to be noted, however, that the Graptolites of the colonies, as well as those of *e* 1 and *e* 2, show upon the whole most strongly marked affinities with those of the *Lower Silurian rocks* of Britain and America. This is especially shown by the occurrence of the genera *Diplograpsus*, *Climacograpsus*, and *Rastrites*, none of which is known to be represented in the Upper Silurian of any other country except Bohemia. Not only is this the case, but a large number of the species of Etage E are identical with those of the Caradoc beds (Coniston mudstones) of the north of England, and of similar strata in the south of Scotland. I shall, however, elsewhere endeavour to show that the Graptolites of Bohemia were introduced by emigration from the British area.

*i. Crinoids.*—No certain remains of Crinoids have been hitherto detected in the colonial zone, except in one doubtful instance. It should be noticed, however, that Crinoids are very rare in the second fauna, whilst there are several species of Cystideans. On the other hand, crinoidal fragments are extremely abundant in *e* 1, although the number of specific forms seems to be very small.

*j. Corals.*—Corals have hitherto been found in only one colony, and here there is only one indubitable species, viz., *Calamopora (Favosities) alveolaris.* As no corals of this group are known in the second fauna, and as they are common in the earlier phases of the third fauna, this establishes another link between the latter and the colonial fauna.

## C. Relationships of the Colonial Fauna as a Whole.

Regarded as a whole, the following conclusions may be drawn from a study of the fossils occurring in the colonies:—

1. Altogether 110 species of fossils are known to occur in the colonies, and although this number is still incomplete, it is to be remarked that the total is little smaller than that of band *d* 5, in which the colonies are situated, and in which 130 fossil species are known in all. It is a very singular fact, therefore, that these 110 species should be "cantoned" so to speak, amongst 130 species belonging to the older second fauna.

2. The independence of the colonial fauna, in spite of its general connexion with the third fauna is shown by the existence of fourteen species exclusively confined to the colonies. This number indicates the amount of extinction which took place in the interval between the last colony and the definitive appearance of the third fauna in Bohemia. It is to be noticed, also, that it is the

numerically largest families, namely, the Cephalopods and Graptolites which have suffered most in the way of extinction.

3. The colonial fauna is related to the second fauna by no more than four species, all Trilobites, and all found in one colony.

4. On the contrary, the specific connections between the colonial fauna and the third fauna are represented by ninety-two species, or eighty-three per cent. of the total of colonial species.

5. The same relationships are shown by the general facies of the fossils, irrespective of specific identities. Thus, the last phases of the second fauna are characterised by a predominance of Trilobites and by the rarity of Cephalopods and Graptolites. On the other hand, the colonies and the first phases of the third fauna were characterised by the rarity of Trilobites and the abundance of Cephalopods and Graptolites.

6. These results lead inevitably to the conception that the species of the colonies have been introduced into Bohemia by migration from a foreign area. This conception becomes more certain by a comparison of the colonial fauna with the Silurian fauna of other countries, by which it appears that many colonial species existed in the Lower Silurian series of the British area, that is at a period earlier than the date of their appearance in Britain.

## V. Palæontological Relations between the Colonial Fauna and the Silurian Fauna of Britain.

The connexions between the Silurian fauna of Britain and Bohemia are two-fold, direct and indirect. The *direct* connexions are shown by the fact that several of the colonial species of Bohemia are found existing in Britain in the "second fauna," *i. e.* in the Lower Silurian period. The *indirect* connexions consist in the fact that some of the Lower Silurian species of Britain are found in Bohemia, not in the colonies, but in the third fauna, *i. e.* in the Upper Silurian period.

The following table shows the number of species which are common to the Lower Silurian of Britain, the colonies, and the Upper Silurian of Bohemia, but which are wholly wanting in the Lower Silurian (second fauna) of Bohemia :—

*Chierurus bimucronatus*, Murch.
*Sphærexochus mirus*, Beyr.
*Atrypa reticularis*, Linn.

*Strophomena* (Leptæna) *euglypha*, Dalm.
*Cardiola interrupta*, Sow.
*Graptolites lobigerus*, McCoy. (= G. Becki, Barr.)
———— *Nilssoni*, Barr.
———— *priodon*, Barr.
———— *Bohemicus*, Barr.
———— *colonus*, Barr.
———— *Roemeri*, Barr.
*Rastrites peregrinus*, Barr.

To these I may add, *Climacograpsus teretiusculus*, His., *Graptolites turriculatus*, Barr., *G. Sedgwickii*, Portl., *Diplograpsus folium*, His., and *Diplograpsus palmeus*, Barr.

Of the above eleven species enumerated by M. Barrande as common to the colonies and the Lower Silurians of Britain, six reappear in the Upper Silurian of Britain, and all are found in the third fauna (Upper Silurian) of Bohemia. M. Barrande, therefore, concludes that these species play the same part of precursors in the two countries compared; and he believes that a common centre of diffusion for these species must have existed somewhere between Britain and Bohemia. It should be remarked, however, that of the above eleven species, four of the Graptolites (viz. *G. lobigerus*, *G Nilssoni*, *G. Bohemicus*, and *Rastrites peregrinus*) are *not* known, as erroneously believed by M. Barrande, to occur in the British Upper Silurian series; nor are any of the five species added by myself to the above list. It should also be noticed that there is great doubt as to the propriety of the introduction of *Cardiola interrupta* into the above list as occurring in the Lower Silurian in Britain. On the contrary, it is becoming extremely probable that all the rocks in which this fossil occurs in Britain are truly of Upper Silurian age.

The following table shows the species of fossils which are found in the third fauna of Bohemia (Upper Silurian), but which existed at an earlier date in the Lower Silurian of Britain:—

Crustaceans.
*Calymene Blumenbachii*, Brongn.
*Staurocephalus Murchisoni*, Barr.

Cephalopods.
*Orthoceras annulatum*, Sow.

Brachiopods.

*Atrypa marginalis*, Dalm.
*Cyrtia trapezoidalis*, Dalm.
*Leptæna sericea*, Sow.
——— *transversalis*, Dalm.
*Orthis elegantula*, Dalm.
——— *hybrida*, Sow.
*Strophomena depressa*, Sow.
——— *pecten*, Linn.

Graptolites.

*Graptolites convolutus*, His.
——— *turriculatus*, Barr.
*Diplograpsus palmeus*, Barr.
*Rastrites Linnæi*, Barr.
*Retiolites Geinitzianus*, Barr.

Corals.

*Favosites alveolaris*, Blainv.
*Halysites catenularius*, Linn.
*Heliolites interstinctus*, Wahl.
——— *tubulatus*, Lonsdale.

Of the above twenty species thus enumerated as common to the Upper Silurians of Bohemia and the Lower Silurians of Britain, four species are found in the Llandeilo, all (with the doubtful exception of *Retiolites Geinitzianus*) are found in the Caradoc, and fifteen species occur in the Llandovery rocks of the latter country. Not one of these species, on the other hand, is found in the corresponding rocks of Bohemia, namely in the second fauna. These species, therefore, go to show that "the elements of the third fauna of Bohemia, which are represented in the colonial fauna, existed in notable numbers in a foreign country, at a time when the second fauna still predominated in the Silurian basin of Bohemia. These species thus establish an indirect connexion between the second fauna of Britain and the colonies of Bohemia.

## VI. General Conclusions.

As to the general conclusions which may be deduced from the whole of the above facts, it will be sufficient to give briefly the series of propositions laid down by M. Barrande, merely remarking that these conclusions are in the main warranted by the facts, and that any subsequent modifications are not likely to affect their general tenor.

In the first place, it seems certain that during the existence of the last phases of the second fauna in Bohemia, the first phases of the third fauna had become more or less fully developed in some other country hitherto unknown.

Starting from this centre of diffusion, migrations must have taken place at different epochs into Bohemia, during the whole of the deposition of the thick band *d* 5.

On every occasion these migrations must have given rise to colonies, which are placed on the same horizon, and consist of graptolitic schists, almost always accompanied by flows of trap, and often containing calcareous concretions.

In consequence of inauspicious conditions, and from the cessation of these schistose and calcareous deposits, all the colonies must have enjoyed a relatively short existence during the period that the Bohemian area was occupied by the second fauna.

The appearance of the colonies coinciding constantly with the graptolitic deposits, we are compelled to attribute both equally to the influence of currents arising in the same quarter.

The introduction of intermittent currents into the isolated basin of Bohemia seems to have been caused by oscillations of the land, connected with the production of the traps which occur so frequently in bands *d* 5 and *e* 1.

In all cases, the colonial species appeared on different horizons without being able to establish themselves permanently in Bohemia during the last phase of the second fauna.

After the complete extinction of the second fauna, however, and after a prolonged intermission, during which the Bohemian basin appears to have been deserted, a new immigration, arising from the same foreign centre, must have invaded the Bohemian sea, and must have succeeded in permanently establishing itself there. (I may remark here that few palæontologists would admit that the presence of a considerable mass of unfossiliferous beds in the midst of a fossiliferous series, necessarily implies a period in which life did not exist, as above assumed by M. Barrande. More probably the local conditions were such as to cause a local migration of the existent fauna, or such as not to allow of their preservation in a fossil condition. There certainly do not seem to be sufficient grounds for the assumption that the whole of the second fauna of Bohemia died out during the deposition of the upper part of *d* 5, and the absence of fossils might be partially accounted for by the lithological nature of the deposits in question, which are stated by Barrande to consist chiefly of graywackes and grits ("quartzites"). Lastly, there are indications that *e* 1 is superimposed unconformably upon *d* 6, in which case the interval between the second and third faunas may have been an enormously long one, and some intermediate deposits may be missing.)

The above definitive introduction, constituting the first phase of the third or Upper Silurian fauna, must have taken place during the deposition of the band *e* 1, the basement band of the superior division, which agrees lithologically with the colonies in being composed of graptolitic schists with calcareous concretions, alternating with sheets of trap.

It is clear that the interpretation of the facts rests chiefly on the hypothesis of migrations. Most geologists now admit the doctrine of migrations, and Bohemia more than any country presents us with proofs of its truth.

Thus, M. Barrande has shown that the Bohemian basin of Silurian times was separated by natural barriers from the contemporaneous ocean which covered the great northern zone of Europe and America. This is shewn by the specific differences between many of the forms (such as the *Cephalopoda*) of these areas; but the occurrence of some species common to Bohemia and Northern Europe has also shown that there must have existed temporary communications between these different regions. Further, M. Barrande has shown (*Mem. sur la Reapparition du genre Arethusina*, 1868,) that although the colonies are the most striking examples of the intermittent appearance of species in Bohemia, there exists besides in the same basin a considerable number of species equally intermittent, and belonging to different classes of fossils. This was particularly shown by the occurrence of four Trilobites and one Cephalopod, which existed in *d* 1, at the commencement of the second fauna, completely disappeared during *d* 2, *d* 3, and *d* 4, and reappeared in *d* 5 at the close of the second fauna, their reappearance coinciding precisely with the introduction of the colonies into the basin.

Both these circumstances can be explained by the same hypothesis, namely by supposing a temporary communication to be formed between the Bohemian basin and other seas. This hypothesis would not only explain the reappearance of the above-mentioned species after the lapse of a vast period of time, but would also allow of the almost inevitable introduction of various other new forms into the same basin at the same time.

We have, then, on the one hand, the fact that the Silurian basin of Bohemia was isolated and separated from other regions, over which successively existed the three general faunas characteristic of the Silurian period (with the Upper Cambrian). On the other hand, divers well established facts demonstrate the co-existence of a certain number of identical species on corresponding horizons in countries geographically widely removed from one another. This co-existence can only be explained by the effect of migrations.

We may suppose, therefore, that the repeated introduction into Bohemia of species which are equally characteristic of the colonies and of the third fauna, may be explained by having recourse to the phenomenon of migrations. We may also suppose that the intermittent appearance of the colonies may be attributed to oscillations of the land during the last phases of the second fauna, the occurrence of such oscillations being testified by the frequent intercalation of traps in the beds in question (viz. in *d* 5).

Lastly, we may define the phenomena of "colonies" as consisting in "the co existence of two general faunæ, which, considered in their entirety, are nevertheless successive."

## THE WHALE OF THE ST. LAWRENCE.

By Dr. J. W. Anderson, President of the Literary and Historical Society of Quebec.

In the early history of Canada, the whale and walrus fishery of the Gulf of St. Lawrence was of no inconsiderable influence, giving employment to many of the Basque and Breton fishermen, and being one of the best nurseries for French seamen In later times when the walrus had become entirely extinct, the whale fishery was prosecuted with energy by the Canadians, especially of the District of Gaspe; and *Bouchette*, writing in 1832, says: "The whale fishery is carried on with some success by a few active and enterprising inhabitants, who are almost exclusively employed in this kind of fishery. Four or five schooners, manned each with from eight to twelve able and skilful persons, are occupied in whaling during the summer months. This business yields about 18,000 gallons of oil, which is principally sent to Quebec.

The number of hands employed in reducing the blubber to oil, preparing casks, and other incidental labour, may amount to about 100."

Mr. Frank Austin, a few years ago, read a paper to the Literary and Historical Society of Quebec, on "Some of the Fishes of the St. Lawrence." In this paper, published in the "Transactions" for 1866, it is stated that it gave profitable employment to a good many schooners of from seventy to eighty tons burthen, each manned by eight men. Each schooner carried two boats, twenty feet long, narrow and sharp, with a pink stern. There were two hundred and twenty fathoms of line to each boat, and the proper supply of harpoons and lances. The species caught was that commonly called the *Humpback*, and each on an average produced three tons of oil. The mode of capture was somewhat different from that practised by the whalers who resort to Davis' Straits and Greenland, and it is said that any active man, accustomed to the management of boats, could soon become proficient. When approaching the whale in the boats, the men used *paddles* instead of oars, finding that less noise was made, and that they were thus surer of their prey. It would appear that the whale of the St. Lawrence was even more easily captured than that of Greenland, being if anything more timid and stupid when once harpooned, for sometimes within fifteen minutes after they had been struck, their huge bodies rolled like helpless logs on the water. The oil-yielded in 1864 by the Gaspe fishery was of the value of $17,000. We have no means at hand to say what the returns have been since then, but we have reason to fear that like the porpoise fishery, the capture of the whale has not received that attention which it deserved, nnd that unless new life be imparted, it will altogether cease to be prosecuted as a regular and remunerative branch of national industry. The valuable walrus fishery was lost by ignorance, which led to the complete extinction of the animal in the St. Lawrence. The whale fishery stands a chance of abandonment from apathy.

We were struck on reading Sir Richard Bonnycastle's book, published in 1845, by remarking the number of whales which he saw on his voyage up and down the St. Lawrence, between Gaspe and Kamouraska. Certainly they do not now frequent the St. Lawrence in such abundance.

In the *Canadian Magazine*, vol. 1, page 283, will be found as follows :—" About the middle of September (1823) a large whale found its way up the St. Lawrence till nearly opposite the village of Montreal, where it continued to play itself for several days, not being able, from the shallowness of the water, to navigate its way down the river. Having attracted the notice of the inhabitants, several enterprising individuals put off in boats with some whale-fishing materials in pursuit of it; and at last after nearly a week's exertion it was harpooned by Captain Brush of the Tow steamboat. It was immediately dragged ashore, and exhibited in a booth fitted up for the purpose, for the gratification of the inhabitants. It was found to measure forty-two feet eight inches in length, six feet across the back, and seven feet deep. It has since been conveyed to Three Rivers and Quebec for the same purpose."

Early in August of this year (1871) two whales were seen sporting on the shores of the Gulf, and a Mr. Chabot, and an Englishman, who claim to have invented a gun harpoon (on Capt. Manby's principle), brought their gun to the shore and discharged the harpoon. As the whale instantly disappeared, and as the rope returned to the shore without the harpoon, they were under the impression that the whale had been struck. Some days afterwards, the government steamer 'Druid' being down the North Channel, saw something on the beach at St. Joachim, which they thought at first was a boat, but on nearer approach it was discovered to be a whale. Ropes were attached to the jaw and tail, and the huge animal was towed to the Police Wharf at Quebec, where for a few days it was visited by thousands, but becoming extremely offensive, and the weather being very hot, the Mayor very properly ordered it to be removed. It was sold by auction, and purchased by Mr. Gregory for $260, and was then towed to 'Patrick's Hole,' close to the Church of St. Laurent, where Wolfe's army first landed, and there beached and preparations made for fleching it.

I had not an opportunity of seeing it at Quebec, but through the politeness of Mr. Gregory, who gave me a passage, I had the satisfaction of seeing it at 'Patrick's Hole.' On approaching the beach we saw a number of the inhabitants around it, and on our nearer approach, our nostrils informed us that it was not the *Guard's bouquet* which made all the women have their handkerchiefs at their noses!

I was not prepared to find so huge an animal. It was supposed that the two whales had been a female and its calf, and I was informed that it was the calf that had been found. It turned out to be an aged male, apparently of the species *Balœna Mysticetus*. I measured it as carefully as I could, and satisfied myself that it was *sixty-five* feet in length. The back was black, the belly furrowed, presenting exactly the appearance of a clinker-built boat, and each furrow alternately black and dingy white. The baleens of one side had been lost by being caught on the rocks while it was being hauled ashore, but the other though it had been removed from the jaw, was quite perfect, till the visitors began to appropriate its plates. With the permission of Mr. Gregory I secured a few plates. I never had an opportunity of seeing so large a whale before, though I saw the skeleton of the whale stranded on the beach of Portobello, near Edinburgh, in 1829, and purchased by Dr. Knox. I concluded after a careful examination that it answered fully the description given by De Kay, as follows:

*Nat. Ord. Cetacea; Genus Balœna; Species, Balœna mysticetus.* Right or common whale. Characteristics, black, occasionally varied with white or yellow. Gape of the mouth, arched, with about 600 laminæ of whalebone. Length, forty to sixty feet.

Description: body thickest in the middle, a little behind the fore paws; somewhat furrowed, tapering towards the tail. Head large, somewhat triangular. Opening of the mouth large, with a few scattering hairs on the end of the jaws. Eyes very small, and placed near the corners of the mouth. External jaw exceedingly minute. Spiracles two, oblong, adjacent, slightly largish in front. Palate and sides of upper jaw with two rows of whalebone from ten to thirteen feet long, and generally curved longitudinally, and giving an arched form to the roof of the mouth. Each series consists of three hundred or more laminae of whalebone, the interior edges of which are covered with a hair-like fringe. Swimming paws rounded, somewhat pointed, 7—9 feet long with a width of 4—5 feet, and situated about two feet behind the angle of the mouth. Tail very broad, notched in the centre, curved on the edges, and pointed at the tips. Colour: blackish throughout, occasionally with a small space under the body, and a larger space on the lower jaw, whitish grey or flesh colour. Very old individuals become varied with white, black, or piebald. Weight from 60 to 100 tons. It is presumed to have a gestation of nine months, produces one at a birth, which it suckles for about a year. It exhibits great maternal fondness, and although at other times remarkably timid, manifests great boldness and even ferocity in defending its young. It is gregarious, and was formerly found in every part of the ocean, but has been driven by the fishermen from the coasts of Europe and America. It was early followed by the Americans to the South Pacific, and its capture is now prosecuted in India and Africa.

From the structure of its jaws and the smallness of its throat, it can only feed on the smaller oceanic animals. such as medusæ or sea jellies, shrimps, crabs, and some minute mollusca. Hence it differs most materially from the genus *cachelot* or *sperm whale*, which has got a *wide gullet*, and is capable of swallowing fishes of very considerable size. It feeds abundantly on the mackerel, and a portion of a shark has even been found in its stomach. At first thought it appears very wonderful that so immense an animal as the common whale should have to depend for its subsistence on minute animals, but the wonder ceases when we examine the waters to which they resort, sometimes in very large herds. De Kay says that he has seen off the coast of Brazil hundreds of miles where the mollusca are so numerous as to discolour the water, giving the appearance of wheat scattered over a reddish sandbank ; and Scoresby has estimated that in some parts of the Arctic seas twenty-three quadrillions of such animalculæ are distributed over a surface of two square miles. There is very great difference in the accounts given of the size of the two whales which I have mentioned. Some writers give the length of the sperm whale at from 70 to 80 feet, and of the common whale at from 80 to 100 feet. It is quite possible that such may have been occasionally found, but they are to be viewed as exceptional, for Capt. Scoresby, the very highest authority, and who had personally engaged in the capture of 322 whales, says that not one of them exceeded 60 feet.

I may mention how apt people are to be deceived as to the size of objects, and that no reliance can be placed on anything but actual measurement. A gentleman of Quebec, noted for his general intelligence and the interest he takes in all these subjects, met me in the library of the Literary and Historical Society, on his return from Cacouna. He said: " So you have had a great visitor at Quebec during my absence, but not so great as one that visited the St. Lawrence nearly fifty years ago, and was captured at Montreal. I have seen that the whale brought here last week was *only* 65 feet long ; I should say that the other was at least a third larger." He was both surprised and amused when I read to him the account from the *Canadian Magazine* which I have already given. The obvious difference between the sperm whale and the common is, that the *sperm* has a dorsal fin, and when the water is smooth the projection or hump is seen two or three feet above the surface. Its throat is also large, so that it would have no difficulty in swallowing a man. The *Mysticetus* or *common* whale, on the other hand, has neither dorsal fin or hnmp, and its gullet, as has been already said, is exceedingly small, not more than $1\frac{1}{2}$ inches in diameter.

According to my admeasurement, corroborated by Mr. Gregory, as the whale lay on the beach at 'Patrick's Hole,' he was *sixty-five* feet long, the fluke of his tail twelve feet, his jaw fifteen feet. From the condition he was in, I could not measure his breadth. When the skeleton was subsequently brought to the Police Wharf I had an opportunity of verifying, at any rate to my own satisfaction, the correctness of my first measure. The jaw bone, as it lay on the wharf stripped of all covering, measured exactly *fourteen feet six inches.* I felt justified from this fact in considering that my other measurements had been equally correct. Taking his length, then, at sixty-five feet, he was twenty-three feet longer than the one killed at Montreal in 1823, and five feet larger than the extreme length given by De Kay to the *Mysticetus.* A whale of such a size under ordinary circumstances should have yielded about sixty barrels of oil; this one only gave *six*, which is endeavoured to be accounted for by the supposition that he was aged, diseased, and worn out. May it not have been possible that having strayed from his feeding grounds, and having wandered up the St. Lawrence, where I believe he would have to depend for his subsistence on shrimps and medusae alone, he may have died from simple inanition. At any rate there was no mark of violence on his body, and Mr. Chabot's brother, who was sent to claim the whale as killed by his harpoon, failed to trace any wound or to find the harpoon, as he had expected. The skeleton has been well cleaned, and is very nearly complete, though the thin bones of the skull have been considerably fractured. It is still in the possession of Mr. Gregory, who has been more desirous of promoting science than enriching himself by the preservation of this splendid skeleton. We trust that some of our scientific bodies may make an effort to secure it, so that it may not be permitted to be sent out of the Province.

# NOTES ON THE PRIMORDIAL ROCKS IN THE VICINITY OF TROY, N. Y.

By S. W. Ford.

(*From the American Journal of Science and Arts, Vol. II., July,* 1871.)

In view of the prevailing uncertainty respecting the age of the rocks of that portion of the Taconic series of Professor Emmons lying east of the Hudson river, I was led several years ago to undertake the investigation of some of these rocks in my own neighbourhood, though I had but few hopes of learning anything essentially new about them. It soon became apparent that much valuable information might be obtained from them; and from certain facts which early came under my observation I was induced to continue their study. I propose here to notice briefly some of the more noteworthy results thus far obtained.

The rocks immediately east of the Hudson at Troy are fine, black, glazed shales, with occasional sandy layers, and have usually been regarded as belonging to the Hudson River formation. They have been greatly crushed, but their general dip is evidently eastward, and at a high angle. They extend eastward about half a mile, and form a hill of considerable magnitude within the city limits. Following the course of this hill northward, we find them frequently well exposed in railway cuttings, and before reaching Lansingburgh, which is three miles distant, in a bold elevation several hundred feet in height.

The only fossils which these shales have afforded, are the obscure form described under the name of *Discophyllum peltatum* (Pal. N. Y., vol. i, 277, plate lxxv, fig. 3), and two or three species of graptolites, the latter having been but recently obtained. The graptolites resemble closely certain well-known Hudson river forms, but whether certainly identical I am at present unable to state. If truly Hudson river shales, then the absence of any other fossils in these rocks, except those above mentioned, appears not a little remarkable.

Upon the east, after an interval of concealment varying somewhat in different localities, these shales are followed by the widely different rocks of the "Taconic" series, likewise dipping eastward, and apparently at about the same angle. The best exposures of these rocks in this vicinity occur opposite the central portion of the city, where they are brought to view in a number of abrupt, quickly concealed ridges. These ridges trend northerly and southerly, and appear to be all constructed upon the same pattern, having on the west a steep, on the east a more gradual slope. Only the western faces are naturally exposed. This uniformity of structure is very striking, and there are reasons for believing that it has resulted largely from successive short, sharp folds in the strata, of which we have a fine example in the rocks east of Lansingburgh; but as nearly the whole district is covered with a thick sheet of drift, and the rocks bear evidence of extensive faulting, much further study will be necessary before it will be fully understood.

These ridges generally consist for the most part of coarse red and yellow weathering slates and shales, with occasional thin-bedded sandstones; but the most of them are supposed, and four of them are known, to hold subordinate limestone deposits. Of these deposits the two westernmost individually consist of a few courses of thick-bedded limestone, and of irregular, sometimes lenticular, sparry and frequently pebbly masses, varying from one to several hundred pounds in weight, imbedded in a coarse, dirty-looking arenaceous matrix: while the others form tolerably compact, even-bedded limestones, with an abundance of scattered black nodules, from twenty-five to thirty feet in thickness.

So far as investigated, these limestones have been found to be highly fossiliferous, though the fossils are usually in a very fragmentary condition. From two of them—one of the conglomerates and one of the even-bedded masses—the writer has made frequent collections during the last three years. With a single exception the same species occur in both. Up to the present time they have yielded eighteen species, which are distributed as follows:

| | | |
|---|---|---|
| Protozoa (*Archeocyathus*) | 1 | species. |
| Brachiopoda | 7 | " |
| Lamellibranchiata | 1 | " |
| Gasteropoda | 1 | " |
| Pteropoda (*Hyolithes*) | 2 | " |
| Annelida (*Salterella*) | 1 | " |
| Crustacea | 5 | " |
| Total, | 18 | " |

Of these, six—*Obolella* (*Avicula?*) *desquamata* (Hall), *O.* (*Orbicula?*) *crassa* (H.), *O.* (*Orbicula*) *cælata* (H.), *Metoptoma rugosa* (H.), *Theca triangularis* (H.), and *Agnostus lobatus* (H.)—were figured and described in the first volume of the Palæontology of New York in 1847, from this locality; and two—*Conocephalites* (*Atops*) *trilineatus* (Emm.) and *Olenellus* (*Elliptocephalus*) *asaphoides* (E.),* from Greenwich, Washington county. All the rest are new or undescribed. †

Desiring further information in regard to certain of these new species, I several months since wrote Mr. E. Billings, Palæontologist of the Geological Survey of Canada, at the same time giving him a list of the species in my possession from this quarter. In reply Mr. B. informed me that he was just engaged upon a collection of new fossils from the Lower Potsdam formation below Quebec, which he strongly suspected to be identical with my own: and on comparison it was found that fifteen out of the eighteen species from Troy were held by us in common, and shown to be perfectly identical. Such an unlooked-for result of course surprised us greatly. That the Lower Potsdam formation below Quebec, and the western portion of the Taconic series near Troy are of the same age, there seems now but little room for doubt.

Two very characteristic fossils of this formation are the opercula of two species of *Hyolithes*, upon which I communicated a

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* These two species, to which great interest has long attached, were, until quite recently, supposed to be confined to an exposure of the "Black Slate" of Dr. Emmons, about two miles north of Bald Mountain, N.Y., where they were first discovered by Dr. Asa Fitch of Salem, N. Y., so long ago as the year 1844. Owing to the imperfection of the specimens furnished by that locality, however, their true relations have long been considered doubtful among geologists. But the state of preservation in which they are now found in limestone leaves no longer a doubt as to their true affinities. Good specimens of these species are comparatively rare in the limestones at Troy, though fragments of large individuals of the *Olenellus asaphoides* are very common. I am indebted to Mr. Billings for having pointed out to me the specific identity of the Troy specimens with the *Atops* and *Elliptocephalus*—an acknowledgment which was unintentionally omitted in this paper as originally published. As it is, however, about to be republished in the "*Naturalist and Geologist*," I gladly embrace this opportunity to set the matter right.

† Unless one of them should prove identical with the species of *Cypricardia* figured by Emmons (American Geology, p. 113, plate 1, fig. 1.)

note in the preceding number of this Journal. One of them was there described as a "minute, circular species, with four pairs of lateral muscular impressions and two smaller dorsal, all radiating from a point near one side;" the other as "larger, and like a *Discina* on the outside." The former occurs quite abundantly in the Troy limestones, and is a very beautiful little object. It varies in size from a mere point to a diameter of three lines. Perfect specimens have a rich, polished appearance. The other occurs more rarely. As might naturally be expected, these rocks contain immense numbers of *Hyolithes*. Indeed, large portions of the limestone are often almost wholly composed of them.

Without doubt this formation in New York will yet afford many new species.* The even-bedded limestone east of Troy, to which especial attention has been given, as well as portions of the conglomerates, are literally loaded with fossils, and promise richly to repay investigation for a long time to come. Their associated slates, shales and sandstones have as yet afforded no fossils. Near Lansingburgh, however, where what is at present regarded as a lower member of the formation, consisting of heavy and thin-bedded gray sandstones with interstratified black slates, is exposed, a few obscure Fucoids have been found, but these rocks have been but imperfectly investigated. Neither the thickness nor precise eastern limit of this formation has yet been ascertained.

Troy, N. Y., May 24, 1871.

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* These rocks have hitherto been referred, though with some doubt, to the Calciferous portion of the Quebec Group; but all modern investigations in our older strata have steadily pointed to their higher antiquity; and it is simply justice to state that, by several geologists besides those who have adopted Prof. Emmons' views of their age, this has long been suspected.

# ON SOME NEW SPECIES OF PALÆOZOIC FOSSILS.

By E. Billings, F.G.S.

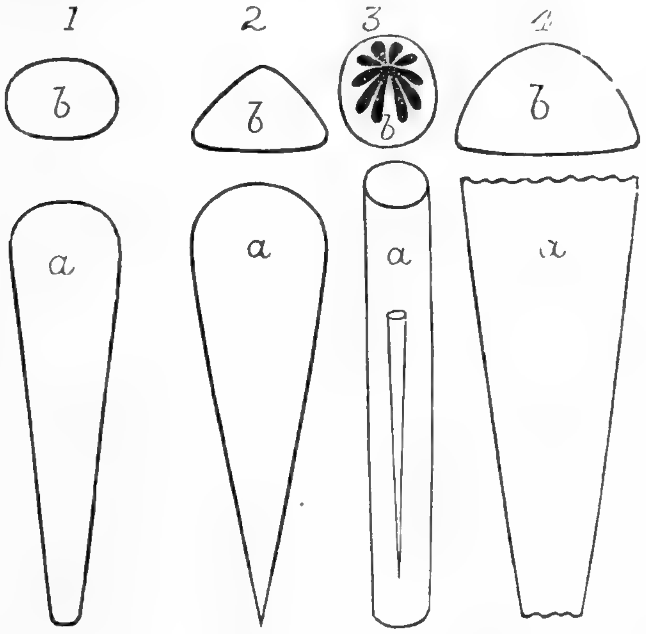


Fig. 1. *Hyolithes communis.* 2. *H. Americanus.* 3. *H. ? micans.* 4. *H. princeps.* In these diagrams *a* represents the rate of tapering of the shell on the ventral side; *b*, the transverse section (except in 3 *b*, which is the inner surface of an operculum enlarged two diameters). The small figure in 3 *a* represents the apical portion of a specimen. N.B.—All these species vary slightly in the rate of tapering.

## Genus Hyolithes, *Eichwald.*

In the following description of new species of *Hyolithes*, I shall call the side of the fossil which is most flattened, or from which there is a projection in front of the aperture, " the ventral side." Directly opposite is the " dorsum." The lateral walls, whether consisting of two sloping planes, as in fig. 2, or rounded as in the other figures, I shall designate simply " the sides." The " width " of the aperture is the greatest distance between the two most projecting points of the sides. This is sometimes close to the ventral side as in fig. 2. The " depth " is the distance between the median line of the ventral side and the dorsum, and is at right angles to the width. That part of the ventral side which projects beyond the aperture is the " lower lip." The " ventral limb " of the operculum is that side which is in contact with the lower lip, when the operculum is in place, in the aperture. The "dorsal limb" is the opposite side of the operculum, in contact with the dorsum. In some of the opercula there is a point around which the surface markings are arranged concentrically; this is the "nucleus."

The following species occur in the pebbles and boulders of a conglomerate which constitutes an important formation on the south shore of the St. Lawrence below Quebec. The age of the rock in which these pebbles are found, is not yet certainly determined, but it is, at all events, near that of the Potsdam.

H. COMMUNIS.—This species attains a length of about eighteen lines, although the majority of the specimens are from ten to fifteen lines in length. The ventral side is flat (or only slightly convex) for about two-thirds the width, and then rounded up to the sides. The latter are uniformly convex. The dorsum, although depressed convex, is never distinctly flattened, as is the ventral side. The lower lip projects forward for a distance equal to about one-fourth or one-third the depth of the shell. In a specimen whose width is three lines the depth is two lines and a-half.

The operculum is nearly circular, gently but irregularly convex, externally and concave within. The ventral limb is seen on the outside as an obscurely triangular, slightly elevated space, the apex of the triangle being situated nearly in the centre of the operculum. The base of the triangle forms the ventral margin. This limb occupies about one-third of the whole superficies of the external surface. The remainder, constituting the dorsal limb, is nearly flat, slightly elevated from the margin towards the centre. On each side of the apex of the ventral limb there is a slight depression, running from the nucleus out to the edge. On the inside there is an obscure ridge, corresponding to each one of the external depressions. It is most prominent where it reaches the edge. These two ridges meet at the centre, and divide the whole of the inner surface of the operculum into two nearly equal portions.

The surface of the operculum is concentrically striated. The shell itself in some of the specimens is covered with fine longitudinal striæ, from five to ten in the width of a line. The shell varies in thickness in different individuals. In some it is thin and composed of a single layer, but in others it is much thickened by concentric laminæ, and thus approaches the structure of a *Salterella*. There are also fine engirdling striæ, and sometimes obscure sub-imbricating rings of growth.

This species has been found at Bic and St. Simon.

Fig. 1, *b*, representing the transverse section, is not so distinctly flattened on the ventral side as it is in most specimens.

Collected by T. C. Weston.

H. Americanus.—Length from twelve to eighteen lines, tapering at the rate of about four lines to the inch. Section triangular, the three sides flat, slightly convex or slightly concave, the dorsal and lateral edges either quite sharp or acutely rounded. Lower lip rounded, projecting about two lines in full-grown individuals. Surface finely striated, the striæ curving forwards on the ventral sides, and passing upwards on the sides at nearly a right angle, curve slightly backwards on the dorsum. In a specimen eighteen lines in length, the width of the aperture is about six lines and the depth about four, the proportions being slightly variable.

The operculum has a very well-defined conical ventral limb, the apex of which is situated above the centre, or nearer the dorsal than the ventral side. The dorsal limb forms a flat margin, and is so situated that when the operculum is in place, the plane of this flat border must be nearly at right angles to the longitudinal axis of the shell. In an operculum six lines wide, the height of the lower limb to the apex of the cone, is two and a-half lines, and the width of the flat border, which constitutes the dorsal limb, about one line.

This species occurs at Bic and St. Simon; also at Troy, N.Y., where it has been found abundantly by Mr. S. W. Ford of that city. It is *Theca triangularis* of Hall, Pal. N.Y., vol. I., p. 213, 1847. As that name was preoccupied by a species previously described by Col. Portlock, Geol. Rep. on Londonderry, p. 375, pl. 28 A, fig. 3*a*, 3*b*, 3*c*, 1843, it must be changed. It is a very abundant species, and varies a good deal.

The Canadian specimens were collected by T. C. Weston.

H. micans.—This is a long slender cylindrical species, with a nearly circular section. The rate of tapering is so small, that it amounts to scarcely half a line in length of eighteen lines, where the width of the tube is from one to two lines. The largest specimen collected is two and a-half lines wide at the larger extremity, and if perfect would be four or five inches in length.

The operculum does not show distinctly a division into a dorsal and ventral limb. It is of an ovate form, depth somewhat greater than the width, the nucleus about one-third the depth from the dorsal margin. Externally it is gently concave in the ventral two-thirds of the surface; a space around the nucleus is convex, and finely striated concentrically. On the inner surface there is a small pit at the dorsal third of the depth, indicating the position of the nucleus. From this point radiate ten elongate ovate scars, arranged in the form of a star, the rays towards the ventral side being the longest. None of these scars quite reach the margin.

The shell and operculum are thin and of a finely lamellar structure, smooth and shining.

Occurs at Bic and St. Simon; also at Troy, N.Y.

Collectors, T. C. Weston and S. W. Ford.

Sometimes numerous small specimens from half a line to three lines in length are found with the operculum on the same slab.

This shell appears to me at present to constitute a new genus, differing from the majority of the species of *Hyolithes* in its circular section, the operculum not divided into dorsal and ventral lines, and in the remarkable system of muscular impressions on the interior. Barrande has figured an operculum of the same type, differing from this in having only three instead of five pairs of impressions. They are, however, arranged on the same plan in both the Canadian and Bohemian species.* It is possible that our species may be a *Salterella*.

H. PRINCEPS.—Shell large, sometimes attaining a length of three or four inches, tapering at the rate of about three lines to the inch. In perfectly symmetrical specimens, the transverse section is nearly a semicircle, the ventral side being almost flat, usually with a slight convexity, and the sides and the dorsum uniformly rounded. In many of the individuals, however, one side is more abruptly rounded than the other, in consequence of which the median line of the dorsum is not directly over that of the ventral side, and the specimen seems distorted. This is not the result of pressure, but is the original form of the shell. Sometimes, also, there is a rounded groove along the median line of the dorsum. The latter is somewhat more narrowly rounded than the sides. Lower lip uniformly convex, and projecting about three lines in a large specimen. Surface with fine striæ and small sub-imbricating ridges of growth. These curve forwards on the ventral side. In passing upwards on the sides, they

* Systême Silurian, &c., vol. III., pl. 9, fig 16 H, and fig. 17.

at first slope backwards from the ventral edge, and then turn upwards and pass over the dorsum at a right angle to the length.

When the width of the aperture is seven lines, the depth is about five. The operculum has not been identified.

Collected by T. C. Weston at Bic and St. Simon.

### Genus OBOLELLA, *Billings*.

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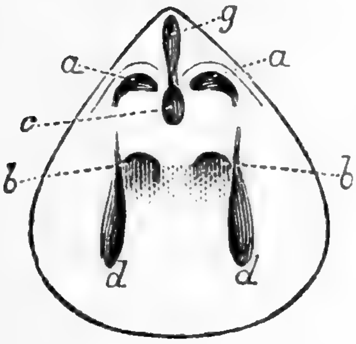


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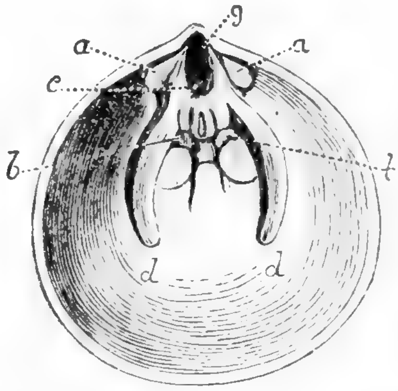


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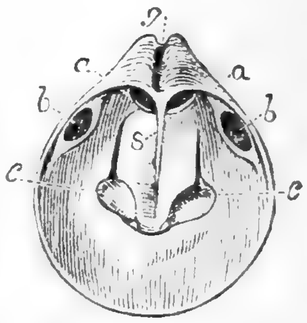


FIG. 5. Interior of the ventral valve of *O. gemma*, enlarged about five diameters. *aa*, the two small scars at the hinge; *bb*, the two central scars; *c*, the small pit near the hinge; *dd*, the two principal muscular scars; *g*, the groove in the area.

6. Interior of the ventral valve of *O. desquamata*, Hall,* enlarged 2½ diameters.

7. Interior of the ventral valve of *Obolus Apollinis*, Eichwald, copied from Davidson's "Introduction to the study of the fossil Brachiopoda."

GENERIC CHARACTERS.—Shell unarticulated, ovate or sub-orbicular, lenticular, smooth, concentrically or radiately striated, sometimes reticulated by both radiate and concentric striæ. Ventral valve with a solid beak and a small more or less distinctly grooved area. In the interior of the ventral valve there are two elongated sub-linear or petaloid muscular impressions, which extend from near the hinge line forward, sometimes to points in front of the mid-length of the shell. These are either straight or curved, parallel with each other or diverging towards the front. Between these, about the middle of the shell, is a pair of small impressions, and close to the hinge line a third pair, likewise small, and often indistinct. There is also, at least in some species, a small pit near the hinge line, into which the groove of the area seems to terminate. In the dorsal valve there are six impressions

* Engraved from a figure kindly drawn for me by Thos. Davidson, Esq., F.R.S., of Brighton, England. The specimen is from the original locality of the species, Troy, N.Y. Collected by T. C. Weston

corresponding to those of the ventral valve, and sometimes an obscure rounded ridge along the median line.

If we compare the interior of the ventral valve of an *Obolella* with that of *Obolus Apollinis*, we see that there are six muscular impressions in each, but not arranged in the same manner. The two small scars *aa* at the hinge line are most probably the same in both genera. The two lateral scars *bb* of *Obolus* have no homologue in *Obolella*, unless they be represented by the two large ones *dd*. Should this be the case, however, the great difference in their position, would no doubt be of generic value. I think it more probable that the large scars *dd* of *Obolella* represent the central pair *cc* of *Obolus*. Again, Eichwald says that in the interior of the ventral valve of *O. Apollonis* there is a longitudinal septum (shown in the above fig. 7 at *s*), which separates the two adductors *cc*, and extends to the cardinal groove (I suppose he means the groove *g* on the area).* No such septum occurs in any species of *Obolella*. I have not seen any description of the dorsal valve of the *O. Appollinis* sufficiently perfect to afford a means of comparison with that of *Obolella*, but the differences in the ventral valve alone are so great that the two genera can scarcely be identical. They are, however, closely related, and occur in nearly the same geological horizon.

In the rocks below Quebec and at the Straits of Belle Isle, we find the following species of *Obolella* :—

1. *O. desquamata*, Hall, = *Avicula ? desquamata*, Pal. N.Y., vol. 1, p. 292, pl. 80, fig. 2. Occurs at Troy, N. Y.

2. *O. crassa*, Hall = *Orbicula ? crassa*, op. cit. p. 299, pl. 79, fig. 8. Occurs at Troy.

3. *O. cœlata*, Hall, = *Orbicula cœlata*, op. cit. p. 290, pl. 79, fig. 9. Occurs at Troy.

4. *O. gemma*, n. sp.

5. *O. circe*, n. sp.

6. *O. chromatica*, Billings, has been found as yet only at the Straits of Belle Isle.

The following are new species :

O. GEMMA.—Shell very small, about two or three lines in length, ovate, both valves moderately convex and nearly smooth.

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* Speaking of the adductors, he says : "Une crête longitudinal occupe le milieu des dernières impressions et arrive jusqu'au sillon cardinal." (Lethea Rossica, vol. 1, p. 925.)

Ventral valve ovate, the anterior margin broadly rounded, with sometimes a portion in the middle nearly straight; greatest width at about one-third the length from the front, thence tapering with gently convex or nearly straight sides to the beak, which is acutely rounded. The area is about one-fifth or one-sixth the whole length of the shell, with a comparatively deep groove, which extends to the apex of the beak. The dorsal valve is nearly circular, obscurely angular at the beak, and rather more broadly rounded at the front margin than at the sides.

In the interior of the ventral valve there are two small muscular impressions of a lunate form, close to the cardinal margin, one on each side of the median line. A second pair consists of two elongate sub-linear scars, which extend from the posterior third of the length of the shell to points situated at about one-fourth the length from the front margin. These scars are nearly straight, parallel or slightly diverging forwards, and divide the shell longitudinally into three nearly equal portions. Between them, about the middle of the shell, are two other small obscurely defined impressions. There is also a small pit close to the hinge line and in the median line of the shell. In the interior of the dorsal valve there is an obscure rounded ridge which runs from the beak along the median line almost to the front margin. Close to the hinge line there is a pair of small scars, one on each side of the ridge. The other impressions in this valve have not been made out.

The surface of both valves is in general nearly smooth, but when well preserved shows some obscure concentric striæ.

This species is closely allied to *O. chromatica*, the species on which the genus was founded, only differing from it, so far as the external characters are concerned, in being much smaller, and the beak of the ventral valve more extended.

Occurs at Bic and St. Simon. Collected by T. C. Weston.

O. Circe.—Ovate, front and sides uniformly rounded, posterior extremity more narrowly rounded than the front, length and width about equal, greatest width at the mid-length, rather strongly and uniformly convex, surface nearly smooth, but with fine concentric striæ. Length seven lines, width a little less. The rostral portion of the shell is much thickened for about one-fifth the length, and in this part there is a deep and wide groove. In front of the thickened portion the muscular impressions are indistinctly seen, but appear to be formed on the same plan as those of the ventral valve of the genus.

The above description is drawn up on one exterior, and several interiors of the same valve, apparently the ventral valve. The exterior is very like that of *O. desquamata*, and is of the same size, but the interior shows it to be an entirely distinct species.

Length of the largest specimen seen, seven lines; width about the same, or slightly less.

Occurs at Trois Pistoles. Collected by T. C. Weston.

Platyceras primævum.—Shell minute, consisting of about two whorls, which as seen from above are ventricose, but most narrowly rounded at the suture; the inner whorl scarcely elevated above the outer. The under side is not seen in the specimen. Diameter, measured from the outer lip across to the opposite side, one line; width of last whorl at the aperture, about one-third of a line.

Collected at Bic by T. C. Weston.

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(Proposed new genus of Brachiopoda.)

Genus Monomerella, N. G.

Generic characters.—Shell unarticulated, ovate or orbicular; ventral valve with a large area and with muscular impressions like those of *Trimerella*. Dorsal valve with muscular impressions in the central and posterior portion of the shell, nearly like those of *Obolus*. In the ventral valve there is only a single septum, which extends from the cardinal line a greater or less distance forwards. There are two cavities in the shell beneath the area. In the dorsal valve there are no cavities in the shell. The main difference between this genus and *Trimerella* are, thus, as follows:—

*Trimerella.*—Cavities in both valves.

*Monomerella.*—Cavities in the ventral valve but none in the dorsal.

The above description is intended to be merely introductory. As Mr. Davidson will soon fully describe and illustrate the genus from both Canadian and Swedish specimens, no more need be said about it here.

This genus was discovered in the spring of 1871, at Hespelar, Ontario, in the Guelph limestone, by T. C. Weston. Before venturiug to describe it, I sent a specimen to Mr. Davidson. and on returning it he stated that he considered it to be a new genus, "very closely allied to *Trimerella*." Lately I received a letter from him in which he states that he has obtained the same genus from Wisby, Island of Gothland, and he requested me to name it, as he was about to publish the Swedish species.

We have two distinct species, both occurring in the Guelph limestone. This formation I consider to be about the age of the Aymestry limestone of the English geologists. I shall characterize our species briefiy as follows. Full descriptions and figures will be given hereafter.

M. PRISCA.—Ventral valve ovate, greatest width at about the anterior third of the length, thence tapering with gently convex sides to the narrowly rounded beak; front margin broadly rounded; septum about one-third the length of the shell. Dorsal valve about one-fourth shorter than the ventral, and more broadly rounded at the anterior extremity. On a side view the outline of the ventral valve would be, so far as we can judge from a cast of the interior, somewhat straight, or only gently arched from the beak to the front margin. The dorsal valve, on the other hand, is rather strongly convex, most prominent in the anterior half. It is evident that the general cavity of the shell of the dorsal valve extends a short distance under the area.

Length of ventral valve, eighteen lines; greatest width, thirteen or fourteen lines; length of dorsal valve about fourteen lines. There are some fragments in the collection which indicate a larger size.

Occurs in the Guelph limestone at Hespelar, Ontario. Collected by T. C. Weston.

M. ORBICULARIS.—Broadly ovate, nearly circular, lenticular, both valves moderately convex; septum about one-third the length. The casts seem to show that a thin plate extends forwards a short distance from the cardinal edge, supported by the septum. The length and width appear to be about twelve or fifteen lines.

Occurs with *M. prisca*. T. C. Weston, collector.

Both *Trimerella* and *Monomerella* are sub-genera of *Obolus*.

There is, besides the above, a third group which differs from the other two in having no cavitias in either valve. It includes the species I have called *Obolus Canadensis* and *O. Galtensis*. For this group I would propose the name OBOLELLINA. It differs from *Obolus Apollinis* in the form of the area of the ventral valve, and in having a small pair of muscular impressions in the dorsal valve, in front of the large central pair. In all three of these sub-genera, there are species which have the large muscular impressions of the ventral valve obliquely striated or grooved. This seems to show that the muscles were not single but composed of several bands. The three genera pass gradually into each other, and yet I think some sort of a subdivision is required. It seems almost absurd to place such shells as *T. grandis* and *O. Canadensis* in the same generic group.

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## NATURAL HISTORY SOCIETY.

### FIELD DAY AT MONTARVILLE.

The fourth of these social gatherings took place on Saturday, June 3rd, the place selected being Montarville, or as it is commonly called, Boucherville Mountain. The weather being propitious, about one hundred persons assembled at the Bonaventure Street Station, at 9 a.m., from whence they were conveyed by a special train to Boucherville Station, which was reached about 10.15. From this point vehicles of various descriptions conveyed the excursionists to the grove near the lake on the grounds of Madame Bruneau, the lady of the manor. When all were assembled together, the President, Principal Dawson, stated that parties would be formed to examine, respectively, the geological features, the zoology, and the botany of the mountain. Principal Dawson, Dr. T. Sterry Hunt, and Mr. A. R. C. Selwyn, undertook the direction of the geological party; Mr. Whiteaves was deputed to lead the zoological expedition; but as no botanist was forthcoming to explain the points of interest in the various plants that might be met with, Mr. S. J. Lyman volunteered to act as guide to those who wished to ascend the mountain. Each party took a different direction, with the understanding that all were to meet again at the lake at 2 p.m. The results obtained by the geologists will be found described in Dr. Hunt's and Principal Dawson's remarks farther on. It may be mentioned, however, that on the way Principal Dawson picked up two pieces of rock of Hudson River group age, one containing a portion of a crinoidal column, the other specimens of *Orthis testudinaria* and *Leptæna sericea*. The followers of Mr. Lyman failed to reach the summit of the hill opposite the lake, and on their return many could sympathise with the plaint of Beattie's Minstrel,

"Ah who can tell *how hard it is to climb*."

The zoologists formed a small but compact body, and looked as if they meant business. A large number of chipmunks were seen during the day, and several of their curious underground burrows were met with. The birds noticed were the black-billed cuckoo, *Coccygus erythrophthalmus;* the gold-winged woodpecker, *Colaptes auratus;* the ruby-throated humming-bird, *Trochilus colubris;* the tyrant flycatcher, *Tyrannus Carolinensis;* the golden-crowned thrush, *Seiurus aurocapillus;* the yellow-rumped and the black-throated green warblers, *Dendroica coronata* and *virens;* the red-eyed and the warbling vireo, *Vireo olivaceus* and *gilvus;* the cat-bird, *Mimus Carolinensis;* the swamp sparrow, *Melospiza palustris;* and the blue jay, *Cyanura cristata.* We are indebted to Mr. Passmore for this list of birds observed. No reptiles of special interest were observed; in the lake, specimens of the American perch, the sun-fish, cat-fish, roach-dace, and striped minnow, were taken. Among the butterflies captured were *Papilio Turnus* and *asterias*, *Colias Chrysostheme*, a *Lycæna*, *Vanessa Antiopa*, a skipper, probably *Hesperia hobomuck*, a *Hipparchia*, and the now formidable cabbage butterfly, *Pieris rapæ*, a species closely allied to those "large white butterflies" spoken of by Mrs. Browning in Aurora Leigh,

"Which look as if the May flower had caught life,
And palpitated forth upon the wind."

The following is a list of the beetles found during the day:—

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| *Cicindela patruelis*, Dejean. | *Dicerca divaricata*, Say. |
| *Pterostichus mutus*, Say. | *Melanotus laticollis.* |
| *Chlænius sericeus*, Forster. | *Dendroides concolor.* |

*Lachnosterna fusca*, Frolich.

Seven species of land shells were collected, the rarest of which was *Helix multidentata*, Binney. It will be observed that no specimens of much rarity in any branch of Natural History were collected, the most common plant noticed during the day was the yellow lady's slipper.

About two p.m. the scattered parties re-assembled in the grove near Madame Bruneau's residence; and an hour was allowed for rest and refreshment. The various collections of plants were then examined, and the following prizes were awarded:—

For the best *named* collection in botany or zoology. No competitor.

For the largest number of species of flowering plants, unnamed. 1. Master Rankin Dawson, 21 species. 2. Miss Lovell, 13 species.

Mr. WHITEAVES gave a short verbal account of the objects of interest met with in the department of zoology, after which

The President of the Society, Principal DAWSON, F.R.S., came forward, and after a few remarks introduced Dr. T. STERRY HUNT, who proceeded to give a brief notice of the Mountain of Montarville and its geological history. This mountain, he said, stands in the north-east part of the Seigniory of Montarville, and being near the Seigniory and Parish of Boucherville is sometimes known as Boucherville Mountain. The family Bruneau, the present lords of the manor, to whose kind courtesy the Natural History Society was indebted for the privilege of holding its meeting on the domain, have however caused the Parish Church near by to be dedicated to St. Bruno, and hence the mountain or rather the group of hills around was now frequently spoken of as the Mountain of St. Bruno. In proceeding to speak of its geological history, Dr. Hunt remarked that Montarville has so much in common with the adjacent mountain of Belœil, which the Natural History Society had visited two years since, that much of what he then said would be equally applicable to the present occasion. He next proceeded to describe the two great classes of rocks into which most of the solid portion of the earth's crust may be divided, viz: stratified and erupted rocks; the formed being chiefly layers of sand, clay and carbonate of lime deposited as sediments from water, and subsequently hardened into rocks, somewhat as mortar and cement harden. These sediments, many thousand feet in thickness, accumulated during ages in the subsiding bottom of the ocean, and enclose the fossil remains of the various species of animals and plants which then lived. The erupted or non-stratified rocks are found breaking through the stratified rocks of various periods from the oldest to the most recent. They are composed of crystalline minerals, chiefly different species of feld-spar, mica, hornblende, pyroxene or augite, olivine and quartz. The nature of these various minerals, and of the different rocks which are made of mixtures of two or more of them was then explained, showing the difference between granite, trachyte, syenite, dolerite, diorite, and basalt, all of which are erupted rocks. Many of these from their peculiar jointed structure, occasionally show at their outcrops a step-like arrangement, which has procured for them the common name of trap, from a Swedish word signifying a stair. It is applied indiscriminately to almost all ancient erupted rocks, and has therefore little scientific value. Such rocks are closely related to the lavas of modern volcanos, which when solidified under pressure resemble trachyte, dolerite, basalt, etc. As the source of lavas is many thousand feet beneath the surface, the lower parts of the lava columns must always be thus solidified. Dr. Hunt then proceeded to explain that Montarville was the site of an ancient and extinct volcano belonging to palæozoic times, and that the crystalline rocks there seen were the basal portion of the former eruption of lava. The whole valley around, being the northward extension of the valley of Lake Champlain to the St. Lawrence, had in palæozoic times been filled with soft stratified rocks to a height much above the present summits of Mount Royal and Belœil, and presented a plateau, above which probably active volcanos marked the sites of the mountain just named, and of Rougemont, Yamaska, Monnoir, and Montarville. In some cases, however, there is reason to suspect that there may be masses of erupted rock which never came to the surface, and hence did not appear as active volcanos in subsequent ages. The eroding action of the elements, air and water, cut away the soft sedimentary rocks. and swept away the volcanic peaks, leaving little more than the hard cores of crystalline rock below, which were better able to resist the eroding agencies. He called attention to the fact that the stratified sediments near their contact with the erupted rocks had been much hardened, and still remained in place, preserving, however, their fine grain, and showing fossil shells within a few inches of the line of contact with the crystalline dolerite, near the spot where the company stood. The slow disintegrating action of the air, water and frost was shown in the crumbling of this crystalline rock beneath their feet, a process to which the oxydation of iron pyrites which had given rise to white crusts of soluble sulphates of iron and magnesia, contributed. The supposed source of erupted rocks was briefly alluded to as probably the fusion of deeply-buried stratified rocks, and the fact was noticed that not only different volcanos in the same region, but the same volcanos at different periods, discharge lava of very unlike characters. This fact was then compared with the different characters of the various mountains of erupted rock around us. Thus Belœil was in great part, at least, a micaceous diorite; Monnoir a diorite of another type; Yamaska presents two kinds of erupted rock, unlike either of these. Montarville, though in a great part a dolerite consisting of a coarse grained mixture of black pyroxene with white feldspar, shows in the hill rising from the lake just behind the manor-house, a rock of very different type, consisting of a coarsely crystalline mixture of dark green pyroxene with a considerable amount of amber-brown olivine or chrysolite, which in other parts of the mass is associated with a white feldspar and with black pyroxene. The various rocks of these different mountains have been described in detail by the speaker in "The Geology of Canada," He concluded by saying that the stratified rocks around the mountain have a history not less beautiful and curious than that of erupted rocks, and would now be described by one far more competent to the task than himself—Principal Dawson.

Dr. Hunt concluded his remarks amid much applause.

Principal Dawson then said that ancient though the volcanos referred to by the last speaker were, there were still more ancient facts represented by some of the specimens which had been collected. The fossil shells and crinoids represented by specimens which he exhibited, showed the evidences of an ancient Lower Silurian sea, which once overspread all the plain of Canada, and in which flourished multitudes of curious creatures now extinct. He particularly referred to the Crinoids or stone lilies, some curious specimens of which had been collected. He then thanked the company for their presence, referred to the fact that the excursion had been honored by the presence of the Director of the Geological Survey, and by many of the *elite* of the citizens of Montreal, and to the kindness of the lady of the manor, who had so liberally given them the use of her grounds; and cordially invited all who might have been interested in the day's works to connect themselves with the Society. The President was warmly applauded.

A little after 4 o'clock the conveyances were again in requisition, and the party returned to Boucherville Station, and arrived at Montreal about 7 p.m.

J. F. W.

## GEOLOGY AND MINERALOGY.

On the Canadian Trilobite with Legs.—The following is an extract from the Report of the Committee of the British Association on the Structure and Classification of the Fossil Crustacea, at the Edinburgh meeting, August, 1871. The committee consists of Henry Woodward, F.G.S., F.Z.S., Dr. Duncan, F.R.S., and R. Etheridge, F.R.S. The report was drawn up by Mr. Woodward.

"Since noticing the occurrence of an Isopod (*Palæga Carteri*), from the Kentish, Cambridge, and Bedford Chalk, Dr. Ferd. Roemer, of Breslau, has forwarded me the cast of a specimen of the same Crustacean from the Chalk of Upper Silesia. This, together with the example from the Miocene of Turin, gives a very wide geographical as well as chronological range to this genus.

A still more remarkable extension of the Isopoda in time is caused by the discovery of the form which I have named *Præarcturus* in the Devonian of Herefordshire, apparently the remains of a gigantic Isopod resembling the modern *Arcturus Baffinsii*.

I have also described from the Lower Ludlow a form which I have referred with some doubt to the Amphipoda, under the generic name of *Necrogammarus*.

Representatives both of the Isopoda and Amphipoda will doubtless be found in numbers in our Palæozoic rocks, seeing that Macrouran Decapods are found as far back as the Coal-measures,* and Brachyurous forms in the Oolites.†

Indeed the suggestion made by Mr. Billings as to the Trilobita being furnished with legs (see Quart. Journ. Geol Soc., vol. xxvi., pl. 21, fig. 1), if established upon further evidence, so as to be applied to the whole class,would carry the Isopodous type back in time to our earliest Cambrian rocks.

I propose to carry out an investigation of this group for the purpose of confirming Mr. Billings's and my own observations, by the examination of a longer series of specimens than have hitherto

* *Anthrapalæmon Grossartii*, Salter, Coal-measures, Glasgow.

† *Palæinachus longipes*, H. Woodw., Forest Marble, Wilts.

been dealt with. In the meantime the authenticity of the conclusions arrived at by Mr. Billings having been called in question by Drs. Dana, Verrill, and Smith (see the American Journ. of Science for May last, p. 320; Annals and Mag. Nat. Hist. for May, p. 366). I have carefully considered their objections, and have replied to the same in the GEOLOGICAL MAGAZINE for July last, p. 289, Pl. VIII.; and I may be permitted here to briefly state the arguments *pro* and *con*, seeing they are of the greatest importance in settling the systematic position of the Trilobita among the Crustacea.

Until the discovery of the remains of ambulatory appendages by Mr. Billings in an *Asaphus* from the Trenton Limestone (in 1870), the only appendage heretofore detected associated with any Trilobite was the hypostome or lip-plate.

From its close agreement with the lip-plate in the recent *Apus*, nearly all naturalists who have paid attention to the Trilobita in the past thirty years have concluded that they possessed only soft membranaceous gill-feet, similar to those of *Branchipus*, *Apus*, and other Phyllopods.

The type-number of segments in Crustacea is 20 or 21. In all the higher forms, as in the Decapoda, Stomapoda, Isopoda, etc., several of these segments are coalesced either in the head, thorax, or abdomen, so that we never meet with a Crustacean having 21 distinctly-marked segments until we arrive at the Branchiopoda and Phyllopoda, many of which have their full number of separate segments.

In the Trilobita, a very variable number of body-rings is met with, from 6 even to 26 (in *Harpes ungula*, Sternb.), so that on that account alone the Trilobita must be considered as a much lower type than the Isopoda, in which the body-segments are usually seven in number. There seems, however, no good reason against the conclusion that the Trilobita were an earlier and more generalized type of Crustacea from which the latter and more specialized Isopoda have arisen.

The large compound sessile eyes, and the hard, shelly, many-segmented body, with its compound caudal and head shield, differ from any known Phyllopod, but offer many points of analogy with the modern Isopods, and one would be led to presuppose the Trilobites possessed of organs of locomotion of a stronger texture than mere branchial frills.

The objection raised by Drs. Dana and Verrill to the special case of appendages in the *Asaphus* assumed by Mr. Billings to possess ambulatory legs, is, that the said appendages were merely the semicalcified arches in the integument of the sternum to which the true appendages were attached.

A comparison, which these gentlemen have themselves suggested, between the abdomen of a Macrouran Decapod and the Trilobite in question, is the best refutation of their own argument.

The sternal arches in question are firmly united to each tergal piece at the margin, not along the median ventral line. If, then, the supposed legs of the Trilobite correspond to these semicalcified arches in the Macrouran Decapod, they might be expected to lie irregularly along the median line, but to unite with the tergal pieces at the lateral border of each somite. In the fossil we find just the contrary is the case; for the organs in question occupy a definite position on either side of a median line along the ventral surface, but diverge widely from their corresponding tergal pieces at each lateral border, being directed forward and outward in a very similar position to that in which we should expect legs (*not sternal arches*) to lie beneath the body rings of a fossil crustacean. The presence, however, of semicalcified sternal arches presupposes the possession of stronger organs than mere foliaceous gill-feet; whilst the broad shield-shaped caudal plate suggests most strongly the position of the branchiæ. In the case of the Trenton *Asaphus* I shall be satisfied if it appears, from the arguments I have put forward, that they are *most probably* legs—feeling assured that more evidence ought to be demanded, before deciding on the systematic position of so large a group as the Trilobita from only two specimens.*

With regard to the embryology and development of the modern King-Crab (*Limulus polyphemus*), we must await the conclusions of Dr. Anton Dohrn before deciding as to the affinities presented by its larval stages to certain of the Trilobita, such relations being only in *general external form*. Dr. Packard (Reports of the American Association for the Advancement of Science, August, 1870) remarks, "The whole embryo bears a very near resemblance to certain genera of Trilobites, as *Trinucleus*, *Asaphus*, and others;" and he adds, "previous to hatching it strikingly resembles *Trinucleus* and other Trilobites, suggesting that the two groups should, on embryonic and structural grounds, be included in the same order, especially now that Mr. E. Billings

* One in Canada, and one in the British Museum, both of the same species.

has demonstrated that *Asaphus* possessed eight pairs of five-jointed legs of uniform size."

Such statements are apt to mislead, unless we carefully compare the characters of each group. And first let me express a caution against the too hasty construction of a classification based upon *larval* characters.

Larval characters are useful guide-posts in defining great groups, and also in indicating affinities between great groups; but the more we become acquainted with larval forms the greater will be our tendency (if we attempt to base our classification on their study) to merge groups together which we had before held to be distinct.

To take a familiar instance: if we compare the larval stages of the common Shore-Crab (*Carcinus mœnas*) with *Pterygotus*, we should be obliged (according to the arguments of Dr. Packard) to place them near to or in the same group.

The eyes in both are sessile, the functions of locomotion, prehension, and mastication are all performed by one set of appendages, which are attached to the mouth; the abdominal segments in both are natatory, but destitute of any appendages.

Such characters, however, are common to the larvæ of many Crustaceans widely separated when adult, the fact being that in the larval stage we find in this group, what has been so often observed by naturalists in other groups of the animal kingdom, namely, a shadowing forth in the larval stages of the road along which its ancestors travelled ere they arrived from the remote past at the living present.

If we place the characters of *Limulus* and *Pterygotus*, side by side, and also those of Trilobita and Isopoda, we shall find they may be, in the present state of our knowledge, so retained in classification.

I.

| *Pterygotus* (Fossil, extinct). | *Limulus* (Fossil and living). |
|---|---|
| 1. Eyes sessile, compound. | 1. Eyes sessile, compound. |
| 2. Ocelli distinctly seen. | 2. Ocelli distinctly seen. |
| 3. All the limbs serving as mouth-organs | 3. All the limps serving as mouth-organs. |
| 4. *Anterior* thoracic segments bearing branchiæ or reproductive organs. | 4. *All* the thoracic segments bearing the branchiæ or reproductive organs. |
| 5. Other segments destitute of any appendages. | 5. Other segments destitute of any appendages. |
| 6. Thoracic segments *unanchylosed.* | 6. Thoracic segments *anchylosed.* |
| 7. Abdominal segments *free and well developed.* | 7. Abdominal segments *anchylosed and rudimentary.* |
| 8. Metastoma, *large.* | 8. Metastoma, *rudimentary.* |

II.

| *Trilobita* (Fossil, extinct). | *Isopoda* (Fossil, and living). |
|---|---|
| 1. Eyes sessile, compound. | 1. Eyes sessile, compound. |
| 2. No ocelli visible. | 2. No ocelli visible. |
| 3. (Appendages partly oral, partly ambulatory, arranged in pairs). | 3. Appendages partly oral partly ambulatory, arranged in pairs. |
| 4. Thoracic segments *variable in number, from* 6 *even to* 26, free and movable (animal sometimes rolling in a ball). | 4. Thoracic segments *usually seven*, free and movable (animal sometimes rolling in a ball). |
| 5. Abdominal somites coalesced forming broad caudal shield (bearing the branchiæ beneath). | 5. Abdominal somites coalesced, forming broad caudal shield, bearing the branchiæ beneath. |
| 6. Lip-plate, *well developed.* | 6. Lip-plate, *small.* |

Should our further researches confirm Mr. Billings's discovery fully, we may propose for the second pair of these groups a common designation (as in the case of the Merostomata); meantime, the above may serve as representing the present state of our knowledge.

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## BOTANY AND ZOOLOGY.

Popular Names of Plants.—Botanists generally ignore the use of any other than scientific names for plants, because it leads to a great deal of confusion in their nomenclature, the same name being frequently applied to two or more plants of entirely different species, and sometimes of widely separated genera; and in other cases the same plant will receive a dozen or more names, varying in different countries, and even in various sections of the same country, among people speaking the same language. For precise nomenclature, therefore, the names given by acknowledged authorities in the botanical world have to be accepted by amateurs and professional men. Nevertheless, the popular names of plants are not merely empirical, but are founded, as the scientific names are founded, upon some peculiar feature or use of the plant.

Of late years these popular names have become the object of very interesting research, as throwing much light upon ethnological history, the antiquity of various nations, and the migrations of the larger tribes of men. We can not, of course, go into a lengthy account of these matters, or give the derivation of all the popular names in use—it would require a large volume to do this; but we will give a few examples of the results of the researches made as to the names of some common trees and plants. With the exception of the hazel-nut, and some other wild berries, the Apple appears to be the only fruit known to our European ancestors, as it is the only name not derived from the Latin or French. In the Zend, or old Persian language, and in the Sanscrit, the name for water is *ap*, and for fruit *p'hala;* hence ethnologists think that the name is compounded of these two words, meaning "water fruit," or "juice fruit." This corresponds with the Latin name *pomum*, derived from *po*, to drink, which is a somewhat curious coincidence. In Welsh it was formerly called *apalis*, now *apfel;* in high-German, *aphol;* in German, *apfel;* in Anglo-Saxon, *æpl*, or, *æppel;* in old Danish, *epli;* in modern Danish, *æble;* in Swedish, *æple;* and in Lithuanian, *obolys*, or *obelis*. This close similarity in the name as used by these various nations, renders it highly probable that they all come from the same root or stock, and that such root or stock originally inhabited the western spur of the Himalayan Mountains or northern Persia.

Again, the name of Beech-tree, given to the *Fagus sylvatica*, is another curious proof of our descent from Asiatic nations. In Sanscrit the word *bôkô* signifies a letter, and the word *bôkôs* writings. In Swedish the name of the Beech-tree is *bok;* in Danish, *bög;* in Dutch, *beuk;* in German, *buch;* in modern high-German, *buoche;* in old high-German, *puocha;* and in Anglo-Saxon, *boc*, *bece*, and *beoce*—names applied indifferently to this tree and to a book, because the ancient books of these different nations were written in their Runic characters upon tablets or leaves made from the bark of this tree. Ethnologists, therefore, consider this as another proof of our descent from the nations of Upper Asia, the more so as the use by the Greeks of the word *biblos*, as signifying a book, is derived from the name of an Egyptian plant that was used in making the material upon which they wrote, showing that our ancestors received their ancient alphabetic signs from India by the way of the north, and not by a southern route.

As a curious example of the way in which the names of plants become transmitted in passing from one language to another, we instance one of the names of the Carnation, or *Dianthus caryophyllus*. Chaucer, in his *Canterbury Tales*, speaks of "A primerole, a piggesnie." This last word, the glossaries state, means "pig's-eye," the first one meaning the primrose. Now "piggesnie" really means Whitsuntide Pink, and comes from the German words *Pingsten*, or *Pfingst*, derived from a Greek word for fiftieth, meaning the fiftieth day after Easter, and *eye* from the French *œillet*, a Pink. The word *Pingsten*, therefore, has reference to the time of its blooming, and *eye* to the circular markings in the flower, and thus *Pinksteneye* has passed into *Piggesnie.*

The *Viola tricolor*, or Pansy, is an instance of numerous and various names being applied to the same plant. The above name comes from the French word *pensée.* Because it has three colors in the same flower it is called "Three faces under a hood," and also "Herb Trinity;" and from its coloring, "Flame Flower." It is also called "Heart's-ease," but this name properly belongs to the Wallflower, which was formerly called *giroflée*, or Clove Flower, because cloves were in former times considered good for diseases of the heart. Of amatory names, the Pansy has probably more than any other plant; we name a few of them: "Kiss Me ere I Rise," "Kiss Me at the Garden Gate," "Jump up and Kiss Me," "Cuddle Me to You," "Tittle my Fancy," "Pink of my John," "Love in Idle," or "in Vain," "Love in Idleness," and many others.

The old herbalists were great believers in the doctrine of signatures; by which they meant that some particular character or habit of the plant indicated its medical use. Thus the spotted leaves of the Pulmonaria indicated that it was a remedy for pulmonary complaints; the tubers of the roots of Scrophularia, being hard and knotty, must be good for glandular affections, and because the Saxifrage grows in the clefts of the rocks it must be good for stone in the bladder. They even ascribed different qualities to various parts of the same plants. An old author says: "The seed of garlic is black; it darkens the eyes with blackness and obscurity. This is to be understood of healthy eyes. But those which are dull through vicious humidity, from these garlic drives it away. The skin of garlic is red; it expels blood. It has a hollow stem, and therefore helps affections of the windpipe."

Some common names are the embodiment of some poetic thought of our forefathers, as the Daisy, Belle's-perennis, which comes from the Anglo-Saxon *dæges-eage*, or the old English Daiesey-ghe, meaning the eye of day, because its flowers are only open in the day time; though some derive the name from *dais*, a canopy, from the shape of the flower, as in the line,

"The *daisie* did unbraid her *crownall small*"—

crownall meaning coronal, the upper part of a canopy.

Other names derive their origin from the uses to which the plant is put, as the Dogwood; which is not named after the animal, but because the wood was formerly used for making skewers, the proper name being *dawkwood*, or skewer-wood, this name coming from the Anglo-Saxon *dalc* or *dolc;* German, *dolch;* Spanish, *daga;* French, *dague;* and old English, *dagge.*

A curious instance of confusion and transposition of names is to be found in the Forget-me-not, as this name has only been given to the pretty blue Myosotis within the past forty or fifty years. For more than two hundred years the name had been given by the English to the *Ajuga chamæpitys*, or Ground-pine, on account of the unpleasant taste it leaves in the mouth. Some of the German botanists and herbalists gave the name to a plant known botanically as *Teucrium Botrys.* In Denmark and some parts of Germany the name was applied to the Speedwell or *Veronica chamædrys*, and by others to *Gnaphalium leontopodium.* The name appears properly to belong to the Veronica, having reference to the way in which the flowers fall off and are blown away as soon as it is gathered; hence the valediction "Speedwell," "Farewell," "Good-by," "Forget-me-not," etc., as applied to this plant. The later application was brought about by the legend in a story of modern date in which a drowning lover snatches it from the river bank, and as he sinks throws it ashore, as a token of remembrance.

J. H. in "Hearth and Home."

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## MISCELLANEOUS.

### OBITUARY.—SIR RODERICK IMPEY MURCHISON, BART., K.C.B., LL.D., D.C.L., M.A., F.R.S., F.G.S., &C., &C., &C.

The death of Sir Roderick Murchison, although at the ripe age of 80 years, is a loss which Geologists and Geographers are alike called upon to mourn. In relation to both these sciences, he has for many years justly occupied the most prominent positions. But, apart from his high social and scientific standing, he was a man full of genial and kindly feeling, who could be readily approached; and those who knew him most intimately acknowledge that he was never known to fail his friends in the hour of need, but was ready to aid them with his advice, his influence, and his purse, as many a young scientific man amongst us can testify.

Born at Tarradale, in Ross-shire, he received his early education as a boy at the Grammar School at Durham.

But the associations of his Highland home—his ancient Scottish pedigree, numbering in the long roll many a staunch supporter of the Stuarts, who had freely laid down their lives for their Sovereign—combined with the stirring events which marked the period of his own youth, no doubt powerfully influenced young Murchison in selecting a profession, until in imagination he too, like Roderick Vich Alpine, heard the mountains say—

> "To you as to your sires of yore,
> Belong the target and claymore!"

Having made up his mind to follow the military profession, he was sent by his father, Mr. Kenneth Murchison, to the Royal Military College, Great Marlow, after which, having pursued his studies for a few months at the University of Edinburgh, he obtained a commission in the army in 1807, and joining his regiment the following year, served in the 36th Foot with the army in Spain and Portugal under Lord Wellington, afterwards on the Staff of his uncle, General Sir Alexander Mackenzie, and lastly as Captain in the 6th Dragoons. He took an active part in several of the most important battles in the war, and earned the reputation of being a brave and able officer. He carried the colours of his regiment at the Battle of Vimiera, and afterwards accompanied the army in its advance to Madrid and its junction with the force under Sir John Moore, and shared in the dangers and retreat at Corunna. At the end of the war in 1815, he married Charlotte, only daughter of the late General Francis Hugonin. It was Sir Roderick's own conviction that to his wife's influence was mainly to be attributed the choice he made in following scientific pursuits with her, and giving up, as he did, the ordinary amusements of a retired cavalry officer.* She was his friend, companion, and fellow-labourer in geology, aiding him in his observations, and making for him those remarkable geolo-

* See notice of Lady Murchison, Geol. Mag., 1869, Vol. VI., p. 227, by Prof. Geikie, F.R.S., President Edinburgh Geological Society.

gical sketches of landscape that illustrate his works. He is also said to have early become acquainted with Sir Humphry Davy, who suggested to him that he should attend the lectures of the Royal Institution. This advice he followed, and he also studied with Mr. Richard Phillips, F.R.S.

In 1825 he was elected a Fellow of the Geological Society of London, and in the same year he read his first paper on "The Geological Formation of the North-west extremity of Sussex, and the adjoining parts of Hants and Surrey," before that Society.†

In 1826 he recorded the results of his investigations in the Oolitic series of Sutherland, Ross, and the Hebrides, and in the same year he was elected to the Fellowship of the Royal Society; the following year he again visited the Highlands in company with Professor Sedgwick and succeeded in showing that the primary Sandstone of McCulloch was really the true Old Red Sandstone or Devonian.

In 1828 he resolved to extend his researches abroad, and to study the extinct volcanos of Auvergne and the geology of the Tyrol. He was accompanied on this occasion by Mr. (now Sir Charles) Lyell.

Following Dr. Buckland's advice, Murchison next devoted himself to a careful examination of the geology of Hereford, Shropshire, and the Welsh Borders, the ancient country of the *Silures*, and it was upon this investigation that his great Silurian system was afterwards founded.

These researches he afterwards followed up by others in Pembrokeshire, to the west of Milford Haven; and his conclusions as to the stratigraphical relation between the Devonian and the underlying Silurian systems was made public at the meeting of the British Association for the Advancement of Science in 1831, but his great work did not appear until 1839.

Further geographical investigations in Devon and Cornwall followed, in which Professor Sedgwick took part, and in 1835 and 1839, two journeys were performed by Sedgwick and Murchison to the Rhenish Provinces; on the latter occasion M. de Verneuil also accompanied them. The result of these researches,

† This paper is of great historical interest, being accompanied by a letter from the illustrious Baron Cuvier, in which he gives a detailed description of the Reptilian remains forwarded to him by Mr. Murchison for examination. The specimens which are figured and described in this paper are now preserved in the British Museum.

and comparison of the English Devonians with those of Rhenish Prussia, was published in 1839, and a final classification adopted.

In 1840, accompanied by De Verneuil, Murchison visited Russia, at that period very little known geologically.

They examined the banks of the rivers Volkoff and Siass, and the shores of Lake Onega, thence to Archangel and the borders of the White Sea, and followed the river Dwina in the government of Vologda. They traversed the Volga and returned by Moscow to St. Petersburg, examining the Valdai Hills, Lake Ilmen, and the banks of the rivers which they passed. They then returned to England, but having been invited by the late Emperor Nicholas to superintend a Geological Survey of Russia, the two geologists returned to St. Petersburg in the spring of 1841, and being joined by Count Keyserling and Lieutenant Kokscharow, they proceeded to explore the Ural Mountains, the Southern Provinces of the Empire and the Coal Districts between the Dneiper and the Don. In 1842 Murchison travelled alone through several parts of Germany, Poland, and the Carpathian Mountains, the better to understand the relations of the great formations to each other over wide areas. In 1844 he explored the Palæozoic rocks of Sweden and Norway. In 1845–6 he completed his great joint work on "The Geology of Russia and the Ural Mountains," in two quarto volumes of 700 and 600 pages, copiously illustrated with maps, sections, and plates of fossils. Not long after the publication of this work, Mr. Murchison was knighted by her Majesty, the Emperor having previously conferred several Russian orders on him, including that of St. Stanislaus. In 1849 he received the Copley medal from the Royal Society, in recognition of his having established the Silurian system in geology.

His researches (extending over six visits) in the Alps, Apennines, and Carpathian mountains, established the fact of a graduated transition from Secondary to Tertiary rocks, and clearly separates the great Nummulitic formation from the Cretaceous formations with which it was confounded.

Ranking next in importance to his definition of the Silurian System was his differentiation of the Permians. Having satisfied himself that the Lower Red Sandstone, and the Magnesian Limestone and Marl Slates constituted one natural group only, which, from their organic contents, must be entirely separated from the overlying formations, he proposed, in 1841, that the group should receive the name of the "Permian" system, from Perm, a Russian Government, where these strata are more extensively developed than elsewhere, occupying an area twice the size of France, and containing an abundant and varied suite of fossils. The name Permian is now generally adopted.

In 1854 Sir Roderick published the first edition of his best-known work, "Siluria," which had, in 1867, reached its fourth edition, and contains 566 pages 8vo. of closely printed matter, 41 plates and explanations.

In 1855 he produced a memoir in conjunction with Prof. Morris on the German Palæozoic rocks, and shows that there is no break between the Permian system and the Triassic series.

By the death of Sir H. T. de la Beche, Sir Roderick, in 1855, succeeded to the post of Director General of the Geological Survey and the Museum of Practical Geology in Jermyn Street, which have owed their efficiency for the past fifteen years very largely to his energy and constant attention.

Sir Roderick Murchison will long be remembered both in the world of science and of commerce in connexion with the discovery of gold in Australia. Long years before the actual discovery of gold in Australia was made known, he inferred the presence of auriferous deposits in the Australian mountain-ranges from the analogy which existed between their rock formations and those of the Ural mountains, with the physical characters of which he had made himself familiar. He endeavoured most earnestly at the time to awaken the attention of the Home Government to the great importance of the subject to our colonies in the Southern hemisphere, but with little success.

During his scientific career he has been identified most intimately with the Geological Society. He acted as Secretary for five years, was elected President in 1831-2, and again in 1842-3.

He aided Sir David Brewster, in 1830, to establish the British Association, of which for several years he acted as General Secretary. He was President at the Meeting for 1846, at Southampton.

In 1844 he was elected President of the Royal Geographical Society, and again in 1845, in 1852, and in 1856; indeed, he has held the Presidential chair of that Society almost down to the present time; having been succeeded only a few months ago by Sir Henry Rawlinson.

His energetic efforts in advocating the search after Sir John

Franklin; his success in raising a monument to Lieutenant Bellot, of the French Navy; his advocacy of the explorers of Central Africa, Burton, Speke, Grant, Baker, and especially his friend Livingstone, are among the proofs of his earnest self-devotion to the cause of Geographical research.

Amongst the many workers in the fields of science how few there are whose actual published labours extend over half a century; yet almost the last Blue Book which has appeared, namely, "the Report of the Commissioners appointed to inquire into the several matters relating to Coal in the United Kingdom," (Vol. I. General Report and Twenty-two Sub-reports, folio, 1871), bears Sir Roderick's name second on the Commission.

The Council of the Geological Society awarded him the Wollaston Gold Medal, in 1864, in recognition of his contributions to geology as an inductive science. The Universities of Oxford, Cambridge, and Dublin have also bestowed on him their Honorary Degree.

He held for many years the post of a Trustee to the British Museum, with great advantage to the Natural History Departments in that Institution, which he specially promoted.

Sir Roderick was created, in 1863, a Knight Commandant of the Order of the Bath (civil division), and in the following year he received the prize named after Baron Cuvier from the French Institute. In 1859 the Royal Society of Scotland presented him with their first Brisbane gold medal, for his scientific classification of the Highland rocks, and for the establishment of the remarkable fact that the Gneiss of the north-west coasts is the oldest rock in the British Islands. He was created a baronet in January, 1866.

One of his latest acts consisted in offering the munificent sum of £6,000 to found a Chair of Geology and Mineralogy in the University of Edinburgh, on condition that the Government would supplement the proceeds by an annual grant of £200. This was duly acceded to, and the chair so endowed, is now held by Professor Geikie, F.R.S , etc.

The death of Lady Murchison in 1869 was most keenly felt by Sir Roderick, indeed it may be said to have given him a shock from which he never wholly recovered. He was first attacked by paralysis in December, 1870, but gradually rallied until two months since, when he had a second stroke, but the symptoms had lately abated. A slight attack of bronchitis, caused by a cold caught in riding out on the 19th ulto., ended his valuable and well-spent life on Sunday evening, Oct. 22, at 8.30 p.m.

His scientific career, now brought to a close, represents the period of the dawn and development of Geology as a science in this country. He commenced work at the moment when William Smith issued the first Geologically-coloured map of England, and he has lived on to see half the world surveyed geologically, and has himself mapped a vast extent of territory in Europe for his Silurian kingdom.

In conclusion (to quote the words of the *Daily News*), "the honors he won are a great testimony to the scientific enlightenment of the age. We have crowned Science Queen, and all her servants form her court, and wear the titles she bestows. And, truly, a scientific man earns his honours more nobly, and wears them more honourably than those who win them in political intrigue or on the field of battle. Sir Roderick Murchison, dying at eighty, covered with titles of literary and scientific honour, and satisfied with social position and renown, is a prophet of the coming time. He may not be looked back on as a great scientific genius; but he is one of the pioneers of that new order of renown which is won by fruitful service rather than by destructive deeds."

—*From the* GEOLOGICAL MAGAZINE *for November*, 1871.

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(Proposed new genus of Pteropoda.)

Genus HYOLITHELLUS, N. G.

Since the sheet containing the description of *Hyolithes micans* was printed off, I have arrived at the conclusion that a new genus for its reception should be instituted. I propose to call it *Hyolithellus.* It differs from *Hyolithes*, in its long slender form and in the peculiar structure of its operculum.

E. BILLINGS.

Published December, 1871.

Fig. 1.

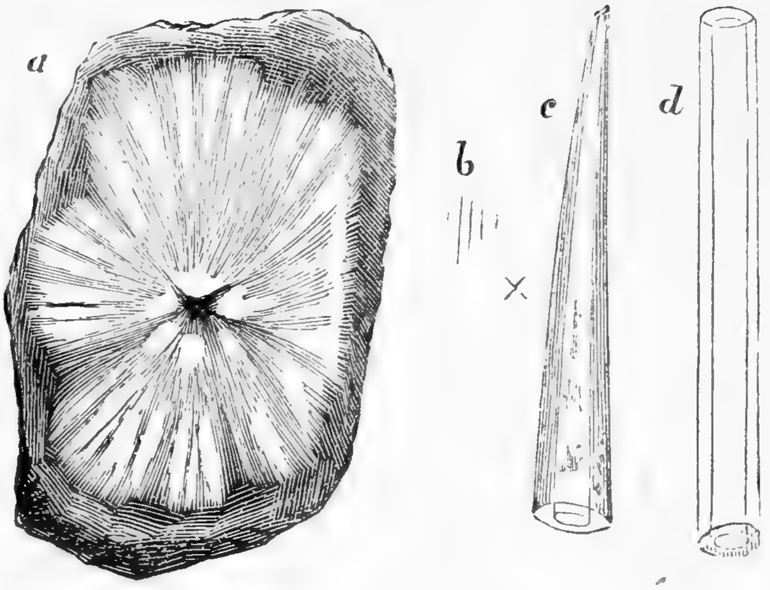


Fig. 2.

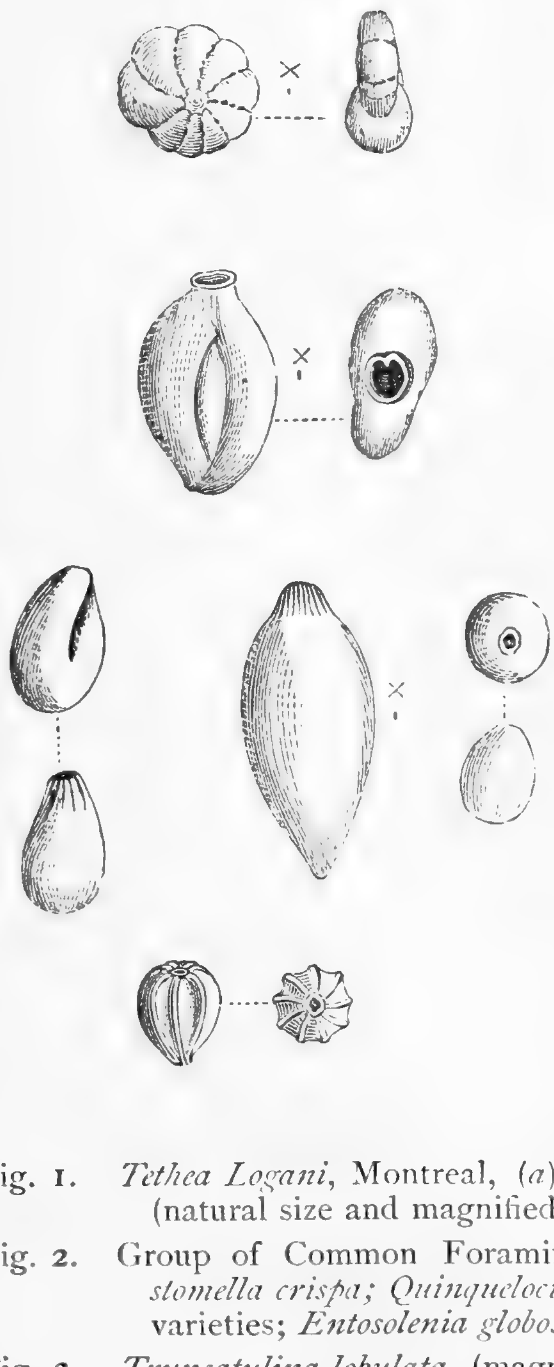

Fig. 3.

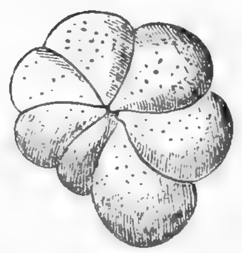

Fig. 4.

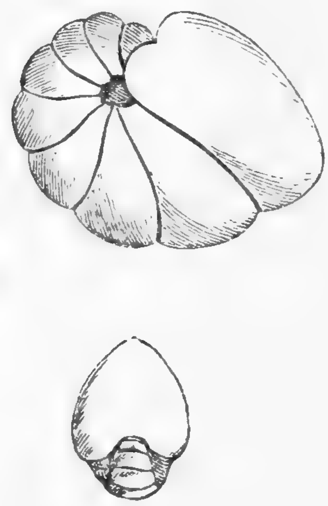

Fig. 5.

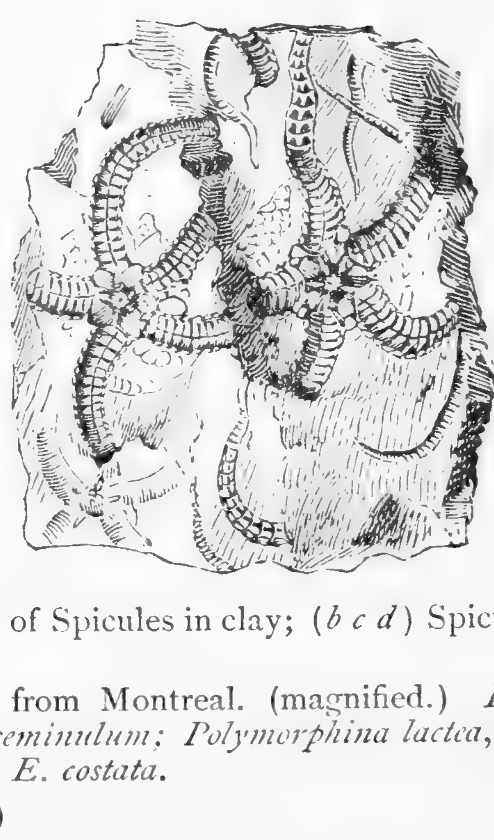

Fig. 1. *Tethea Logani*, Montreal, (*a*) Mass of Spicules in clay; (*b c d*) Spicules, (natural size and magnified.)

Fig. 2. Group of Common Foraminifera from Montreal. (magnified.) *Polystomella crispa; Quinqueloculina seminulum; Polymorphina lactea*, two varieties; *Entosolenia globosa* and *E. costata.*

Fig. 3. *Truncatulina lobulata.* (magnified.)

Fig. 4. *Nonionina scapha.*—Var. *Labradorica.* (magnified.)

Fig. 5. *Ophioglypha Sarsii*, Duck Cove, St. John, N. B.

THE

# CANADIAN NATURALIST

AND

# Quarterly Journal of Science.

## THE POST-PLIOCENE GEOLOGY OF CANADA.

By J. W. Dawson, LL.D., F.R.S., F.G.S.

### PART II.—LOCAL DETAILS.—(*Continued.*)

### 5. *Lower St. Lawrence—South Side.*

The Report of the Geological Survey of Canada (1863), includes all that is yet known of the Post-pliocene formations at Gaspé, and thence upward to Trois Pistoles. According to this Report, the Boulder-clay and overlying sands and gravels are extensively spread over the Peninsula of Gaspé. On the Magdalen River they have been traced up to a height of 1600 feet above the sea, though marine shells are not recorded at this great height. Terraces occur at various elevations, and in one of the lower at Port Daniel, only fifteen feet above the sea, marine shells occur. On the coast westward of Cape Rosier, terraces occur at many places, and of different heights, and marine shells have been found ninety feet above the sea. I have not had opportunities to examine these deposits to the eastward of the place next to be mentioned.

*Trois Pistoles.*—At this place one of the most complete and instructive sections of the Post-pliocene in Canada, has been exposed by the deep ravine of the river, and by the cuttings for the Intercolonial Railway. The most important terrace at the mouth of the Trois Pistoles River, that in which the railway cutting has been made, is about one hundred and fifty feet above the level of the sea, and is composed of clay capped with sand and gravel. At no great distance inland, there rises a second terrace one hundred and sixty feet higher than the first, or about three hundred and ten feet above the sea. In some places the front of this terrace is cut into two or more. It consists of clay capped with sand and gravel, with some large stones and Laurentian boulders. Still farther inland is a third terrace, the height of which was estimated at four hundred to four hundred and fifty feet.

In the first mentioned of the above terraces, a very deep railway cutting has been made, exposing a thick bed of homogeneous clay of a purplish gray colour and extremely tenacious. It contains few fossils; and these, as far as I could ascertain, exclusively *Leda truncata*. It is, in short, a typical Leda clay, and its thickness in this lower terrace can scarcely be less than one hundred and twenty feet. As the inland terraces are probably also cut out of it, this may be less than half of its maximum depth. Under the Leda clay a typical Boulder-clay had been exposed at one place in digging a mill sluice. It seemed to be about twenty feet thick, and rests on the smoothed edges of the shales of the Quebec group.

Though the Leda clay at the Trois Pistoles seems perfectly homogeneous, it shows indications of stratification, and holds a few large Laurentian boulders, which become more numerous in tracing it to the westward. A short distance westward of Trois Pistoles, it is seen to be overlaid by a boulder deposit, in some places consisting of large loose boulders, in others approaching to the character of a true Boulder-clay or associated with stratified sand and gravel. We thus have Boulder-clay below, next Leda clay, and above this a second Boulder drift associated with the Saxicava sand, and apparently resting on the terraces cut out of the older clays. This is the arrangement which prevails throughout this part of Canada. It is modified by the greater or less relative thickness of the Boulder-clay and Leda clay, by the irregular distribution of the overlying sands, and by the projection through it of ridges of the underlying rocks.

The section at Trois Pistoles may be represented as follows in descending order:

1. *Sand and Gravel*, capping the terraces cut in the previous deposits, and forming slight ridges or eskers in some of the lower levels. It contains on the lower terraces a few shells of *Leda* and *Tellina*. At the bottom of this deposit there are seen in places many large boulders of Laurentian and Lower Silurian rocks, resting on the Leda clay below.
2. *Leda Clay*, exposed in the railway cutting and seen also in the edge of the second terrace. Thickness one hundred and twenty feet or more. It holds a few large boulders and shells of *Leda truncata*—the latter uninjured and with the valves united.
3. *Boulder clay*, or hard gray till, with boulders and stones. Seen in a mill-sluice near the bridge, and estimated at twenty feet in thickness, at this place; though apparently increasing in thickness farther to the westward.
4. *Shales* of Lower Silurian age, seen in the bottom of the River near the bridge. They are smoothed over, but show no striæ, though they have numerous structure lines which might readily be mistaken for ice-striæ.

To the eastward of the mouth of Trois Pistoles River, the first terrace above-mentioned is brought out to the shore by a projecting point of rock. In proceeding westward toward Isle Verte, it recedes from the coast, leaving a flat of considerable breadth, which represents the lowest terrace seen on this part of the St. Lawrence, and is elevated only a few feet above the sea. This flat is in many places thickly strewn with large boulders, probably left when it was excavated out of the clay. In proceeding westward the first or railway terrace of Trois Pistoles, inland of the flat above mentioned, is seen to consist of Boulder-clay, either in consequence of this part of the deposit thickening in this direction, or of the Leda clay passing into Boulder-clay. It still, however, at Isle Verte, contains a few shells of *Leda truncata* in tough reddish clay holding boulders.

*Rivière-du-Loup and Cacouna.*—The country around Cacouna and Rivière-du-Loup rests on the shales, sandstones, and conglomerates of the Quebec and Potsdam groups of Sir W. E. Logan. As these rocks vary much in hardness, and are also highly inclined and much disturbed, the denudation to which they have been subjected has caused them to present a somewhat uneven surface. They form long ridges running nearly parallel to the coast, or north-east and south-west, with intervening longitudinal valleys excavated in the softer beds. One of these ridges forms the long reef off Cacouna, which is bare only at low tide; another, running close to the shore, supports the village of Cacouna; another forms the point which is terminated by the pier; a fourth rises into Mount Pilote; and a fifth stretches behind the town of Rivière-du-Loup.

The depressions between these ridges are occupied with Post-pliocene deposits, not so regular and uniform in their arrangement as the corresponding beds in the great plains higher up the St. Lawrence, but still presenting a more or less definite order of succession. The oldest member of the deposit is a tough Boulder-clay, its cement formed of gray or reddish mud derived from the waste of the shales of the Quebec group, and the stones and boulders with which it is filled partly derived from the harder members of that group, and partly from the Laurentian hills on the opposite or northern side of the river, here more than twenty miles distant. The thickness of this Boulder-clay is, no doubt, very variable, but does not appear to be so great as farther to the eastward.

Above the Boulder-clay is a tough clay with fewer stones, and above this a more sandy Boulder-clay, containing numerous boulders, overlaid by several feet of stratified sandy clay without boulders; while on the sides of the ridges, and at some places near the present shore, there are beds and terraces of sand and gravel, constituting old shingle beaches apparently much more recent than the other deposits.

All these deposits are more or less fossiliferous. The lower Boulder-clay contains large and fine specimens of *Leda truncata* and other deep-water and mud-dwelling shells, with the valves attached. The upper Boulder-clay is remarkably rich in shells of numerous species; and its stones are covered with Polyzoa and great Acorn-shells (*Balanus Hameri*), sometimes two inches in diameter and three inches high. The stratified gravel holds a few littoral and sub-littoral shells, which also occur in some places in the more recent gravel. On the surface of some of the terraces are considerable deposits of large shells of *Mya truncata*, but these are modern, and are the 'kitchen-middens' of the Indians, who in former times encamped here.

Numbers of Post-pliocene shells may be picked up along the shores of the two little bays between Cacouna and Rivière-du-Loup; but I found the most prolific locality to be on the banks of a little stream called the Petite Rivière-du-Loup, which runs between the ridge behind Cacouna and that of Mount Pilote, and empties into the bay between Rivière-du-Loup and the pier. In these localities I collected and noticed in my paper on this place* more than eighty species, about thirty-six of them not previously published as occurring in the Post-pliocene of Canada.

We have thus at Rivière-du-Loup indubitable evidence of a marine Boulder-clay, and this underlies the representative of the Leda clay, and rests immediately on striated rock surfaces—the striæ running north-east and south-west.

The Cacouna Boulder-clay is a somewhat deep-water deposit. Its most abundant shells are *Leda truncata*, *Nucula tenuis*, and *Tellina proxima*, and these are imbedded in the clay with the valves closed, and in as perfect condition as if the animals still inhabited them. At the time when they lived, the Cacouna ridges must have been reefs in a deep sea. Even Mount Pilote has huge Laurentian boulders high up on its sides, in evidence of this. The shales of the Quebec group were being wasted by the waves and currents; and while there is evidence that much of the fine mud worn from them was drifted far to the south-west to form the clays of the Canadian plains, other portions were deposited between the ridges, along with boulders dropped from the ice which drifted from the Laurentian shore to the north. The process was slow and quiet; so much so that in its later stages many of the boulders became encrusted with the calcareous cells of marine animals before they became buried in the clay. No other explanation can, I believe, be given of this deposit; and it presents a clear and convincing illustration, applicable to wide areas in Eastern America, of the mode of deposit of the Boulder-clay.

A similar process, though probably on a much scaller scale, is now going on in the Gulf. Admiral Bayfield has well illustrated the fact that the ice now raises, and drops in new places, multitudes of boulders, and I have noticed the frequent occurrence of this at present on the coast of Nova Scotia. At Cacouna itself, there is, on some parts of the shore, a band of large Laurentian boulders between half tide and low-water mark, which are moved

* *Canadian Naturalist*, April, 1865.

more or less by the ice every winter, so that the tracks cleared by the people for launching their boats and building their fishing-wears, are in a few years filled up. Wherever such boulders are dropped on banks of clay in process of accumulation, a species of Boulder-clay, similar to that now seen on the land, must result. At present such materials are deposited under the influence of tidal currents, running alternately in opposite directions; but in the older Boulder-clay period, the current was probably a steady one from the north-east, and comparatively little affected by the tides.

The Boulder-clay of Cacouna and Rivière-du-Loup, being at a lower level and nearer the coast than that found higher up the St. Lawrence valley, is probably newer. It may have been deposited after the beds of Boulder-clay at Montreal had emerged. That it is thus more recent, is farther shown by its shells, which are, on the whole, a more modern assemblage than those of the Leda clay of Montreal. In fossils, as well as in elevation, these beds more nearly resemble those on the coast of Maine. It would thus appear that the Boulder-clay is not a continuous sheet or stratum, but that its different portions were formed at different times, during the submergence and elevation of the country; and it must have been during the latter process that the greater part of the deposits now under consideration were formed.

The assemblage of shells at Rivière-du-Loup, is, in almost every particular, that of the modern Gulf of St. Lawrence, more especially on its northern coast. The principal difference is the prevalence of *Leda truncata* in the lower part of the deposit. This shell, still living in Arctic America, has not yet occurred in the Gulf of St. Lawrence, but is distributed throughout the lower part of the Post-pliocene deposits in the whole of Lower Canada and New England, and appears in great numbers at Rivière-du-Loup, not only in the ordinary form, but in the shortened and depauperated varieties which have been named by Reeve *L. siliqua* and *L. sulcifera.*

Of *Astarte Laurentiana*, supposed to be extinct, and which occurs so abundantly in the Post-pliocene at Montreal, few specimens were found, and its place is supplied by an allied but apparently distinct species, to be noticed in the sequel, which is still abundant at Gaspé and Labrador, and on the coast of Nova Scotia.

It must be observed that though the clays at Rivière-du-Loup are more recent than those of Montreal, they are still of considerable antiquity. They must have been deposited in water perhaps fifty fathoms deep, and the bottom must have been raised from that depth to its present level; and in the meantime the high cliffs now fronting the coast must have been cut out of the rocks of the Quebec group.

The order of succession of beds, as seen in the banks of the Little Rivière-du-Loup, may be stated as follows, in descending order:

1. Large Loose Boulders, mostly of Laurentian rocks, seen in the tops of ridges of rock and gravel. One angular mass of Quebec group conglomerate was observed ninety feet in circumference and ten to fifteen feet high. Near it was a rounded boulder of Anorthosite Felspar from the Laurentian, 13 feet long.

2. Stratified sand and gravel resting on the sides of the ridges of rock projecting through the drift. Thickness variable.

3. Stratified sandy clay and sand with *Tellina Grœnlandica* and *Buccinum*. 10 feet.

4. Gray clay and stones. *Rhynconella psittacea*, and *Terebratulina Spitzbergensis*, &c. 1 foot or more.

5. Gray clay with large stones, often covered with Bryozoa and Acorn-shells. *Tellina calcarea* very abundant, also *Leda truncata*. 3 feet.

6. Tough, hard, reddish clay, with stones and boulders, passing downward into Boulder-clay, and holding *Leda truncata*. 6 feet or more.

It was observable that the boulders were more abundant on the south side of the ridges than on the north; and between Rivière-du-Loup and Quebec there are numerous small ridges and projecting masses of rock rising above the clays, which generally show the action of ice on their N. E. sides; while the large boulders lying on the fields are seen to have their longer axes N. E. and S. W.

At the Petite Rivière-du-Loup the surface of the red clay (No. 6 above) was observed to have burrows of *Mya arenaria*, with the shells (of a deep-water form) still within them.

## VI.—*River St. Lawrence above Quebec, and Ottawa Valley.*

*Quebec and its Vicinity.*—The deposits at Beauport, near Quebec, were described by Sir C. Lyell in the Geological Transactions for 1839; and a list of their fossils was given, and was compared with those of Montreal in my paper of 1859. As exposed at the Beauport Mills, the Post-pliocene beds consist of a thick bed of Boulder-clay, on which rests a thin layer of sand with *Rhynconella psittacea* and other deep-water shells. Over this is a thick bed of stratified sand and gravel filled with *Saxicava rugosa* and *Tellina*. In a brook near this place, and also in the rising ground behind Point Levi, the deep-water bed attains to greater thickness, but does not assume the aspect of a true Leda clay. Above Quebec, however, the clays assume more importance; and between that place and Montreal are spread over all the low country, often attaining a great thickness, and not unfrequently capped with the Saxicava sand. At Cap a la Roche the officers of the Geological Survey have found a bed of stratified sand under the Leda clay. The Beauport deposit is evidently somewhat exceptional in its want of Leda clay, and this I suppose may have been owing to the powerful currents of water which have swept around Cape Diamond at the time of the elevation of the land out of the Post-pliocene sea. The layer of sand at the surface of the Boulder-clay is evidently here the representative of the Leda clay, and affords its characteristic fossils, while the stones projecting above the Boulder-clay are crusted with Bryozoa and Acorn-shells. At St. Nicholas, there is a sandy Boulder-clay, not unlike that of Rivière-du-Loup, which has afforded some very interesting fossils. It is stated in the Report of the Survey to be one hundred and eighty feet above the sea.

*Montreal.*—In the neighbourhood of Montreal very interesting exposures of the Post-pliocene beds occur, and with the terraces on the Mountain have been described in my papers of 1857 and 1859. I may here merely condense the leading facts, adding those more recently obtained.

An interesting section of the deposits is that obtained at Logan's Farm, which may be thus stated in descending order:

| | ft. | in. |
|---|---|---|
| Soil and sand, | 1 | 9 |
| Tough reddish clay, | 0 | 0½ |
| Gray sand, a few specimens of *Saxicava rugosa*, *Mytilus edulis*, *Tellina Grœnlandica*, and *Mya arenaria*, the valves generally united, | 0 | 8 |
| Tough reddish clay, a few shells of *Astarte Laurentiana, and Leda truncata*, | 1 | 1 |
| Gray sand, containing detached valves of *Saxicava rugosa*, *Mya truncata, and Tellina Grœnlandica:* also *Trichotropis borealis*, and *Balanus crenatus;* the shells, in three thin layers. | 0 | 8 |
| Sand and clay, with a few shells, principally *Saxicava* in detached valves. | 1 | 3 |
| Band of sandy clay, full of *Natica clausa*, *Trichotropis borealis*, *Fusus tornatus*, *Buccinun glaciale*, *Astarte Laurentiana*, *Balanus crenatus*, &c. &c., sponges and *Foraminifera*. Nearly all the rare and deep-sea shells of this locality occur in this band, | 0 | 3 |
| Sand and clay, a few shells of *Astarte* and *Saxicava*, and remains of sea-weeds with *Lepralia* attached; also *Foraminifera*,... | 2 | 0 |
| Stony clay (Boulder-clay). Depth unknown. | | |

In this section the greater part of the thickness corresponds to the Leda clay, which at this place is thinner and more fossiliferous than usual. Along the south-east side of the Mountain, and in the city of Montreal, the beds have been exposed in a great number of places, and are in the aggregate at least 100 feet thick, though the thickness is evidently very variable. The succession may be stated as follows:

1. *Saxicava Sand.*—Fine uniformly grained yellowish and gray silicious sand with occasional beds of gravel in some places, and a few large Laurentian boulders, *Saxicava*, *Mytilus*, &c., in the lower part. Thickness variable, in some places 10 feet or more.

2. *Leda Clay.*—Unctuous gray and reddish calcareous clay, which can be observed to be arranged in layers varying slightly in colour and texture. Some of these layers have sandy partings in which are usually Foraminifera and shells or fragments of shells. In the clay itself the only shells usually found are *Leda truncata* and a smooth deep-water form of *Tellina Grœnlandica;* but toward the

surface of the clay in places where it has not been denuded before the deposition of the overlying sand, there are many species of marine shells. A few large boulders are scattered through the Leda clay.

3. *Boulder-clay.*—Stiff gray stony clay or till, with large boulders and many glaciated stones, often of the same Trenton rocks which occur on the flanks of the Mountain. It is of great thickness, though it has been much denuded in places, and has not been observed to contain fossils. It is especially thick at the south and south-west sides of the Montreal Mountain.

The Montreal Mountain, like other isolated trappean hills in the great plain of the Lower St. Lawrence, presents a steep craggy front to the north-east, and a long slope or tail to the south-west; and in front of its north-east side is a bare rocky plateau of great extent, and at a height of rather more than 100 feet above the river. This plateau must have been produced by marine denudation of the solid mass of the Mountain in the Post-pliocene period, and proves an astonishing amount of this kind of erosive action in hard limestones interleaved with trap dykes, and which have been ground and polished with ice at the same time that the plateau was cut into the hill. By ice also must the debris produced by this enormous erosion have been removed, and piled along the more sheltered sides of the hill in the Boulder-clay.

With regard to the crag-and-tail attitude of Montreal Mountain, I have to observe that in large masses of this kind reaching to a considerable height, and rising above the Post-pliocene sea, the north-east or exposed side has been cut into steep cliffs, but in smaller projections of the surface over which the ice could grind, the exposed side is smoothed or "moutonnée," and the sheltered side is angular. A little reflection must show that this must be the necessary action of a sea burdened with heavy floating ice.

The most strongly marked terraces on the Montreal Mountain, are at heights of 470, 440, 386, and 220 feet above the sea, but there are less important intermediate terraces. On the highest of these, on the west side of the Mountain, over Cote des Neiges village, there is a beach with marine shells, and on the summit of the Mountain, at a height of about 700 feet, there are rounded surfaces, probably polished by ice, though no striation remains, and large Laurentian boulders, which must have been carried probably a hundred miles from the Laurentian regions to the north-east, and over the deep intervening valley of the St. Lawrence.

I have already, in the first part of this memoir, noticed the striation on rock surfaces at Montreal, and may merely add that it is often very perfect, and must have been produced by a force acting up the St. Lawrence valley from the north-east, and planing all the spurs of the Mountain on that side, while leaving the Mountain itself as a bare and rugged unglaciated escarpment. In the streets of Montreal the true Boulder-clay is often exposed in excavations, and is seen to contain great numbers of glaciated stones, most of which are of the hardened Lower Silurian shales and limestones of the base of the Mountain; and though no marine shells have been found, the sub-aquatic origin of the mass is evidenced by its gray unoxidised character, and by the fact that many of the striated stones at once fall to pieces when exposed to the frost, so that they cannot possibly have been glaciated by a sub-aerial glacier.

At the Glen brick-work, near Montreal, the Leda clay and underlying deposits have been excavated to a considerable depth, and present certain remarkable modifications. The section observed at this place is as follows:

| | ft. | in. |
|---|---|---|
| 1. Hard gray laminated clay, *Foraminifera* and *Leda*, in thin layers | 7 | 0 |
| 2. Red layer, in two bands | 0 | 6 |
| 3. Sandy clay | 1 | 0 |
| 4. Gray and reddish clay | 9 | 0 |
| 5. Hard buff sand, very fine and laminated | 15 | 0 |
| 6. Sand with layers of tough clay, holding glaciated stones, and very irregularly disposed | 4 | 0 |
| 7. Fine sand | 1 | 0 |
| 8. Gray sand, with rounded pebbles, and laminated obscurely and diagonally | 4 | 0 |
| 9. Fine laminated yellow sand | 3 | 0 |
| 10. Gravel | 0 | 4 |
| 11. Very irregular mass of laminated sand, with mud, gravel, stones and large boulders | 12 | 0 |
| | 56 | 10 |

The whole of these deposits except the Leda clay, are very irregularly bedded, and are apparently of a littoral character. They seem to shew the action of ice in shallow water before the deposition of the Leda clay. The only way of avoiding this conclusion would be to suppose that the underlying beds are really of the age of the Saxicava sand, and that the Leda clay has been placed above them by slipping fram a higher terrace; but I failed to see good evidence of this. A little farther west at the gravel pits dug in the terrace for railway ballast, a deep section is exposed showing at the top Saxicava sand, and below this a very thick bed of sandy clay with stones and boulders, constituting apparently a somewhat arenaceous and partially stratified equivalent of the Boulder-clay. A little above this place, at the Brick-works, the Saxicava sand is seen to rest on a highly fossiliferous Leda clay, which probably here intervenes between the two beds seen in contact nearer the edge of the terrace.

*Ottawa River.*—The Leda clay and Saxicava sand are well exposed on the banks of the Ottawa; and Green's Creek, a little below Ottawa City, has become celebrated for the occurrence of hard calcareous nodules in the clay, containing not only the ordinary shells of this deposit, but also well-preserved skeletons of the Capelin (*Mallotus*) of the Lump-sucker (*Cyclopterus*) and of a species of stickleback (*Gasterosteus*). Some of these nodules also contain leaves of land plants and fragments of wood, and a fresh-water shell of the genus Lymnea has also been found. At Packenham Mills west of the Ottawa, the late Sheriff Dickson found several species of land and fresh-water shells associated with Tellina Grœnlandica and apparently in the Saxicava sand. These facts evidence the vicinity of the Laurentian shore, and indicate a climate only a little more rigorous than that of Central Canada at present. They were noticed in some detail in my paper of 1866 in *The Canadian Naturalist*..

The marine deposits on the St. Lawrence are limited, as already stated, to the country east of Kingston; and the clays of the basin of the great lakes to the south-westward have, as yet, afforded no marine fossils. I have, however, just learned from Prof. Bell, of the Geological Survey, a discovery made by him in the past summer and which is of very great interest, namely that two hundred miles north of Lake Superior the marine deposits reappear. The details of this important discovery will be given in a forthcoming Report of the Geological Survey, and its theoretical significance will be referred to in the concluding part of this memoir.

In the above local details, I have given merely the facts of greatest importance, and may refer for many subordinate points to the papers catalogued in the introduction to this memoir, and to the reports of the Geological Survey of Canada.

## PART III.—REVISION OF POST-PLIOCENE FOSSILS OF CANADA.

The list of Post-pliocene fossils published previously to 1856, amounted to only about 26 species. In my papers published between that year and 1863, the number was raised to nearly 80. My lists were tabulated, along with some additional species furnished in MS, in the Report of the Geological Survey for 1863, the list there given amounting to 83 species, exclusive of Foraminifera. In my paper on the Post-pliocene of Rivière-du-Loup and Tadoussac, published in 1865, I added 38 species, and shall be able still farther to increase the number in the present revision, which will afford a very complete view of the subject up to the present time; and though additional species will no doubt be found, yet all the principal deposits have been so carefully explored that only very rare species can have escaped observation. For some of the additional species included in the present list, I am indebted to Mr. G. T. Kennedy of Montreal, Dr. Anderson of Quebec, and other friends, to whom reference will be made in connection with the several species in the catalogue.

## SUB-KINGDOM RADIATA.

### CLASS I.—PROTOZOA.

### (1) *Foraminifera.*

*Nodosaria (Glandulina) lævigata.*

——————————(Var. *Dentalina communis*)

Fossil—Leda clay, Montreal.

Recent—Gulf St. Lawrence, 30 to 300 fathoms, G.M.D.*

This species is very rare in the Post-pliocene, but sometimes of large size and of different varietal forms.

* The initials G. M. D., refer to the List of Foraminifera by Mr. G. M. Dawson in *The Canadian Naturalist*, 1870.

*Lagena Sulcata* —— (Var. *distoma.*)
———————— (Var. *semisulcata.*)

Fossil—Leda clay, Montreal; Quebec; Murray Bay; Rivière-du-Loup; Portland (Maine.)

Recent—Gulf St. Lawrence, 18 to 313 fathoms, G.M.D.

Rather rare in the Post-pliocene as well as in the recent.

*Entosolenia globosa.*
——————*costata.*
——————*marginata.*
——————*squamosa.*

Fossil—Montreal, Leda clay; Labrador; Rivière-du-Loup; Murray Bay; Quebec; Portland (Maine).

Recent—Gulf and River St. Lawrence, 20 to 313 fathoms. G. M. D.

Generally diffused in the Post-pliocene, and presenting the same range of forms as in the recent; but not common. I regard the supposed species of *Entosolenia* above named as merely varietal forms.

*Bulimina Presli.*
—————— (Var. squamosa)

Fossil—Montreal, Leda clay; Labrador; Rivière-du-Loup; Murray Bay; Quebec; Portland (Maine).

Recent—Gulf and River St. Lawrence, 10 to 313 fathoms, G. M. D.

Generally diffused in the Post-pliocene. In the recent it seems to be a deep-water form. What Parker and Jones call the essentially arctic form *B. elegantissima* is not uncommon, though other forms also occur.

*Polymorphina lactea.*

Fossil—Montreal, Leda clay; Labrador; Rivière-du-Loup; Murray Bay.

Recent—Gulf and River St. Lawrence, 30 to 313 fathoms. G. M. D.

Not uncommon in the Post pliocene, particularly in the deeper parts of the Leda clay. Less common recent. I observed in the Rivière-du-Loup gatherings a small individual of this species with the internal pipe at the aperture characteristic of Entosolenia, which is also sometimes observed in recent specimens.

*Truncatulina lobulata.*

Fossil—Leda clay, Labrador; Rivière-du-Loup.

Recent—Gulf St. Lawrence, very common 30 to 50 fathoms.

This species is much less common in the Post-pliocene than in the recent.

*Orbulina universa.*

Fossil—Leda clay, Montreal; Rivière-du-Loup; Labrador.

This may be regarded as a rare and somewhat doubtful Post-pliocene fossil. It has not yet been recognized in the Gulf of St. Lawrence.

*Globigerina bulloides.*

Fossil—Rivière-du-Loup.

Recent—Gulf St. Lawrence, more especially in the deeper water, where it is common. It is very rare in the Post-pliocene.

*Pulvinulina repanda.*

Fossil—Montreal, Leda clay; Rivière-du-Loup; Murray Bay; Labrador; Quebec; Portland (Maine).

Recent—Gulf St. Lawrence, 30 to 313 fathoms, G. M. D.

Somewhat rare both in the Post-pliocene and recent, and of the small size usual in the arctic seas.

*Polystomella crispa.*—(Var. *Striatopunctata*).
——————— (Var. *Arctica.*)

Fossil—Montreal, Leda clay; Labrador; Rivière-du-Loup; Murray Bay; Quebec; Portland (Maine); St. John, N. B.

Recent—Gulf and River St. Lawrence, 30 to 40 fathoms. G. M. D.

Very common, especially in depths of 10 to 40 fathoms. This is by far the most abundant species in the Post-pliocene deposits, as it is also in all the shallow parts of the Gulf of St. Lawrence at present, and also in the Arctic Seas, according to Parker and Jones. It is the only species yet found in the Boulder-clay of Montreal, and this very rarely.

*Nonionina scapha.*
———————(Var. *Labradorica.*)

Fossil—Leda clay, Montreal; Rivière-du-Loup; Labrador; Murray Bay; Quebec; St. John, N. B.

Recent—Gulf and River St. Lawrence, 10 to 313 fathoms. Var. *Labradorica* is the deeper water form and is rare in the Leda clay.

*Textularia pygmæa.*

Fossil—Leda clay, Labrador; Rivière-du-Loup; Quebec; also at Portland (Maine).

Recent—Gulf St. Lawrence, 10 to 30 fathoms.

The Textulariæ are rare and of small size, both in the Post-pliocene and recent.

*Cornuspira foliacea.*

Fossil—Leda clay, Montreal.

Recent—Gulf St. Lawrence, 16 to 250 fathoms, G. M. D.

This species is rare both fossil and recent.

*Quinqueloculina seminulum.*

Fossil—Leda clay, Montreal; Labrador; Quebec; Portland (Maine).

Recent—Gulf St. Lawrence, 10 to 313 fathoms, most abundant in shallow water. G. M. D.

This species is by no means common and not usually large in the Post-pliocene. It is more abundant in the clays of Maine than in those of Canada.

*Biloculina ringens.*

Fossil—Leda clay, Montreal; Labrador; Rivière-du-Loup; Murray Bay; Quebec.

Recent—Gulf St. Lawrence, 30 to 313 fathoms. G. M. D.

Rather rare in the Post-pliocene as well as in the recent.

*Triloculina tricarinata.*

Fossil—Leda clay, Rivière-du-Loup; Murray Bay; Quebec.

Recent—Gaspé, 30 to 50 fathoms. G. M. D.

Rare both in Post-pliocene and recent, but perhaps more generally diffused in the former.

*Lituola* and *Saccammina.*

A very few minute sandy forms referable to these genera are found among the finer part of the washings from Riviére-du-Loup.

*Euglypha?*

A single minute test, apparently identical in form with that of *Euglypha alveolata,* was found in washing the Rivière-du-Loup clays.

In general terms it may be stated that all the species of Foraminifera found in the Post-pliocene still inhabit the Gulf and River St. Lawrence. Several species found in the Gulf of St. Lawrence have not yet been recognized in the Post-pliocene, and these are mostly inhabitants of depths exceeding 90 fathoms, or among the more southern forms found in the Gulf.

On the whole, the assemblage, as in the northern part of the Gulf of St. Lawrence at present, is essentially arctic, and not indicative of very great depths.

The sandy forms which are not uncommon in the Gulf are very rare in the Post-pliocene; but this may be accounted for by the greater difficulty of washing them out of the clay, or possibly their cementing material may have decomposed, allowing them to fall to pieces. As the epidermal matter of shells is often preserved, the last supposition seems less likely. The Leda clays are, however usually very fine and calcareous, so that there was probably more material for calcareous than for arenaceous forms.

The Foraminifera are very generally diffused in the Post-pliocene clays, though much more abundant in some layers than in others. They may easily be detected by a pocket lens, and are usually in as fine preservation as recent specimens, especially in the deeper and more tenacious layers of the Leda clay. They are however, usually most abundant in the somewhat arenaceous layers near the top of the Leda clay, and immediately below the Saxicava sand, and especially where this layer contains abundance of shells of Mollusca. I have nowhere found them more abundant or in greater variety than at the Glen Brick-work, Montreal, on the McGill College Grounds, and at Logan's Farm. At the Glen Brick-work a few worn specimens of Polystomella are contained in the beds underlying the Leda clay and equivalent to the Boulder-clay, which, however, has in general, in the vicinity of Montreal as yet afforded no marine fossils.

In searching for Foraminifera in the clays of Rivière-du-Loup, I have observed in the finer washings several species of Diatomaceæ; among these a species of Coscinodiscus very frequent in the deeper parts of the Gulf of St. Lawrence. But on the whole Diatoms appear to be rare in these deposits. In the Rivière-du-Loup clays I have also observed the pollen grains of firs and spruces.

The nomenclature used above is that of Parker and Jones, in their paper on the North Atlantic Soundings, in the Transactions of the Royal Society. For figures of the species, I may refer to that memoir, and to my previous papers published in the *Naturalist.*

### (2) *Porifera.*

*Tethea Logani*, Dawson.

Leda clay, Montreal. This species has not yet been recognised in a living state, though allied to *Tethea hispida*, Bowerbank, of the coast of Maine. Its spicules in considerable masses, looking like white fibres, are not uncommon in the Post-pliocene at Montreal.

*Tethea ?*

Another silicious sponge is indicated by little groups of small spicules found at the Tanneries, near Montreal, by Mr. G. T. Kennedy, and at Riviere-du-Loup by the author. Its spicules are long and acerate, and much more slender than those of *Tethea Logani.* They resemble those of *T. hispida*, recent on the coast of Maine, and also those of a species of *Polymastia*, dredged by Mr. Whiteaves in the Gulf of St. Lawrence.

## Class II.—Anthozoa.

## Class III.—Hydrozoa.

No distinct organisms referable to the above groups have yet been found in the Post-pliocene deposits of Canada. As our recent fauna includes no stony coral, and the recent species of the Gulf of St. Lawrence have no parts likely to be preserved other than minute spicules, this is not to be wondered at. In washing the clays for Foraminifera, however, numerous fragments are obtained, which resemble portions of the horny skeletons of hydroids, though not in a state admitting of determination.

## Class IV.—Echinodermata.

### (1) *Ophiuridea.*

*Ophioglypha Sarsii*, Lutken.

Fossil—Leda clay, near St. John, N. Brunswick; Mr. Matthew.

Recent—River St. Lawrence, at Murray Bay; also found of large size in deep water in the Gulf of St. Lawrence, by Mr. Whiteaves.

*Ophiocoma.*

Fragments of a small species of ophiuroid starfish not determinable, have been found in the Leda clay at Montreal, and in nodules at Green's creek.

(2) *Echinoidea.*

*Euryechinus drobachiensis,* Müller.

Fossil—Leda clay, Beauport; Rivière-du-Loup; Montreal.

This species is rare in the Post-pliocene, but very common in all parts of the Gulf of St. Lawrence at present.

(3) *Holothuridea.*

*Psolus phantopus?* Oken.

Scales of an animal of this kind have been found in the Leda clay at Montreal. They may belong to *P. phantopus*, or to the species *P.* (*Lophothuria*) *Fabricii,* also found on our coasts.

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# ON THE ORIGIN AND CLASSIFICATION OF ORIGINAL OR CRYSTALLINE ROCKS.

By Thomas Macfarlane.

(*Continued from page* 312—Vol. V.)

## V.—MINERALOGICAL CONSTITUTION.

Having, in the foregoing, adverted to the texture and chemical composition of original rocks, it now becomes necessary to refer more particularly to their mineralogical constitution. In order to continue the analogy which has been shewn to exist between furnace slags and original rocks, it will be well here to refer to those instances which have been observed of the formation of well developed crystals in the cooling of artificial silicates. The rapid manner in which furnace slags are commonly allowed to cool is of course detrimental to the formation of any mineral-like aggregations, but it is sometimes possible to observe in copper furnace slags that, when they have been allowed to solidify in large blocks or cakes, they shew an actynolitic structure in their mass, often closely resemble hornblende rock, and very commonly contain cavities lined with the most beautiful crystals. The formation of pyroxene in slags from iron furnaces has been frequently observed and well authenticated. Nöggerath described augite crystals from the slags of the iron furnace of Olsberg near Bigge in Westphalia. Montefiori Levi analysed augites taken from the slags of the iron furnace at Augreé near Liege. Richter described and examined similar crystals from the iron works of Rufskberg in the Banat; Von Leonhard mentions acicular augite crystals in the iron furnace slags of Skis-hytta in Sweden. F. Sandberger describes similar occurences; and numerous others might here be mentioned. Mitscherlich and Berthier obtained by melting silica, lime, and magnesia together, in a charcoal crucible placed in a porcelain furnace, a mass possessing cleavage corresponding to the faces of augite, and the hollow cavities in which were crowded with the most beautiful crystals of that mineral. These are also of very common occurrence in the lava streams not only of extinct but of active volcanoes; and well-developed augite crystals have not unfrequently been ejected from their craters. Olivine has been observed in the slags of iron furnaces quite as frequently as augite, and it, as well as magnetite, is one of the commonest minerals in streams of basaltic lava. So is leucite, although it has not yet been produced artificially. Mitscherlich observed transparent six-sided tabular crystals of mica, and leaves of it several inches broad, in the cavities of old copper furnace slags near Garpenberg in Dalecarlia. Gurlt also mentions artificially formed mica, and it appears frequently in ancient and modern lava streams. With regard to felspar, Hausmann makes mention as early as 1810, of felspar crystals which had been formed in one of the Mansfield furnaces. In 1834 Herne found similar crystals in the copper furnace of Sangershausen after it had been blown out, and in the iron furnace of Josephshütte in the Hartz, they were also detected. In 1810 the formation of felspar crystals in glass works was first observed; and in 1848 Prechtl gave an account of their occurring in a mass of glass weighing 133⅓ lbs. which had been melted in the plate glass factory at Neuhaus. They were of various sizes, some an inch in length, with perfectly sharp edges. The formation of sanidine and other varieties of felspar, in lavas of recent age, is a matter of common occurrence. No instance is known of the production of quartz from artificial silicates, nor do those lavas of the present day which are highly siliceous, develope it in cooling. These solidify as vitreous uncrystalline masses, but many lavas of extinct volcanoes in the Andes and the Siebengebirge contain it in well-formed crystals, shewing that it must have crystallized out from the mass of the rock.

The number of minerals which enter into the constitution of rocks is very small compared with the number of the mineral species which are found described in the various treatises on mineralogy. Of the latter there are upwards of six hundred, but the great majority of these are rare minerals, occurring in veins or cavities, and not entering into the constitution of the rocks themselves. The number of minerals which are found in original rocks is still more limited, and if from it if we deduct the sparingly occurring, or so-called accessorial constituents. the number is reduced to twenty minerals, which may be called the essential constituents of original rocks. The following table gives their names and the silica contents of the extreme acid and basic varieties.

| *Mineral.* | *Percentage of Silica.* |
|---|---|
| Quartz | 100 —— |
| Orthoclase | 69 —62.75 |
| Oligoclase | 64.25—59.28 |
| Labradorite | 55.83—50 31 |
| Anorthite | 47.63—42.01 |
| Leucite | 58.10—53 50 |
| Nepheline | 45.31—43.50 |
| Potash mica | 51.73—43 47 |
| Magnesia mica | 44.63—36.17 |
| Hornblende | 60.60—37 84 |
| Pyroxene | 57.40—38.58 |
| Hypersthene | 51.35—— |
| Enstatite | 56.91—— |
| Diallage | 53.71—49.12 |
| Olivine | 44.67—36.30 |
| Magnetite | 00.00—— |

The separation of the minerals occurring in rocks into essential and accessorial constituents originated with German lithologists and may perhaps be regarded as arbitrary. In characterising the sixteen minerals just mentioned as *essential* constituents, we have however, to some extent, been guided by their chemical constitution. In the preceding chapter silicic acid, alumina, peroxide of iron, protoxide of iron, magnesia, lime, soda and potash were indicated as the essential chemical constituents of rocks; and only such minerals as contain these substances, and no others, as *essential ingredients*, have been admitted into the table. This mode of selection may perhaps be considered as arbitrary as any other, for it causes the exclusion of the mineral tourmaline, which sometimes appears to deserve the rank of an essential constituent.

Tourmaline, however, contains, besides some of the subtances just mentioned, boracic acid and fluorine, and, in its mode of occurrence, resembles such accessorial or accidental minerals as zircon, apatite, titanite and others. Garnet, corundum, epidote, cordierite and scapolite are rock minerals, containing no other chemical constituents than those above mentioned, but they have been excluded from our list because they resemble the accessorial constituents in the manner of their occurrence.

With regard to these essential minerals it is first to be remarked that the analyses which have been made of them are not, in every case, of such specimens as have actually formed part and portion of some rock species. To obtain pure specimens of the minerals of rocks is often a matter of great difficulty, and well-developed crystals from veins or geodes have been preferred for analysis to the generally amorphous particles of the same species which enter into the constitution of rocks. The composition of these minerals cannot, like that of well-crystallised artificial chemical compounds, be unequivocally expressed by chemical formulæ. Attempts, the most painstaking and persevering, have been made in this direction by mineralogists, and the result has only been to shew that, in the majority of cases, each analysis of the same species demands a different formula for expressing its composition in chemical equivalents. The composition of micas, augites and hornblendes is especially variable, and even with regard to the felspars it has been maintained that those of our list are not distinct or independent species but are mixtures of one with the other or with other supposed species, such as krablite, albite or adularia. It has therefore been considered best here to neglect their various assumed chemical formula and to regard principally their average chemical composition.

Certain differences in the composition of these minerals cause their subdivision into two different classes. The minerals of the first class are mostly silicates of alumina, lime, potash and soda, and *it may be called the felspathic class.* It includes, however, leucite and nepheline, which can scarcely be called felspars, and quartz, which, although of very different composition, nevertheless possesses lithological affinities connecting it closely with the acid felspars. The minerals of the second class also contain lime, but alumina and the alkalies are less frequent or absent altogether, being replaced by magnesia and protoxide of iron. They are generally of a more basic nature than the felspathic class, and the purely basic mineral magnetite may be placed, as lithologically related, along with them. The minerals of this class may therefore be called the basic essential constituents of rocks. We have thus the following classification of these essential rock minerals.

Class 1st.—Felspathic—Quartz, Orthoclase, Oligoclase, Labradorite, Anorthite, Leucite, Nepheline.

Class 2nd.—Basic—Potash mica, Magnesia mica, Hornblende, Pyroxene, Diallage, Enstatite, Hypersthene, Olivine, Magnetite.

The extent to which these minerals enter into the constitution of original rocks will be best seen by repeating here the general view given of the families of rocks, placing at the head of each column the names of the principal constituents.

### Table II.

General View of the Mineralogical Constitution of the families of Original Rocks.

| | *Basic Rocks.* | *Basic us Rocks* | *Neutral Rocks* | *Siliceous R'ks* | *Silicic Rocks.* |
|---|---|---|---|---|---|
| Felspathic Min'ls | Anorthite.... Nepheline ... | Oligoclase. Labradorite. Anorthite. Nepheline. | Orthoclase. Oligoclase. | Quartz Orthoclase Oligoclase. | Quartz. Orthoclase. |
| Basic Minerals .. | Pyroxene .... Olivine ...... Magnetite ... | Mag: mica. Hornblende. Pyroxene. Olivine. | Mag: mica. Hornblende. | Mag: mica. | Pot: mica. |
| I. Coarse and small-grained . | Anorthosite.. | Greenstone. | Syenite. | Granitite. | Granite. |
| II. Schistose .... | Basic schist.. | Greenstone schist. | Syenitic schist. | Gneiss. | Gneissite. |
| III. Slaty ....... | .............. | Greenstone slate. | Clay slate. | Siliceous slate. | Silicic Slate. |
| IV. Porphyritic.. | Augitic porphry. | Greenstone porphry. | Melaphyre. | Porphyrite. | Porphyry. |
| V. Variolitic .... | .............. | Variolite. | Var. basaltite | .............. | Spherulyte. |
| VI. Fine grained | Anhydrous basalt. | Trap. | Basaltite. | Eurite. | Felsite. |
| VII. Trachytic.. | Nephelinite. | Dolerite. | Andesite. | Trachyte. | Rhyolite. |
| VIII. Volcanic.. | Nephelinite lava. | Doleritic lava | Andesitic. | Trachytic lava. | Obsidian. |

It will be observed from this table that a certain degree of consistency is observed by the essential minerals in entering into the constitution of original rocks. Such acid minerals as quartz and orthoclase never occur in the basic rocks; nor, on the other hand, do we find augite or labradorite entering into the composition of siliceous granites or trachytes. Towards the basic extreme of chemical composition in rocks, the siliceous minerals diminish or disappear, and, towards the acid extreme, basic minerals act in the same way. This behaviour alone is sufficient to shew that the mineralogical constitution of a rock is not the result of accident, but mainly the consequence of the chemical nature of the plastic magna from which it resulted, an inference which is borne out by the varying composition of the minerals themselves.

It will be seen that at the heads of the columns the minerals have been arranged according to the classification already given. Now it would appear, with regard to the members of each of the classes which we have distinguished, that not only do they resemble each other in chemical composition but they seem to replace each other when they enter into the composition of original rocks. That is to say, the increase, in quantity, of one of them in a rock is generally accompanied by a decrease on the part of another member of the class,and generally of that member which most closely approaches the first in chemical composition. This appears to be well borne out by the table,and numerous examples of such substitutions might be cited. Thus hornblende replaces mica in granitite forming syenite; oligoclase replaces orthoclase in the passage from syenite to diorite; and diallage replaces pyroxene in that species of greenstone called gabbro. There are thus formed gradual transitions from one rock species to another in mineralogical constitution as well as chemical composition. In the subjoined table (III) the nature and manner of these transitions are exhibited. It will be seen that the distinctions already made as to the orders and families of rocks are kept steadily in view while at the same time an attempt is made to give a systematic arrangement of the different species of original rocks and their mutual relations.

## III.—Table showing the Mineralogical Constitution of the Species of Original Rocks.

| | *Basic non-felspathic Rocks.* | *Basic Rocks.* | *Basous Rocks.* | *Neutral Rocks.* | *Siliceous Rocks.* | *Silicic Rocks.* | *Silicic non-felspathic Rocks.* |
|---|---|---|---|---|---|---|---|
| Silica Contents. | | Below 49 p. c. | 49 to 56 p. c. | 56 to 63 p. c. | 63 to 70 p. c. | 70 p. c. & upw'ds. | |
| Essential felspathic constituents. | | Saussürite. Anorthite. Nepheline. | Oligoclase. Labradorite. | Orthoclase. Oligoclase. | Quartz. Orthoclase. Oligoclase. | Quartz. Orthoclase. | Quartz. |
| I. Coarse & small-grained | | | | | | | |
| with no basic constituents | | | Noryte. | Miascyte. | | Granitelle. | Quartzyte. |
| " Mica | | | Mica diorite. | Syenite. | Granityte. | Granite. | Greisen. |
| " Hornblende | Amphibotyte. | Corsyte. | Diorite. | | Hornb. Granityte. | | |
| " Pyroxene | Pyroxenyte. | Eukryte. | Diabase. | | | | |
| " DiallageorSwaragdite | Omphazyte. | Euphotide. | Gabbro. | | | | |
| " Hypersthene | | | Hyperyte. | | | | |
| " Enstatate | | Protobastyte. | | | | | |
| " Olivine | Dunyte. | | | | | | |
| " Magnetite | Magnetite. | | | | | | |
| II. Schistose | | | | | | | |
| with no basic constituents | | | | | | Granulite. | Quartz schist |
| " Mica | | | | Syenite schist. | Gneiss. | Gneissyte. | Mica schist. |
| " Hornblende | Hornb. Schist. | | Diorite schist. | | Syen. gneiss. | | |
| " Pyroxene | | | Diabase schist. | Argillyte. | | | |
| III. Slaty | | Green slate. | Aphanite slate. | | Siliceous slate. | Felsitic slate. | |
| IV. Porphyritic. | | | | Melaphyre. | | | |
| with no basic con. develp. | | | | Minette. | Porphyrite. | Felsitic porphy. | |
| with Mica separated | | | Kersantone. | Hornb Melaphyre | Mica porphyrite. | Mica porphyry. | |
| " Hornblende separated | | Anorthite porph. | Diorite porph. | Aug. Melaphyre. | Horn. porphyrite. | | |
| " Augite separated | | Augitic porph. | Diabase porph. | | | | |
| V. Variolitic | | | Variolyte. | | | Spherulyte. | |
| VI. Fine-grained. | | | | Basaltyte. | | | |
| Unasso'd with other rocks | | Basanyte. | Aphanyte. | | Euryte. | Felsyte. | |
| Asso. with dioritic rocks.. | | | Dior. aphanyte. | | | | |
| " diabase " | | | Diab. aphanyte. | | | | |
| " basaltic " | | Basalt. | Anamesyte. | | | | |
| VII. Trachytic. | | | | | | | |
| with no basic constituents | | | | Andesyte. | | Rhyolyte. | |
| " mica and hornblende | | | | Aug. Andesyte. | Trachyte. | Dacyte. | |
| " Augite | | Nephelinyte. | Doleryte. | | Aug. Trachyte. | | |
| " Augite and olivine | Lherzolyte. | Oliv. Nephelinyte | Ol. Doleryte. | | | | |
| VIII. Volcanic. | | | | | | | |
| Vitreous | | | | Aud. pumice. | Obsidian. | Silicic obsidian. | |
| Cavernous | | | | Aud. lava. | Pumice. | | |
| Scoriaceous | | Neph. lava. | Dol Lava. | | | | |

In preparing table III, the same care has been taken as with those already given to introduce no new terms, and to use the various names of the species only in the sense which at present is generally attached to them by petrologists. In a few instances, where such names have hitherto borne a too general or a more or less indefinite meaning, an attempt has been made to confine their application to one species. The name rhyolite is for instance used in a somewhat more restricted sense than that given it by its originator, and the very vague, generally condemned, but still much used or misused, name, melaphyre, is, as applied to a particular species, limited to those porphyrite rocks which are neutral in chemical composition and in which crystals of triclinic felspars only are developed. In some other cases, where the same species possessed several synonyms, a slightly different signification has been given to one, and generally the least used of them, in order to make it of use in our system. For instance, eurite and felsite have hitherto been synonymous. In our table the latter term is made to indicate the more silicic species of fine grained rocks. Such names of rocks as have been derived from those of minerals have their terminations, in accordance with Dana's suggestion, altered from *ite* to *yte*.

It will be observed that, in table III, the minerals of the felspathic class only are placed at the head of the vertical columns, while the other essential minerals have been placed under each variety of texture on the left hand side. The cause of this arrangement may here be stated. The felspars, being of very constant occurrence in original rocks, and being frequently difficult to determine, have not been much made use of in distinguishing species until quite recently. For instance, oligoclase very often can only be distinguished from orthoclase by an experienced mineralogist, and only an experienced chemist after a minute analysis, can distinguish between oligoclase, labradorite and anorthite in a compound rock. On the other hand the minerals of the other class possess very well marked physical characters, and the presence of one or other of them was readily detected by the earlier petrologists and made use of by them for characterising different rocks. Thus, mica, hornblende and olivine are very widely apart both as regards form, colour, hardness and fusibility. The only two minerals of the second and third classes which are difficult to distinguish from each other are hornblende and augite, and this is only the case in fine grained compound rocks. By giving prominence to each of these non-felspathic minerals and placing their names on the horizontal lines of our table, it becomes possible to shew at a glance the rocks which they form with the felspathic minerals named at the heads of the vertical columns, and the manner in which, by gradually replacing each other, they form the different species of original rocks. Thus it will be observed that among the schistose rocks the most basic is diabase schist; that the latter becomes diorite schist when hornblende replaces pyroxene; that the diorite schist, as its oligoclase is replaced by orthoclase. becomes syenite schist, and, as quartz makes its appearence and increases, syenitic gneiss is produced. At the next step in a silicic direction, mica replaces the hornblende, producing common gneiss, then when the mica disappears, granulite results. If, instead of the mica, the orthoclase disappears, mica schist is developed, and when from the latter rock the mica in greater part is withdrawn, it becomes quartz schist. The other varieties of texture, such as the porphyritic and trachytic, each exhibit a similar series of transitions, the most fully developed being the granular order. In the latter it becomes possible, by means of the peculiar arrangement of our table, to shew the mineralogical nature of each of the species of the complicated family of the greenstones. Diorite, gabbro, hyperyte, diabase and protobastyte rock are shewn to be respectively characterised by hornblende, diallage, hypersthene, pyroxene and enstatite in combination with various felspars. The great majority of original rocks contain some variety of felspar, but there are a few species in which that mineral is absent and which are called non-felspathic rocks. In order as far as possible to shew these also in our table, two columns have been added to it, one at each side. The right hand one shews the silicic, and the left hand the basic rocks void of felspar.

## VI.—ACCESSORIAL CONSTITUENTS.

Besides the minerals mentioned in the foregoing chapter as the essential constituents of crystalline rocks, there are others of less frequent and only accidental occurrence, which have been called by German lithologists the accessorial constituents. Among these such minerals are not included as are only found in the veins, cavities, or even joints enclosed in rocks. Only those which are found in intimate mechanical union with the essential constituents in the body of the rock itself are regarded as accessorial constituents. They are sometimes made up of the same common chemical components as the essential rock constituents, but much more frequently other and rarer elements enter into their composition. It is indeed almost exclusively from these accessorial minerals that many of the rare simple elements have been derived with which chemists alone have any intimate acquaintance. Thus glucinum, cerium, yttrium, lanthanium, columbium, tantalum, tungsten and zirconium are only found as components of accessorial rock constituents, while other elements, such as sulphur, phosphorus, boron, fluorine, chlorine, tin, copper, lead, chromium and titanium are frequently found in them, which but rarely occur in essential rock constituents. The following is a catalogue of the accessorial constituents of rocks, arranged according to Dana's system, which at the same time indicates briefly their chemical nature.

I. *Native elements.*

Gold.
Silver.
Mercury.
Iron.
Diamond.
Graphite.

II. *Sulphides, &c.*

Molybdenite.
Galena.
Blende.
Magnetic pyrites.
Iron pyrites.
Copper pyrites.
Skuterdite.
Cobaltite.
Leucopyrite.
Mispickel.

III. *Fluorides.*

Fluorite.
Fluocerite.

IV. *Anhydrous Oxides.*

Corundum.
Hematite.
Ilmenite.
Perofskite.
Spinelle.
Gahnite.
Chromite.
Chrysoberyl.
Tinstone.
Rutile.

V. *Anhydrous Silicates.*

1. Bi silicates.
Aegirite.
Acmite.
Spodumene.
Crocidolite.
Beryll.
Eudialite.

2. Uni silicates.
Leucophanite.
Wohlerite.
Phenakite.
Helvine.
Zircon.
Vesuvianite.
Melilite.
Epidote.
Saussurite.
Allanite.
Gadolinite.

Mosandrite.
Lievrite.
Cordierite.
Lepidolite.
Scapolite.
Meionite.
Dipyre.
Sodalite.
Haüyn.
Nobean.
Leucite.

3. Subsilicates.
Tourmaline.
Andalusite.
Cyanite.
Topaz.
Titanite.
Staurolite.

VI. *Tantalates, Columbates and Tungstates.*

Pyrochlore.
Tantalite.
Columbite.
Yttrotantalite.
Aeschinite.
Polycrase.
Polymignite.
Mengite.
Wolframite.

VII. *Phosphates.*

Apatite.
Monazite.
Tryphllite.

From this list it will be seen that the accidentally-occurring minerals in crystalline rocks are five times as numerous as the essential minerals. It is scarcely possible to take a general view of the list without noting not only the number of rare elements which are found among their components, but also the preponderance of bases in their composition. The number of subsilicates and unisilicates largely exceeds that of the bisilicates. The rare tantalates, columbates, &c., are exceedingly basic, while no less than ten consist exclusively of anhydrous oxides. Another peculiarity in the composition of the silicates among them is the presence of sesqui-oxides in large quantity. Epidote, lievrite and others are silicates of alumina and peroxide of iron, while andalusite, cyanite, topaz and many others contain the former base in great abundance.

With regard to their distribution among original rocks, it is to be remarked that by far the greater number are native to the coarse-grained and schistose series, and occur in largest quantity in their neutral or siliceous families. Granites and syenites are especially rich in them, a remarkable instance being the zircon syenite of Fredericksvaern in Norway, in which no less than fifty different minerals are found, among whose components there are nine rare elements. These accessorial minerals become less frequent in the porphyritic and trachytic rocks, until among modern lavas very few of them are to be found.

The following statement shews the distribution of the accessorial minerals among the various orders of original rocks:

*In coarse and small-grained rocks.*

Aegirite.
Aeschinite.
Acmite.
Allanite.
Analcime.
Andalusite.
Apatite.
Apophyllite.
Beryll.
Blende.
Calcspar.
Catapleiite.
Columbite.
Copper pyrites.
Cordierite.
Corundum.
Crocidolite.
Chrysoberyll.
Cyanite.
Diamond.
Epidote.
Eudnophite.
Eukolite.
Fluocerite.
Fluorite.
Gadolinite.
Gahnite.
Galena.
Gold.
Graphite.
Hematite.
Hypostilbite.
Ilmenite.
Iron pyrites.
Lepidolite.
Leucophane.
Magnetic pyrites.
Mengite.
Mercury.
Molybdenite.
Monazite.
Mosandrite.
Phenakite.
Pinite.
Polycrase.
Polymignite.
Prehnite.
Pyrochlore.
Rutile.
Saponite.
Saussurite.
Scapolite.
Silver.
Sodalite.
Spodumene.
Tantalite.
Thorite.
Tinstone.
Titanite.
Tourmaline.
Triphylite.
Tritonite.
Vesuvianite.
Wolframite.
Wöhlerite.
Yttrotantalite.
Zircon.

*In Schistose rocks.*

Andalusite.
Apatite.
Beryll.
Calcspar.
Cordierite.
Corundum.
Cyanite.
Dolomite.
Fluorite.
Graphite.
Hematite.
Iron pyrites.
Lepidolite.
Molybdenite.
Rutile.
Spinelle.
Staurolite.
Titanite.
Tourmaline.
Zircon.

*In Slaty Rocks.*

Chiastolite.
Chloritoid.
Damourite.
Dipyre.
Fahlunite.
Ottrelite.
Paragonite.
Sericite.
Staurolite.

*In Impalpable rocks.*

Hauyuite.
Ilmenite.
Iron.
Iron pyrites.
Magnetic pyrites.
Nepheline.
Noscan.
Sapphire.
Titanite.
Zircon.

*In Porphyritic rocks.*

Apatite.
Calcspar.
Crocidolite.
Delessite.
Epidote.
Fluorite.
Giesceckite.
Halloysite.
Iron pyrites.
Liebenerite.
Titanite.
Tourmaline.

*In Trachytic rocks.*

Apatite.
Faujasite.
Hauynite.
Hematite.
Iron pyrites.
Leucite.
Melilite.
Nepheline.
Nosean.
Sapphire.
Titanite.
Zircon.

With regard to the origin of these accessorial minerals it may be maintained that by far the greater number of those just mentioned have been developed during the solidification of the rocks containing them, and somewhat in advance of the essential constituents among which they are found. The evidence of this statement will, however, be given in the following chapter.

## VII.—ON THE ORDER IN WHICH THE CONSTITUENTS OF ORIGINAL ROCKS WERE DEVELOPED.

It cannot be assumed that, in the slow crystallisation of a rock from igneous fusion, its minerals were all developed at one and the same instant. On the contrary, many of them are found under circumstances which prove that, even after their formation, the mother magna still possessed some degree of plasticity, and many of the constituents of rocks are so associated and surrounded as fairly to lead to the conclusion that a certain order was maintained in their gradual developement.

The well-known phenomena of fractured crystals in original rocks first deserves mention in this connection. Felspar crystals are frequently found in granites, broken in two pieces, these fragments being displaced, and the space between them filled up with granitic substance. This is the case with the orthoclase crystals of the porphyry of Elba and of the quartz poryhyry of Ilmenan; with the sanidine in the trachyte of Drachenfels, and with the tourmaline of the granite of Winkelsdorf in Moravia. These phenomena serve to prove that the solidification of original rocks took place very gradually, and that their crystallisation was in progress long before they became completely consolidated.

Very many of the facts recorded regarding the occurrence of accessorial minerals in rocks go to prove that they were the first to separate from the fluid magma and assume their characteristic forms. Blum has observed that the long tourmaline crystals which occur in the chloritic schists and granites of Aschoffenburg and of Winkelsdorf in Moravia, and which are frequently found fractured, have their separated fragments frequently bent out of their proper direction and cemented together by mica. The proof here seems plain as to the formation of the tourmaline prior to that of the mica.* In the large grained granite of Bergstiege, near Ruhla in Thuringia, Senft has observed that the quartz partly surrounds the tourmaline and wholly surrounds the mica plates, and regards this occurrence as proving that the formation both of the tourmaline and of the mica preceded that of the quartz.† Very many instances have been observed which go to prove the formation of tourmaline prior to quartz, and not a few from which it may reasonably be inferred that it crystallised before both mica and felspar. In connection with the ore deposits of Scandinavia, mention is made of the occurrence of iron pyrites completely enclosed in a crystal of tourmaline. A similar relation has been observed in the case of garnet, which very frequently encloses in its crystals a kernel of magnetite. Garnet is, however, noted for enclosing many other minerals, quartz, mica, iron glance, vesuvian, epidote, copper pyrites, iron pyrites, galena, blende, and especially hornblende varieties, having been found in the interior of its crystals. According to Blum the orthoclase crystals of the porphyrite of the Baranco des las Angustias, on the Island of

* Zirkel, Petrographie I, C3.

† Die Krystallinische Felsgementheile, p. 512.

Palma, contain radiating particles of epidote which gradually merge into the mass of the orthoclase. This and similar instances can scarcely be explained otherwise than on the supposition that the formation of the epidote preceded that of the orthoclase. Other facts concerning the occurrence of epidote in syenitic rocks would seem to indicate that the formation of the hornblende preceded or took place contemporaneously with that of the epidote. Senft has observed, near Brotterode, staurolite crystals enclosed in transparent plates of mica, and G. Rose describes both staurolite and cyanite columns as occurring in a similar manner. According to Senft, tourmaline, garnet, staurolite and cyanite are very constant companions of potash mica in crystalline rocks, and most frequently occur bedded in it as well developed crystals, and when separated from the surrounding mass of mica, leave in it an accurately bounded, smooth sided and sharp angled impression of their several forms.*

The order of the formation of the minerals of granite has been a matter of frequent discussion, and the impression prevails that the mica preceded the formation of at least the quartz in that rock. Senft thus gives the result of his observations on this matter: "Potash mica shews itself most frequently associated "with amorphous quartz and with orthoclase; with the first "usually so that it lies imbedded in its mass, which would in- "dicate a later formation for the quartz; with the orthoclase, on "the contrary, frequently so that it appears to sit upon it, so "that one must regard the mica as the newest mineral. How- "ever, there are not wanting examples of the occurrence of mica "sitting upon the quartz, nor of others in which it appears so "evenly intermixed with fresh orthoclase that one must ascribe "to them a contemporaneous origin." †

Senft has also the following remark on the mutual relations of oligoclase and hornblende: "Where oligoclase occurs in very "distinct intermixture with crystals of hornblende, it, for the "most part, surrounds them, and, indeed, often completely encloses "them in its mass. This relation plainly indicates that although "both minerals were produced in one and the same original "magma, nevertheless, the hornblende was the first born, and the "oligoclase was obliged to produce itself out of that part of the "magma remaining after the formation of the hornblende."

* Felsgemengtheile, p. 707.

† Felsgemengtheile, p. 707.

The study of the manner and order of the formation of crystalline minerals in coarse-grained, compound crystalline rocks, has not, on the whole, had that attention which it deserves. On the other hand many of the results obtained in the microscopical examination of fine-grained original rocks have an important bearing upon this subject. Vogelsang* has described with the most painstaking accuracy his observations on the mutual relations of the minerals of many pitchstones, trachytes and porphyries. Mention must first be made of a very interesting phenomenon which he has detected in the microscopical structure of many trachytic and porphyritic rocks. This is called Fluidal-structure, and seems to have been discovered somewhat earlier and independently by E. Weiss.† This term is to be understood to denote such a position of the constituents of a rock relatively to each other, as to allow of the inference being drawn that a movement of the mass either as a whole or in its smallest parts, had taken place while the process of crystallisation or solidification was going on. Eight different illustrations of this phenomenon are given in the beautifully coloured plates accompanying Vogelsang's work. One of these shews a trachytic pitchstone from the Euganean hills magnified 100 times. In a brownish perfectly vitreous matrix there are found yellowish grains of glassy felspar, needles of hornblende and microscopical crystals of magnetite. The whole of the vitreous matrix is, besides, filled with small prismatic crystals which are sharply distinguishable from the dark ground. These, Vogelsang hesitates to declare to be felspars, and in the meantime, for convenience sake, terms them "microlites." These little crystals are quite frequent in many rocks, and it is possible to distinguish light and dark coloured microlites, the former being in all likelihood scapolites or felspars, the latter augites or hornblendes. The figure shews the position of these little crystals in relation to the larger ones above named, and it is easily observed that the former lie with their longest axes parallel to each other except in the neighbourhood of the larger crystals of felspar, hornblende and magnetite, around certain sides of which they crowd more closely than elsewhere. The drawing shews the effect of the

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* Beiträge zur Kemetuiss der Feldspath bildung, Haarlem, 1866.

† Vogelsang—Philosophie der Geologie und Microscopische Gesteins-studien—Bonn, 1867.

last movement of the mass at the moment of its final solidification. The observer can plainly see that this movement proceeded from right to left, crowded the microlites against the right sides of the larger previously formed crystals, and then carried them past these in the direction of the flow, namely, towards the left. The figure further shews that one large dark coloured crystal of hornblende had been broken into two pieces, and that the smallest of these, after the fracture, had been caused by the motion of the mass to assume a new position against the end of the larger piece. There can be no doubt, says Vogelsang, as to this fact, for each piece possesses a crystalline and a fractured end, and at the latter, in the larger piece, a crystal of magnetite is seen which corresponds exactly to a space visible in the broken end of the smaller piece. The crystal has evidently been broken at this weak place, and the pieces afterwards turned and pressed against each other. Sometimes the felspar crystals in this rock shew a light brown edge round the clear central mass of the crystal. When more strongly magnified, it becomes plain that the brown vitreous matrix has penetrated the crystal in innumerable places by the cleavage planes. In some crystals this only takes place to a certain depth; others are penetrated through and through by the matrix. Fluidal-structure, sometimes closely resembling that just described and sometimes considerably modified, has been observed by Vogelsang in the basalts of Unkel and Obercassel, in the lava of the island of Ischia, in the diabase of Weilburg on the Sahn, in the quartzose trachyte of Campiglia, in the black pitchstone of Zwickau, and in the quartzose porphyry of Wurtzen in Saxony. Another figure gives a representation of a part of the last named rock magnified 200 times. In this example the Fluidal-structure is not indicated by the position of crystals previously developed, but by a varied colouring which corresponds to differences of densities in the vitreous matrix. A similar appearance is frequently visible in window glass when its substance has not been rendered perfectly homogeneous in the manufacture. Through the whole of the matrix of this rock there are scattered very fine black points, but these are found much less frequently in the dark than in the light-coloured portions of the matrix.

Many of the facts observed by the naked eye, concerning the order of the formation of rock minerals, are confirmed by Vogelsang's researches with the microscope. Especially decided is the result as regards magnetite, which is invariably observed to be the oldest formed mineral in the more recent eruptive rocks, all the crystalline constituents of which enclose it. The felspars contained in trachytes, basalts, dolerites, and melaphyres, and the augites and hornblendes of the same rocks, all found the magnetite ready formed when their developement began, and enclosed it as their growth progressed. Even leucite and olivine, which are ordinarily free from foreign enclosures, are found to contain magnetite. On the other hand magnetite is seldom enclosed by quartz, but it is to be remembered that rhyolites very seldom carry the former mineral. In the matrices of many basalts, melaphyres and trachytes, which, in an undecomposed condition, present under the microscope a mass of microlites, the magnetite is found inserted between the needles and determining their limits. The andesite of Lowenburg in Siebengebirge shews, under the microscope, many of these phenomena clearly and distinctly.

In considering the observations that have been made on this subject one cannot avoid remarking that magnetite, tourmaline, and other basic accessory minerals, appear to have been the first to separate from the solidifying magma of crystalline rocks. After the very basic minerals the essential constituents seem to have been formed somewhat in the following order: 1st. Mica; 2nd. Hornblende; 3rd. Felspar; 4th. Quartz. It would, therefore, seem possible to recognise the operation of a definite law in the order of the separation of these minerals from their mother magma, namely, that the minerals of original rocks have crystallised out in the order of their basicity. Some facts, in support of the existence of such a law, are observable in connection with the composition of porphyritic rocks. Not unfrequently the felspar crystals found in these, and which we must suppose, in accordance with facts stated above, to have been produced previous to the solidification of their matrices, have a more basic composition than the latter, or, what amounts to the same thing, the composition of the matrices is more siliceous than that of the whole rock including the crystals. Thus, according to Laspeyres, the felsitic porphyry of Mühlberg, near Halle, enclosing colourless sanidine, oligoclase, quartz and a little mica, contains 72.24 p. c. silica, while the dark greyish green matrix contains 74.41 p. c. Again, the porphyrite of Gänse-Schnabel, near Ilfeld, containing triclinic felspar and other crystals has a silica contents of 64.34 p.c. The homogeneous, nearly infusible matrix of the same rock contains 67.36 p.c. of silica. The labradorite porphyrite of Mühlenthal, near Elbingerode in the Hartz, possesses a black, very fresh and hard matrix, which encloses undecomposed very lustrous crystals of labradorite, and a dark green or black augitic or hornblendic mineral. The labradorite contains 51.11 p.c. silica, while the whole rock, in spite of the presence of the, doubtless more basic, black mineral, contains 57.57 p.c. silica. On the other hand, in many porphyries and rhyolites distinct quartz crystals are developed, which, of course, must be more acid than the enclosing matrix. In spite of this exception, the law above referred to still applies so far as regards the minerals developed in crystalline rocks or separated out from their matrices during solidification.

### VIII.—SPECIFIC GRAVITY.

It has been already remarked that in general the specific gravity of original rocks decreases with the increase of silica and increases with the decrease in quantity of the same substance; the most acid rocks are specifically the lightest, the most basic rocks are specifically the heaviest. Abich was the first to call attention to this as exhibited among the volcanic rocks, and to shew the conclusions which might be drawn regarding the silica contents of these rocks from their ascertained specific gravities. Although the same relation has been observed to exist among the granitic and porphyritic rocks, and doubtless runs through all the orders, it has not been found that a certain specific gravity invariably corresponds to a certain degree of silicification or that, for instance, because a syenite containing 59.83 p.c. of silica has a specific gravity of 2,730, a trachyte having the same silica contents will have the same specific gravity. On the contrary we find decided differences as to specific gravity in rocks of similar composition, but belonging to different orders of texture. The following table shews the average specific gravity of the various families of granular, porphyritic and trachytic rocks:

| | GRANULAR. | PORPHYRITIC. | TRACHYTIC. |
|---|---|---|---|
| Hypersilicic rocks with over 77 p.c. silica. | Pegmatites below 2,6 | Quartz porph. below 2.6 | Q. trachyte below 2.57 |
| Silicic...70 to 77 p.c. silica | Granites.. 2.65 to 2.6 | Porphyry... 2.65 to 2.6 | Rhyolite ... 2.62 to 2.57 |
| Siliceous 63 to 70 " | Granitites 2.72 to 2.65 | Porphyrite.. 2.75 to 2.65 | Trachyte ... 2.7 to 2.62 |
| Neutral. 56 to 63 " | Syenites.. 2.8 to 2.72 | Melaphyre.. 2.8 to 2.75 | Andesite ... 2.8 to 2.7 |
| Basous.. 49 to 56 " | Gr'nstones 3.0 to 2.8 | Gr, porphyry 2,9 to 2.8 | Dolerite.... 2.86 to 2.8 |
| Basic ... 42 to 49 " | Anorthosyte 2.9 to 3. | Aug.porphyry 2.7 to 2,9 | Nephelinite, 2,6 to 2.86 |

It will be observed from this table that the specific gravity of granular rocks is generally greater than that of the trachytic rocks which correspond with them in degree of acidity; granites are heavier than rhyolites, and greenstones than dolerites. (The rule does not hold good when applied to the basic rocks, but this may be owing to the facility with which they become decomposed and absorb water, which causes a material diminution of gravity.) The porphyritic rocks seem to occupy a position between the other two series, being neither so dense, relatively, as the granular nor so light as the trachytic rocks. This would seem to indicate that the coarsely granular rocks crystallised more slowly and perfectly than the porphyries and the latter more than the trachytes. This difference in density between rocks having the same percentage of silica is even more observable between trachytic and vitreous rocks. Obsidian has invariably a much less specific gravity than a quartzose trachyte which possesses the same percentage of silica. Thus we have the specific gravity of

| | | |
|---|---|---|
| Rhyolite from Palmarola | with 74.54 p. c. Si. $O_2$ | = 2·529 |
| Obsidian from Lipari | with 74.05 " | = 2.370 |
| Quartz trachyte from Besobdal, Asia Minor, | with 76.56 " | = 2.656 |
| Obsidian from Little Ararat | with 77.27 " | = 2.394 |

The cause of the difference seems merely to be that while the rhyolites cooled slowly and shrank together to a denser mass, the obsidians are quickly cooled unannealed natural glasses. It is well known that garnet, vesuvianite, orthoclase, labradorite, augite, and olivine have their densities much decreased by being fused and quickly cooled, and the same thing has been remarked with regard to rocks. St. Claire Deville, and Delesse experimented on several rocks, and found that their specific gravities were diminished after fusion. St. Claire Deville's results were as follows:

| | Specific Gravities before fusion. | Specific Gravities after fusion. |
|---|---|---|
| Vitreous lava from the Peak of Teneriffe...... | 2.570 | 2.464 |
| Trachyte from Chahorra.................... | 2.727 | 2.617 |
| Basaltic lava from the Peak of los Majorquines | 2.945 | 2.836 |
| Basalt from Pic de Foga, Cape of Good Hope.. | 2.971 | 2.879 |
| Granite from Andoux...................... | 2.662 | 2.360 |

Delesse found the loss to be less with fine-grained and semi-vitreous rocks than with those of a distinctly crystalline character. According to his results, if the rocks experimented on be arranged according to the degree of diminution which their specific gravities undergo in fusion, beginning with those which experience greatest loss, those rocks will be found at the head of the list which are commonly considered to be the oldest in age. Delesse found the following per centages of diminution, the specific gravity of the various rocks before fusion being regarded as = 100.

| | | |
|---|---|---|
| Granite, granulite and quartz porphyry | 9—11 | p. c. |
| Syenitic granite, and syenite | 8— 9 | " |
| Porphyry with orthoclase and oligoclase, with and without quartz | 8—10 | " |
| Diorite and diorite porphyry | 6— 8 | " |
| Melaphyre | 5— 7 | " |
| Basalt, trachyte, and old volcanic rocks | 3— 5 | " |
| Lavas and volcanic rocks | 0— 4 | " |

As early as 1841, Gustav Bischof made observations on the comparative volumes of Basalt, Trachyte and Granite in their crystalline, melted, and vitreous conditions, with the following results :

| | Volume in vitreous condition. | in crystalline. |
|---|---|---|
| Basalt | 1 | 0.9298 |
| Trachyte | 1 | 0.9214 |
| Granite | 1 | 0 8420 |

| | Volume in a fluid state. | in crystalline. |
|---|---|---|
| Basalt | 1 | 0.8960 |
| Trachyte | 1 | 0.8187 |
| Granite | 1 | 0.7431 |

Nothing can be more obvious from these data and experiments than that original rocks in cooling, solidifying and crystallising, underwent contraction, increasing thereby their density, and that the amount of contraction was the greater the more thoroughly and coarsely crystalline the rock, and the earlier the dates of its eruption in the geological history of the earth. It is not customary in treating of eruptive rocks usually to entertain any very definite ideas as to their age, but it ought not to be forgotten that the geological experience of Europe has shewn that they made their appearance on the earth's surface somewhat in the same order as they occupy in Table III. It would therefore seem that those rocks which have experienced most perfect crystallisation and the greatest amount of contraction or increase of density during that process are the oldest in geological age, that those which have crystallised imperfectly and experienced but a moderate amount of contraction, belong to the middle age of geological history, and that those which have solidified quickly to a semi-vitreous condition, and have experienced in so doing scarcely any contraction, are exactly those which are the most recent, and have been denominated volcanic rocks. Such results ought not to surprise us, but ought rather to be anticipated if the theory of the original igneous fluidity of the globe be well founded. The enormous degree of heat, which only could have occasioned such a condition, could not have disappeared suddenly. A gradual decrease of temperature must have taken place from the time when the solidification of the earth began down to recent geological periods. It follows that this gradually decreasing temperature must have had more or less influence upon the cooling of the various rocks protruded through the earth's crust during different geological ages. Those which appeared in earlier periods must have cooled when the earth's temperature was very high, and must therefore have enjoyed the most favorable conditions for slow and perfect crystallization and great contraction of volume, while on the other hand, those which were erupted in later ages must have appeared at a time when the temperature had much diminished, and consequently they must have solidified much more rapidly, crystallised much more imperfectly, and experienced less increase of density than their predecessors. Thus there can be distinctly traced a very decided connection between the universally accepted theory of the earth's original fluid condition and many of the facts which have been here stated with regard to the density of original rocks.

But although, generally, definite relations can be shewn to exist between the age and texture of rocks, it is not to be supposed that this is invariably the case, that there are no exceptions to the rule. It is not to be forgotten that other conditions besides the temperature of the earth's surface may have exerted their influence. Thus it is frequently the case that veins or dykes of diorite have in the centre a distinctly compound texture, while toward the sides they become almost impalpable. Then again beds of basaltite are often seen to be in the upper part and at the bottom fine-grained and compact, while in the middle they are small-grained and variolitic in texture. It is also frequently to be observed that masses of granite distinctly granular in the centre, assume towards the periphery a schistose texture, the direction of which is most generally parallel to the line of junction with the neighbouring rock. Thus it appears that in the solidification of a rock, the space which it occupied, the pressure to which it was exposed, the temperature of the enclosing rocks at the time of eruption, and the circumstances under which it was erupted, whether, for instance, on land or under water, must have influenced more or less its resulting density as well as its texture.

# HISTORY OF THE NAMES CAMBRIAN AND SILURIAN IN GEOLOGY.

By T. Sterry Hunt, LL.D., F.R.S.

It is proposed in the following pages to give a concise account of the progress of investigation of the lower paleozoic rocks during the last forty years. The subject may naturally be divided into three parts: 1. The history of Silurian and Upper Cambrian in Great Britain from 1831 to 1854; 2. That of the still more ancient paleozoic rocks in Scandinavia, Bohemia, and Great Britain up to the present time, including the recognition by Barrande of the so-called primordial paleozoic fauna; 3. The history of the lower paleozoic rocks of North America.

## I. Silurian and Upper Cambrian in Great Britain.

Less than forty years since, the various uncrystalline sedimentary rocks beneath the coal-formation in Great Britain and in continental Europe were classed together under the common name of graywacke or grauwacké, a term adopted by geologists from German miners, and originally applied to sandstones and other coarse sedimentary deposits, but extended so as to include associated argillites and limestones. Some progress had been made in the study of this great Graywacke formation, as it was called, and organic remains had been described from various parts of it; but to two British geologists was reserved the honor of bringing order out of this hitherto confused group of strata, and establishing on stratigraphical and paleontological grounds a succession and a geological nomenclature. The work of these two investigators was begun independently and simultaneously in different parts of Great Britain. In 1831 and 1832, Sedgwick made a careful section of the rocks of North Wales from the Menai Strait across the range of Snowdon to the Berwyn hills, thus traversing in a south-eastern direction Caernarvon, Denbigh and Merionethshire. Already, he tells us, he had in 1831, made out the relations of the Bangor group, (including the Llanberris slates and the overlying Harlech grits,) and showed that the fossiliferous strata of Snowdon occupy a synclinal, and are stratigraphically several thousand feet above the horizon of the latter. Following up this investigation in 1832, he established the great Merioneth anticlinal, which brings up the lower rocks on the south-east side of Snowdon, and is the key to the structure of North Wales. From these, as a base, he constructed a section along the line already indicated, over Great Arenig to the Bala limestone, the whole forming an ascending series of enormous thickness. This limestone in the Berwyn hills is overlaid by many thousand feet of strata as we proceed eastward along the line of section, until at length the eastern dip of the strata is exchanged for a westward one, thus giving to the Berwyn chain, like that of Snowdon, a synclinal structure. As a consequence of this, the limestone of Bala re-appears on the eastern side of the Berwyns, underlaid as before by a descending series of slates and porphyries. These results, with sections, were brought before the British Association for the Advancement of Science at its meeting at Oxford, in 1832, but only a brief and imperfect account of the communication of Sedgwick on this occasion appears in the Proceedings of the Association. He did not at this time give any distinctive name to the series of rocks in question. [L. E. & D. Philos. Mag. [1854] IV, viii, 495.]

Meanwhile, in the same year, 1831, Murchison began the examination of the rocks on the river Wye, along the southern border of Radnorshire. In the next four years he extended his researches through this and the adjoining counties of Hereford and Salop, distinguishing in this region four separate geological formations, each characterized by peculiar fossils. These formations were moreover traced by him to the south-westward across the counties of Brecon and Caermarthen; thus forming a belt of fossiliferous rocks stretching from near Shrewsbury to the mouth of the river Towey, a distance of about 100 miles along the north-west border of the great Old Red sandstone formation, as it was then called, of the west of England.

The results of his labors among the rocks of this region for the first three years were set forth by Murchison in two papers presented by him to the Geological Society of London in January, 1834. [Proc. Geol. Soc. II., 11.] The formations were then named as follows in descending order: 1. Ludlow, 2. Wenlock, constituting together an upper group; 3. Caradoc, 4. Llandeilo (or Builth) forming a lower group. The Llandeilo formation, according to him, was underlaid by what he called the Longmynd and Gwastaden rocks. The non-fossiliferous strata of the Longmynd hills in Shropshire were described as rising up to the east from beneath the Llandeilo rocks; and as appearing again in South Wales, at the same geological horizon, at Gwastaden in Breconshire, and to the west of Llandovery in Caermarthenshire; constituting an underlying series of contorted slaty rocks many thousand feet in thickness, and destitute of organic remains. The position of these rocks in South Wales was, however, to the north-west, while the strata of the Longmynd, as we have seen, appear to the east of the fossiliferous formations.

In the *Philosophical Magazine* for July, 1835, Murchison gave to the four formations above named the designation of Silurian, in allusion, as is well known, to the ancient British tribe of the Silures. It now became desirable to find a suitable name for the great inferior series, which, according to Murchison, rose from beneath his lowest Silurian formations to the north-west, and appeared to be widely spread in Wales. Knowing that Sedgwick had long been engaged in the study of these rocks, Murchison, as he tells us, urged him to give them a British geographical name. Sedgwick accordingly proposed for this great series of Welsh rocks, the appropriate designation of Cambrian, which was at once adopted by Murchison for the strata supposed by him to underlie his Silurian system. [Murchison, Anniv. Address, 1842; Proc. Geol. Soc. III., 641.] This was almost simultaneous with the giving of the name of Silurian, for in August, 1835, Sedgwick and Murchison made communications to the British Association at Dublin on Cambrian and Silurian Rocks. These, in the volume of Proceedings (pp. 59, 60) appear as a joint paper, though from the text they would seem to have been separate. Sedgwick then described the Cambrian rocks of North Wales as including three divisions: 1. The Upper Cambrian which occupies the greater part of the chain of the Berwyns, where, according to him, it was connected with the Llandeilo formation of the Silurian. To the next lower division, Sedgwick gave the name of Middle Cambrian, making up all the higher mountains of Caernarvon and Merionethshire, and including the roofing-slates and flagstones of this region. This middle group, according to him, afforded a few organic remains, as at the top of Snowdon. The inferior division, designated as Lower Cambrian, included the crystalline rocks of the south-west coast of Caernarvon and a considerable portion of Anglesea, and consisted of chloritic and micaceous schists, with slaty quartzites and subordinate beds of serpentine and granular limestone; the whole without organic remains.

These crystalline rocks were, however, soon afterwards excluded by him from the Cambrian series, for in 1838 [Proc. Geol. Soc. II, 679] Sedgwick describes further the section from the Menai Strait to the Berwyns, and assigns to the chloritic and micaceous schists of Anglesea and Caernarvon a position inferior to the Cambrian, which he divides into two parts; viz., Lower Cambrian, comprehending the old slate series, up to the Bala limestone beds; and Upper Cambrian, including the Bala beds and the strata above them in the Berwyn chain, to which he gave the name of the Bala group. The dividing line between the two portions was subsequently extended downwards by Sedgwick to the summit of the Arenig slates and porphyries. The lower division was afterwards subdivided by him into the Bangor group, (to which the name of Lower Cambrian was henceforth to be restricted,) including the Llanberris roofing-slates and the Harlech grits or Barmouth sandstones; and the Festiniog group, which included the Lingula-flags and the succeeding Tremadoc slates.

In the communication of Murchison to the same Dublin meeting, in August, 1835, he repeated the description of the four formations to which he had just given the name of Silurian; which were, in descending order, Ludlow and Wenlock (Upper Silurian), and Caradoc and Llandeilo (Lower Silurian). The latter formation was then declared by Murchison to constitute the base of the Silurian system, and to offer in many places in South Wales distinct passages to the underlying slaty rocks, which were, according to him, the Upper Cambrian of Sedgwick.

Meanwhile, to go back to 1834, we find that after Murchison had, in his communication to the Geological Society, defined the relation of his Llandeilo formation to the underlying slaty series, but before the names of Silurian and Cambrian had been given to these respectively, Sedgwick and Murchison visited together the principal sections of these rocks from Caermarthenshire to Denbighshire. The greater part of this region was then unknown to Sedgwick, but had been already studied by Murchison, who interpreted the sections to his companion in conformity with the scheme already given; according to which the beds of the Llandeilo were underlaid by the slaty rocks which appear along their north-western border. When, however, they entered the region which had already been examined by Sedgwick, and reached the section on the east side of the Berwyns, the fossiliferous beds of Meifod were at once pronounced by Murchison to be typical Caradoc, while others in the vicinity were regarded as Llandeilo. The beds of Meifod had, on paleontological grounds, been by Sedgwick identified with those of Glyn Ceirog, which are seen to be immediately overlaid by Wenlock rocks. These determinations of Murchison were, as Sedgwick tells us, accepted by him with great reluctance, inasmuch as they involved the upper part of his Cambrian section in most perplexing difficulties. When however, they crossed together the Berwyn chain to Bala, the limestones in this locality were found to contain fossils nearly agreeing with those of the so-called Caradoc of Meifod. The examination of the section here presented showed, however, that these limestones are overlaid by a series of several thousand feet of strata bearing no resemblance either in fossils or in physical characters to the Wenlock formation which overlies the Caradoc beds of Glyn Ceirog. This series was, therefore, by Murchison supposed to be identical with the rocks which, in South Wales, he had placed beneath the Llandeilo, and he expressly declared that the Bala group could not be brought within the limits of his Silurian system. It may here be added that in 1842 Sedgwick re-examined this region, accompanied by that skilled paleontologist, Salter, confirming the accuracy of his former sections, and showing moreover by the evidence of fossils that the beds of Meifod, Glyn Ceirog and Bala are very nearly on one parallel. Yet, with the evidence of the fossils before him, Murchison, in 1834, placed the first two in his Silurian system, and the last deep down in the Upper Cambrian; and consequently was aware that on paleontological grounds it was impossible to separate the lower portion of his Silurian system from the Upper Cambrian of Sedgwick. (These names are here used for convenience, although we are speaking of a time when they had not been applied to designate the rocks in question.)

This fact was repeatedly insisted upon by Sedgwick, who, in the Syllabus of his Cambridge lectures, published very early in 1837, enumerated the principal genera and species of Upper Cambrian fossils, many of which were by him declared to be the same with those of the Lower Silurian rocks of Murchison. Again, in enumerating in the same Syllabus the characteristic species of the Bala limestone, it is added by Sedgwick: "all of which are common to the Lower Silurian system." This was again insisted upon by him in 1838 and 1841. [Proc. Geol. Soc. II, 679; III, 548.] It was not until 1840 that Bowman announced the same conclusion, which was reiterated by Sharpe in 1842. [Ramsay, Mem. Geol. Sur. III, part 2, page 6.]

In 1839, Murchison published his *Silurian System*, dedicated to Sedgwick, a magnificent work in two volumes quarto, with a separate map, numerous sections and figures of fossils. The succession of the Silurian rocks, as there given, was precisely that already set forth by the author in 1834, and again in 1835; being, in descending order, Ludlow and Wenlock, constituting the Upper Silurian, and Caradoc and Llandeilo (including the Lower Llandeilo beds or Stiper-stones), the Lower Silurian. These are underlaid by the Cambrian rocks, into which the Llandeilo was said to offer a transition marked by beds of passage. Murchison, in fact, declared that it was impossible to draw any line of separation either lithological, zoological or stratigraphical between the base of the Silurian beds (Llandeilo) and the upper portion of the Cambrian,—the whole forming, according to him, in Caermarthenshire, one continuous and conformable series from the Cambrian to the Ludlow. [Silurian System, pages 256, 358.] By Cambrian in this connection we are to understand only the Upper Cambrian or Bala group of Sedgwick, as appears from the express statement of Murchison, who alludes to the Cambrian of Sedgwick as including all the older slaty rocks of Wales, and as divided into three groups, but proceeds to say that in his present work (the Silurian System) he shall notice only the highest of these three.

Since January, 1834, when Murchison first announced the stratigraphical relations of the lower division of what he afterwards called the Silurian system, the aspect of the case had materially changed. This division was no longer underlaid, both to the east in Shropshire and to the west in Wales, by a great unfossiliferous series. His observations in the vicinity of the Berwyn hills with Sedgwick in 1834, and the subsequently published statements of the latter had shown, that this supposed older series was not without fossils; but on the contrary, in North Wales, at least, held a fauna identical with that characterising the Lower Silurian. Hence the assertion of Murchison in his *Silurian System*, in 1839, that it was not possible to draw any line of demarcation between them. The position was very embarrassing to the author of the *Silurian System*, and for the moment, not less so to the discoverer of the Upper Cambrian series. Meanwhile, the latter, as we have seen, in 1842 re-examined with Salter his Upper Cambrian sections in North Wales, and satisfied himself of the correctness, both structurally and paleontologically, of his former determinations. Murchison, in his anniversary address as President of the Geological Society in 1842, after recounting, as we have already done, the history of the naming by Sedgwick in 1835, of the Cambrian series, which Murchison supposed to underlie his Silurian system, proceeded as follows: "Nothing precise was then known of the organic contents of this lower or Cambrian system except that some of the fossils contained in its upper members in certain prominent localities were published Lower Silurian species. Meanwhile, by adopting the word Cambrian, my friend and myself were certain that whatever might prove to be its zoological distinctions, this great system of slaty rocks being evidently inferior to those zones which had been worked out as Silurian types, no ambiguity could hereafter arise. * * * In regard, however, to a descending zoological order it still remained to be proved whether there was any type of fossils in the mass of the Cambrian rocks different from those of the Lower Silurian series. If the appeal to nature should be answered in the negative, then it was clear that the Lower Silurian type must be considered the true base of what I had named the protozoic rocks; but if characteristic new forms were discovered, then would the Cambrian rocks, whose place was so well established in the descending series, have also their own fauna, and the paleozoic base would necessarily be removed to a lower horizon." If the first of these alternatives should be established, or in other words, if the fauna of the Cambrian rocks was found to be identical with that of the Lower Silurian, then, in the author's language, "the term Cambrian must cease to be used in zoological classification, it being, in that sense, synonymous with Lower Silurian." That such was the result of paleontological inquiry, Murchison proceeded to show by repeating the announcements already made by Sedgwick in 1837 and 1838, that the collections made by the latter from the great series of fossiliferous strata in the Berwyns, from Bala, from Snowdon and other Cambrian tracts, were identical with the Lower Silurian forms. These strata, it was said, contain throughout "the same forms of Orthis which typify the Lower Silurian rocks." It was farther declared by Murchison in this address, that researches in Germany, Belgium and Russia led to the conclusion that the "fossiliferous strata characterized by Lower Silurian Orthidæ are the oldest beds in which organic life has been detected." [Proc. Geol. Soc. III, 641, et seq.] The Orthids here referred to are, according to Salter, *Orthis calligramma*, Dalm, and its varieties. [Mem. Geol. Survey III, part 2, 335–337.]

Meanwhile Sedgwick's views and position began to be misrepresented. In 1842, Mr. Sharpe, after calling attention to the fact that the fossils of the Bala limestone were, as Sedgwick had long before shown, identical with those of Murchison's Lower Silurian, declared that Sedgwick had placed the Upper Cambrian, in which the Bala beds were included, beneath the Silurian, and that this determination had been adopted by Murchison on Sedgwick's authority. [Proc. Geol. Soc. IV, 10.] This statement Murchison suffered to pass uncorrected in a complimentary review of Sharpe's paper in his next annual address (1843). In his *Siluria*, 1st edition, page 25, (1854) he speaks of the term Cambrian as applied (in 1835) by Sedgwick and himself "to a vast succession of *fossiliferous* strata containing undescribed fossils, the whole of which were supposed to rise up from beneath well-known Silurian rocks. The Government geologists have shown that this *supposed* order of superposition was erroneous," &c. The italics are the author's. Such language, coupled with Mr. Sharpe's assertion noticed above, helped to fix upon Sedgwick the responsibility of Murchison's error. Although the historical sketch, which precedes, clearly shows the real position of Sedgwick in the matter, we may quote farther his own words: "I have often spoken of the great Upper Cambrian group of North Wales as inferior to the Silurian system, * * * * * on the sole authority of the Lower Silurian sections, and the author's many times repeated explanations of them before they were published. So great was my confidence in his work that I received it as perfectly established truth that his order of superposition was unassailable. * * * * I asserted again and again that the Bala limestone was near the base of the so-called Upper Cambrian group. Murchison asserted and illustrated by sections the unvarying fact that his Llandeilo flag was superior to the Upper Cambrian group. There was no difference between us until his Llandeilo sections were proved to be wrong." [Philos. Mag. IV, viii, 506.] That there must be a great mistake either in Sedgwick's or in Murchison's sections was evident, and the Government surveyors, while sustaining the correctness of those of Sedgwick, have shown the sections of Murchison to have been completely erroneous.

The first step towards an exposure of the errors of the Silurian sections is, however, due to Sedgwick and McCoy. In order better to understand the present aspect of the question it will be necessary to state in a few words some of the results which have been arrived at by the Government surveyors in their studies of the rocks in question, as set forth by Ramsay in the Memoirs of the Geological Survey. In the section of the Berwyns, the thin bed of about twenty feet of Bala limestone, which, (as originally described by Sedgwick) they have found outcropping on both sides of the synclinal chain, is shown to be intercalated in a vast thickness of Caradoc rocks; being overlaid by about 3,300 and underlaid by 4,500 feet of strata belonging to this formation. Beneath these are 4,500 feet additional of beds described as Llandeilo, which rest unconformably upon the Lingula-flags just to the west of Bala; thus making a thickness of over 12,000 feet of strata belonging to the Bala group of Sedgwick. A small portion of rocks referred to the Wenlock formation occupies the synclinal above mentioned. [Memoirs, III, part 2, 214, 222.] The second member, in ascending order, of the Silurian system, to which the name of Caradoc was given by him in 1839, was originally described by Murchison under the names of the Horderley and May Hill sandstone. The higher portions of the Caradoc were subsequently distinguished by the Government surveyors as the Lower and Upper Llandovery rocks; the latter (constituting the May Hill sandstone, and known also as the Pentamerus beds, being by them regarded as the summit of the Caradoc formation. In 1852, however, Sedgwick and McCoy showed from its fauna that the May Hill sandstone belongs rather to the overlying Wenlock than to the Caradoc formation, and marks a distinct paleontological horizon.

This discovery led the geological surveyors to re-examine the Silurian sections, when it was found by Aveline that there exists in Shropshire a complete and visible want of conformity between the underlying formations and the May Hill sandstone; the latter in some places resting upon the nearly vertical Longmynd rocks, and in others upon the Llandeilo flags, the Caradoc proper or Bala group, and the Lower Llandovery beds. Again, in

South Wales, near Builth, the May Hill sandstone or Upper Llandovery rests upon Lower Llandeilo beds; while at Noeth Grug the overlying formation is traced transgressively from the Lower Llandovery across the Caradoc to the Llandeilo. These important results were soon confirmed by Ramsay and by Sedgwick. [Ibid, 4, 236.] The May Hill sandstone often includes, near its base, conglomerate beds made up of the ruins of the older formation. To the north-east, in the typical Silurian country, it is of great thickness and continuity, but gradually thins out to the south-west.

There exists, moreover, another region where not less curious discoveries were made. About forty miles to the eastward of the typical region in South Wales appear some important areas of Silurian rocks. These are the Woolhope beds, appearing through the Old Red sandstone, and the deposits of Abberley, the Malverns and May Hill, rising along its eastern border, and covered along their eastern base by the newer Mesozoic sandstone. The rocks of these localities were by Murchison in his *Silurian System* described as offering the complete sequence. When however it was found that his Caradoc included two unconformable series, examination showed that there was no representative of the older Caradoc or Bala group in these eastern regions, but that the so-called Caradoc was nothing but the Upper Llandovery or May Hill sandstone. The immediately underlying strata, which Murchison had regarded as Llandeilo, or rather as the beds of passage from Llandeilo to Cambrian, and had compared with the north-west parts of the Caermarthenshire sections, (Sil. Sys. 416.) have since been found to be much more ancient deposits, of Middle Cambrian age, which rest upon the crystalline hypozoic rocks of the Malverns, and are unconformably overlaid by the May Hill sandstone. We shall again revert to this region, which has been carefully studied and described by Prof. John Phillips. [Mem. Geol. Sur. II., part 1.]

What then was the value and the significance of the Silurian sections of Murchison, when examined in the light of the results of the Government surveyors? The Llandeilo rocks, having throughout the characteristic Orthis so much insisted upon by Murchison, were shown to be the base of a great conformable series, and to the eastward, in Shropshire, to rest on the upturned edges of the Longmynd rocks; while westward, near Bala, they overlie unconformably the Lingula-flags, and in the island of

Anglesea repose directly upon the ancient crystalline schists. According to the author of the *Silurian System*, there existed beneath the base of the Llandeilo formation a great conformable series of slaty rocks into which this formation passed, and from which it could not be distinguished either zoologically, stratigraphically or lithologically. The sequence, determined from what were considered typical sections in the valley of the Towey in Caermarthenshire, as given by Murchison, for several years both before and after the publication of his work, was as follows: 1. Cambrian; 2. Llandeilo flags; 3. Caradoc sandstone; 4. Wenlock and Ludlow beds; 5. Old Red sandstone; the order being from north-west to south-east. What then were these fossiliferous Cambrian beds underlying the Llandeilo and indistinguishable from it? Sedgwick, with the aid of the Government surveyors, has answered the question in a manner which is well illustrated in his ideal section across the valley of the Towey. The whole of the Bala or Caradoc group rises in undulations to the north-west, while the Llandeilo flags at its base appear on an anticlinal in the valley, and are succeeded to the south-east by a portion of the Bala. The great mass of this group on the south-east side of the anticlinal is however concealed by the overlapping May Hill sandstone,—the base of the unconformable upper series which includes the Wenlock and Ludlow beds. [Philos. Mag. IV, viii, 488.] The section to the south-east, commencing from the Llandeilo flags on the anticlinal, was made by Murchison the Silurian system, while the great mass of strata on the north-west side of the Llandeilo, (which is the complete representative of the Caradoc or Bala beds, partially concealed on the south-west side,) was supposed by him to lie beneath the Llandeilo, and was called Cambrian; (the Upper Cambrian of Sedgwick). These rocks, with the Llandeilo at their base, were in fact identical with the Bala group studied by the latter in North Wales, and are now clearly traced through all the intermediate distance. This is admitted by Murchison, who says: "The first rectification of this erroneous view was made in 1842 by Prof. Ramsay, who observed that instead of being succeeded by lower rocks to the north and west, the Llandeilo flags folded over in those directions, and passed under superior strata, charged with fossils which Mr. Salter recognized as well-known types of the Caradoc or Bala beds." [Siluria, 4th ed., p. 57, foot-note.]

The true order of succession in South Wales was in fact: 1, Llandeilo; 2, Cambrian (= Caradoc or Bala); 3, Wenlock and Ludlow; 4, Old Red sandstone; the Caradoc or Bala beds being repeated on the two sides of the anticlinal, but in great part concealed on the south-east side by the overlapping May Hill or Upper Llandovery rocks. These latter, as has been shown, form the true base of the upper series which, in the Silurian sections, was represented by the Wenlock and Ludlow. Murchison had, by a strange oversight, completely inverted the order of his lower series, and turned the inferior members upside down. In fact, the Llandeilo flags, instead of being, as he had maintained, superior to the Cambrian (Caradoc or Bala) beds, were really inferior to them, and were only made Silurian by a great mistake. The Caradoc, under different names, was thus made to do duty at two horizons in the Silurian system, both below and above the Llandeilo flags. Nor was this all, for by another error, as we have seen, the Caradoc in the latter position was made to include the Pentamerus beds of the unconformably overlying series. Thus it clearly appears that with the exception of the relations of the Wenlock and Ludlow beds to each other and to the overlying Old Red sandstone, which were correctly determined, the Silurian system of Murchison was altogether incorrect, and was moreover based upon a series of stratigraphical mistakes, which are scarcely paralleled in the history of geological investigation.

It was thus that the Lower Silurian was imposed on the scientific world; and we may well ask with Sedgwick, whether geologists "would have accepted the Lower Silurian classification and nomenclature had they known that the physical or sectional evidence upon which it was based had been, from the first, positively misunderstood." Feeling that his own sections were, as has since been fully established, free from error, Sedgwick naturally thought his name of Upper Cambrian should prevail for the great Bala group. Hence the long and embittered discussion that followed, in which Murchison, in many respects, occupied a position of vantage as against the Cambridge professor, and finally saw his name of Lower Silurian supplant almost entirely that of Upper Cambrian given by Sedgwick, who had first rightly defined and interpreted the geological relations of the group.

In a paper read before the Geological Society in June, 1843, [Proc. Geol Soc. IV, 212-223] when the perplexity in which the relations of the Upper Cambrian and Lower Silurian rocks were involved had not been cleared up by the discovery of Murchison's errors in stratigraphy, Sedgwick proposed a compromise, according to which the strata from the Bala limestone to the base of the Wenlock were to take the name of Cambro-Silurian; while that of Silurian should be reserved for the Wenlock and Ludlow beds, and for those below the Bala the name of Cambrian should be retained. The Festiniog group (including what were subsequently named the Lingula-flags and the Tremadoc slates) would thus be Upper instead of Middle Cambrian, the original Upper Cambrian being henceforth Cambro-Silurian; it being understood that, wherever the dividing line might be drawn, all the groups above it should be called Cambro-Silurian, and all those below it Cambrian. This compromise was rejected by Murchison, who in the map accompanying the first edition of his *Siluria*, in 1854, extended the Lower Silurian color so as to include all but the lowest division of the Cambrian; viz., the Bangor group. When, however, the relations of Upper Cambrian and Silurian were made known by the discoveries of Sedgwick and the Government surveyors, this compromise was seen to be uncalled for, and was withdrawn in 1854 by Sedgwick, who re-claimed the name of Upper Cambrian for his Bala group.

In June, 1843, Sedgwick proposed that the whole of the fossiliferous rocks below the horizon of the Wenlock should be designated Protozoic, and on the 29th of November, 1843, presented to the Geological Society an elaborate paper on the Older Paleozoic (Protozoic) Rocks of North Wales, with a colored geological map. This paper, which embodied the results of the researches of Sedgwick and Salter, was not, however published at length, but an abstract of it was prepared by Mr. Warburton, then president of the society, with a reduced copy of the map. [Proc. Geol. Soc. IV, 212 and 251-268; also Geol. Jour. I, 5-22.] In this map of Sedgwick's three divisions were established, viz., the hypozoic crystalline schists of Caernarvonshire, the "*Protozoic*," and the "*Silurian*." On the legend of the reduced map, as published by the Geological Society, these latter names were altered so as read "*Lower Silurian (Protozoic)*" and "*Upper Silurian.*" These changes, in conformity with the nomenclature of Murchison, were, it is unnecessary to say, made without the knowledge of Sedgwick, who did not inspect the reduced and altered map until it was appealed to as an evidence that he had abandoned his former ground, and had recognized the equivalency of the whole of his Cambrian with the Lower Silurian of Murchison. The reader will sympathize with the indignation with which Sedgwick declares that his map was " most unwarrantably tampered with," and will, moreover, learn with surprise, that an inspection of the proof-sheets of Warburton's abstract of Sedgwick's paper was refused him, notwithstanding his repeated solicitations. The story of all this, and finally of the refusal to print in the pages of the Geological Journal the reclamations of the venerable and aggrieved author, make altogether a painful chapter, which will be found in the Philos. Magazine, for 1854 [IV, viii, pp. 301-317, 359-370, and 483-506] and more fully in the Synopsis of British Paleozoic Rocks, which forms the introduction to McCoy's British Paleozoic Fossils.

In connection with this history it may be mentioned that in March, 1845, Sedgwick presented to the Geological Society a paper on the Comparative Classification of the Fossiliferous Rocks of North Wales and those of Cumberland, Westmoreland, and Lancashire; which appears also in abstract in the same volume of the Geological Journal that contains the abstract of the essay and the map just referred to. [I, 442.] That this abstract also is made by another than the author is evident from such an expression as " the author's opinion seems to be grounded on the following facts, etc.," (p. 448) and from the manner in which the terms Lower and Upper Silurian are applied to certain fossiliferous rocks in Cumberland. Yet the words of this abstract are quoted with emphasis in Siluria [1st ed., 147] as if they were Sedgwick's own language recognizing Murchison's Silurian nomenclature.

## II.—Middle and Lower Cambrian.

Investigations in continental Europe were, meanwhile, preparing the way for a new chapter in the history of the lower paleozoic rocks. A series of sedimentary beds in Sweden and Norway had long been known to abound in singular petrifications, some of which had been examined by Linnaeus, who gave to them the name of *Entomolithi*. They were also studied and described by Wahlenberg and by Brongniart, the latter of whom, from two varieties of the *Entomolithus paradoxus*, Linn, established in 1822 two genera, *Paradoxides* and *Agnostus*. In 1826 appeared a memoir by Dalman on the Palæadæ or so-called Trilobites; which was followed, in 1828, by his classic work on the same subject. [Uber de Palaeaden oder so-genanten Trilobiten, 4to. with six plates, Leipsic.] In these works were described and figured, among many others, two genera—*Olenus*, which included *Paradoxides*, Brongn, and *Battus*, including *Agnostus* of the same author. Meanwhile, Hisinger was carefully studying the strata in which these trilobites were found in Gothland, and in the same year (1828) published in his *Anteckningar*, or Notes on the Physical and Geognostical Structure of Norway and Sweden, a colored geological map and section of these rocks as they occur in the county of Skaraborg; where three small circumscribed areas of nearly horizontal fossiliferous strata are shown to rest upon a floor of old crystalline rocks, in some parts granitic and in others gneissic in character. The section and map, as given by Hisinger, show the succession in the principal area to be as follows, in ascending order: 1. granite or gneiss; 2. sandstone; 3. alum-slates; 5. orthoceratite-limestones; 4. clay-slates. By a curious oversight the colors on the legend are wrongly arranged and wrongly numbered, as above; for in the map and section it is made clear that the succession is that just given, and that the clay-slates (4), instead of being below, are above the orthoceratite-limestones (5).

In 1837, Hisinger published his great work on the organic remains of Sweden, entitled *Lethæa Suecica* [4to. with forty-two plates.] In this he gives a tabular view, in descending order, of the rock-formations, and of the various genera and species described. The rocks of the areas just noticed appear in his fourth or lowest division, under the head of *Formationes transitionis*, and are divided as follows:

*a.* Strata calcarea recentiora Gottlandiæ.
*b.* Strata schisti argillacei.
*c.* Strata schisti aluminaris.
*d.* Strata calcarea antiquiora.
*e.* Strata saxi arenacei.

The succession thus given was however erroneous, and probably, like the mistake in the legend of the same author's map just mentioned, the result of inadvertence, the true position of the alum-slates (*c*) being between the older limestone (*d*) and the basal sandstone (*e*). This is shewn both by Hisinger's map of 1828, and by the testimony of subsequent observors. In Murchison's work on the Geology of Russia in Europe, published in 1845, there is given (page 15 et seq.) an account of his visit to this region in company with Prof. Loven, of Christiania; which, with figures of the sections, is reproduced in the different editions of Siluria. The hill of Kinnekulle on Lake Wener, is one of the three areas of transition rocks delineated on the map of Hisinger above referred to. Resting upon a flat region of nearly vertical gneissic strata, we have, according to Murchison; 1. a fucoidal sandstone; 2. alum-slates; 3. red orthoceratite limestone; 4. black graptolitic slates; the whole series being little over 1000 feet in thickness, and capped by erupted greenstone. Above these higher slates there are found in some parts of Gothland, other limestones with orthoceratites, trilobites and corals, the newer limestone strata (*a*) of Hisinger; the whole overlaid by thin sandstone beds. These higher limestones and sandstones contain the fauna of the Wenlock and Ludlow of England; while the lower limestones and graptolitic slates afford *Calymene Blumenbachii*, *Orthis calligramma*, and many other species common to the Bala group of North Wales. The alum-slates below these however, contained, according to Hisinger, none of the species then known in British rocks, but in their stead five species of *Olenus* and two of *Battus* (*Agnostus*.)

In 1854, Angelin published his *Palæontologica Scandinavica*, part I, *Crustacea formationis transitionis*, [4to. forty-one plates] in which he divided the series of transition rocks above described by Hisinger into eight parts designated by Roman numerals, counting from the base. Of these I was named *Regio Fucoidarum*, no organic remains other than fucoids being know therein; while the remaining seven were named from their characteristic genera of trilobites, which were as follows, in ascending order; certain letters being also used to designate the parts: II. (A) Olenus; III. (B) Conocoryphe; IV. (BC) Ceratopyge; V. (C) Asaphus; VI. (D) Trinucleus; VII. (DE) Harpes; VIII. (E) Cryptonymus. In the *Regio Olenorum* (II) was found also the allied genus *Paradoxides*. With regard to the characteristic genus of Regio III., the name of *Conocoryphe* was proposed for it by Corda in 1847, as synonymous with Zenker's name of *Conocephalus* (*Conocephalites*) already appropriated to a genus of insects.

Meanwhile, the similar crustaceans which abound in the transition rocks of Bohemia had been studied and described by Hawle, Corda and Beyrich, when Barrande began his admirable investigations of this ancient fauna and of its stratigraphical relations. He soon found that beneath the horizon characterized by fossils of the Bala group (Llandeilo and Caradoc) there existed in Bohemia a series of strata distinguished by a remarkable fauna, entirely distinct from anything known in Great Britain, but closely allied to that of the alum-slates of Scandinavia, corresponding to Regiones II. and III. of Angelin. To this he gave the name of the first or primordial fauna, and to the rocks yielding it that of the Primordial Zone. Resting upon the old gneisses of Bohemia appears a series of crystalline schists designated by Barrande as *Etage A*, overlaid by a series of sandstones and conglomerates, *Etage B*, upon which repose the fossiliferous argillites of the primordial zone or *Etage C*. The rocks of the Etages A and B were by Barrande regarded as azoic, but in 1861, Fritsch of Prague, after a careful search, discovered in certain thin-bedded sandstones of B, the traces of filled-up vertical double tubes; which, according to Salter, [Mem. Geol. Sur. III., 243] are probably the marks of annelides, and are identical with those found in the rocks of the Bangor or Longmynd group in Great Britain; which will be shown to belong to the primordial zone. It is, therefore, probable that the Etage B, which apparently corresponds to the Regio Fucoidarum or basal sandstone of Scandinavia, should itself be included in the primordial zone. It may here be noticed that it is in the crystalline schists of A that Gumbel has found *Eozoon Bavaricum*. To the Etage C in Bohemia, Barrande assigns a thickness of about 1200 feet, and to this his first fauna is confined, while in the succeeding divisinos he distinguished a second and a third. The second fauna, which characterizes Etage D, corresponds to that of the Bala group; while the third fauna, belonging to the Etages E, F, G and H, is that of the May Hill, Wenlock and Ludlow formations of Great Britain.

This classification of the ancient Bohemian faunas was first set forth by Barrande in 1846, in his *Notice Preliminaire*, in which he declared that the first fauna was below the base of the Llandeilo of Murchison, unknown in Great Britain, and, moreover, "new and independent in relation to the two Silurian faunas (his second and third) already established in England." This opinion he reiterated in 1859. These three divisions form in Bohemia an apparently continuous series, and being connected with each other by some common species, Barrande was led to look upon the whole as forming a single stratigraphical system;

and finally to assert that these three independent faunas "form by their union an indivisible triad which is the Silurian system." [Bul. Soc. Geol. de Fr. II, xvi, 529-545.] Already, in 1852, in his magnificent work on the Silurian System of Bohemia, Barrande had given to the strata characterized by his first fauna the name of Primordial Silurian. It is difficult to assign any just reason for thus annexing to the Silurian,—already augmented by the whole Upper Cambrian or Bala group of Sedgwick, (Llandeilo and Caradoc)—a great series of fossiliferous rocks lying below the base of the Llandeilo, and unsuspected by the author of the Silurian system; who persistently claimed the Llandeilo beds, with their characteristic second fauna, as marking the dawn of organic life.

Up to this time the primordial paleozoic fauna of Bohemia and of Scandinavia was, as we have said, unknown in Great Britain. The few organic remains mentioned by Sedgwick in 1835 as occurring in the region occupied by his Lower and Middle Cambrian, on Snowdon, were found to belong to Bala beds, which there rest upon the older rocks: nor was it until 1845 that Mr. Davis found in the Middle Cambrian remains of Lingula. In 1846, Sedgwick, in company with Mr. Davis, re-examined these rocks, and in December of the same year described the Lingula-beds as overlaid by the Tremadoc slates and occupying a well-defined horizon in Caernarvon and Merionethshire, beneath the great mass of the Upper Cambrian rocks. [Geol. Jour. II, 75, III, 139.] Sedgwick, at the same time, noticed about this horizon certain graptolites and an Asaphus, which were supposed to belong to the Tremadoc slates, but have since been declared by Salter to pertain to the Arenig or Lower Llandeilo beds, the base of the Upper Cambrian. [Mem. Geol. Sur. III, 257, and Decade II.]

This discovery of the Lingula-flags, as they were then named, and the fixing by Sedgwick of their geological horizon, was at once followed by a careful examination of them by the Government surveyors, and in 1847, Selwyn detected in the Lingula-flags, near Dolgelly, in Merionethshire, the remains of two crustacean forms, the one a phyllopod, which has received the name of *Hymenocaris vermicauda*, Salter, and the other a trilobite which was described by Salter in 1849 as *Olenus micrurus*. [Geol. Survey, Decade II.] A species of Paradoxides, apparently identical with *P. Forchhammeri* of Sweden, was also about this time recognized among specimens supposed to be from the same horizon. It has since been described as *P. Hicksii*, and found to belong to the basal beds of the Lingula-flags,—the Menevian group.

Upon the flanks of the Malvern Hills there are found resting upon the ancient crystalline rocks of the region, and overlaid by the Pentamerus beds of the May Hill sandstone (originally called Caradoc by Murchison) a series of fossiliferous beds. These consist in their lowest part of about 600 feet of greenish sandstone, which have since yielded an *Obolella* and *Serpulites*, and are overlaid by 500 feet of black schists. In these, in 1842, Prof. John Phillips found the remains of trilobites, which he subsequently described, in 1848, as three species of Olenus. [Mem. Geol. Survey II, part 1, 55.] These black shales, which had not at that time furnished any organic remains, were by Murchison in his Silurian System (p. 416) in 1839 compared to the supposed passage-beds in Caermarthenshire between the Llandeilo and the Cambrian (Bala) rocks; which, as we have seen, were newer and not older strata than the Llandeilo flags. From their lithological characters, and their relations to the Pentamerus beds, these lower fossiliferous strata of Malvern were subsequently referred by the Government geologists to the horizon of the Caradoc proper or Bala group; nor was it until 1851, that their true geological age and significance were made known. In that year, Barrande, fresh from the study of the older rocks of the continent, came to England for the purpose of comparing the British fossils with those of the primordial zone, which he had established in Bohemia and Scandinavia, and which he at once recognized in the Lingula-flags of Sedgwick and in the black schists at Malvern; both of which were characterized by the presence of the genus *Olenus*, and were referred to the horizon of his Etage C. This important conclusion was announced by Salter to the British Association at Belfast in 1852. [Rep. Brit. Assoc., abstracts, p. 56, and Bull. Soc. Geol. de Fr. II, xvi, 537.] Since that time the progress of investigation in the Middle and Lower Cambrian rocks of Wales has shown a fauna the importance and richness of which has increased from year to year.

The paleontological studies of Salter, while they confirmed the primordial character of the whole of the great mass of strata which make up the Middle Cambrian or Festiniog group of Sedgwick, (consisting of the Lingula-flags and the Tremadoc slates,) led him to propose several sub-divisions. Thus he distinguished on paleontological grounds between the upper and lower Tremadoc slates, and for like reasons divided the Lingula-flags into a lower and an upper portion. For the discussion of these distinctions the reader is referred to the memoirs of the Geol. Survey [III, 240-257.] Subsequent researches led to the division of the original Lingula-flags into three parts, an upper and a middle, to which the names of Dolgelly and Maentwrog were given by Mr. Belt, and a third consisting of the basal beds, which were separated in 1865, by Salter and Hicks, with the designation of Menevian, derived from the ancient Roman name of St. David's in Pembrokeshire. It was here that in 1862, Salter found *Paradoxides* with *Agnostus* and *Lingula* in fine black shales at the base of the Lingula-flags, resting comformably on the green and purple grits of the Lower Cambrian or Harlech beds. The locality was afterwards carefully studied by Hicks, and it was soon made apparent that the genus Paradoxides, both here and in North Wales, was confined to a horizon below the great mass of the Lingula-flags; which, on the contrary, are characterized by numerous species of Olenus. These lower or Menevian beds are hence regarded by Salter as equivalent to the lowest portion of the Etage C of Barrande.

Beneath these Menevian beds there lies, in apparent conformity, the great Lower Cambrian series, frequently called the bottom or basement rocks by the Government surveyors; represented in North Wales by the Harlech grits, and in South Wales, near St. Davids, by a similar series of green and purple sandstones, considered by Murchison, and by others, as the equivalent of the Harlech rocks. They were still supposed to be unfossiliferous until in June, 1867, Salter and Hicks announced the discovery in the red beds of this lower series, at St. Davids, of a Lingulella, very like *L. ferruginea* of the Menevian. [Geol. Jour. XXIII, 339; Siluria 4th ed. 550.] This led to a farther examination of these Lower Cambrian beds, which has resulted in the discovery in them of a fauna distinctly primordial in type, and linked by the presence of several identical fossils to the Menevian; but in many respects distinct, and marking a lower fossiliferous horizon than anything known in Bohemia or in Scandinavia.

The first announcement of these important results was made to the British Association at Norwich in 1868. Further details were, however, laid before the Geological Society in May, 1871, by Messrs. Harkness and Hicks, whose paper on the Ancient Rocks of St. David's Promontory appears in the Geological Journal for November, 1871. [XXVIII, 384.] The Cambrian sediments here rest upon an older series of crystalline stratified rocks, described by the geological surveyors as syenite and greenstone, and having a north-west strike. Lying unconformably upon these, and with a north-east strike, we have the following series, in ascending order: 1. quartzose conglomerate, 60 feet; 2. greenish flaggy sandstones, 460 feet; 3. red flags or slaty beds, 50 feet, containing *Lingulella ferruginea*, besides a larger species, *Discina*, and *Leperditia Cambrensis*; 4. purple and greenish sandstones, 1000 feet; 5. yellowish gray sandstones, flags and shales, 150 feet, with *Plutonia*, *Conocoryphe*, *Microdiscus*, *Agnostus*, *Theca* and *Protospongia*; 6. gray, purple and red flaggy sandstones, with most of the above genera, 1500 feet; 7. gray flaggy beds, 150 feet, with *Paradoxides*; 8. true Menevian beds, richly fossiliferous, 500 feet. The latter are the probable equivalent of the base of Barrande's Etage C, and at St. David's are conformably overlaid by the Lingula-flags; beneath which we have, including the Menevian, a conformable series of 3370 feet of uncrystalline sediments, fossiliferous nearly to the base, and holding a well-marked fauna distinct from anything hitherto known in Great Britain or elsewhere.

The Menevian beds are connected with the underlying strata by the presence of *Lingulella ferruginea*, *Discina pileolus*, and *Obolella sagittatis*, which extend through the whole series; and also by the genus Paradoxides, four species of which occur in these lower strata; from which the genus Olenus, which characterizes the Lingula-flags, seems to be absent. To a large tuberculated trilobite of a new genus found in these lowest rocks the name of *Plutonia Sedgwickii* has been given. Hicks has proposed to unite the Menevian with the Harlech beds, and to make the summit of the former the dividing line between the Lower and Middle Cambrian, a suggestion which has been adopted by Lyell. [Proc. Brit. Assoc. for 1868, p. 68, and Lyell, Student's Manual of Geology, 466–469.]

Both Phillips and Lyell give the name of Upper Cambrian to the Lingula-flags and the Tremadoc slates, which together constitute the Middle Cambrian of Sedgwick, and concede the title of Lower Silurian to the Bala group or Upper Cambrian of Sedgwick. The same view is adopted by Linnarsson in

Sweden, who places the line between Cambrian and Silurian at the base of the Llandeilo or the second fauna. It was by following these authorities that I, inadvertently, in my address to the American Association for the Advancement of Science in August, 1871, gave this horizon as the original division between Cambrian and Silurian. The reader of the first part of this paper will see with how much justice Sedgwick claims for the Cambrian the whole of the fossiliferous rocks of Wales *beneath* the base of the May Hill sandstone, including both the first and the second fauna. I cannot but agree with the late Henry Darwin Rogers, who, in 1856, reserved the designation of "the true European Silurian" for the rocks *above* this horizon. [Keith Johnson's Physical Atlas, 2nd ed.]

The Lingula-flags and Tremadoc slates have been made the subject of careful stratigraphical and paleontological studies by the Geological Survey, the results of which are set forth by Ramsay and Salter in the third volume of the Memoirs of the Geological Survey, published in 1866, and also, more concisely, in the Anniversary Address by the former to the Geological Society in 1863. [Geol. Jour. XIX, xviii.] The Lingula flags (with the underlying Menevian, which resembles them lithologically) rest in apparent conformity upon the purple Harlech rocks both in Pembrokeshire and in Merionethshire, where the latter appear on the great Merioneth anticlinal, long since pointed out by Sedgwick. The Lingula-flags, (including the Menevian) have in this region, according to Ramsay, a thickness of about 6000 feet. Above these, near Tremadoc and Festiniog, lie the Tremadoc slates, which are here overlaid, in apparent conformity, by the Lower Llandeilo beds. At a distance of eleven miles to the north-west, however, the Tremadoc slates disappear, and the Lingula-flags are represented by only 2,000 feet of strata; while in parts of Caernarvonshire, and in Anglesea, the whole of the Lingula-flags and moreover the Lower Cambrian rocks, are wanting, and the Llandeilo beds rest directly upon the ancient crystalline schists. In Scotland and in Ireland, moreover, the Lingula-flags, are wholly absent, and the Llandeilo rocks there repose unconformably upon grits regarded as of Lower Cambrian age. Thus, without counting the Tremadoc slates, which are a local formation, unknown out of Merionethshire, we have (including the Bangor group and Lingula-flags,) beneath the Llandeilo, over 9,000 feet of fossiliferous strata, which disappear entirely in the distance of a few miles. From a careful survey of all the facts, the conclusion of Ramsay is irresistible, that there exists between the Lingula-flags and the Llandeilo not merely one, but two great stratigraphical breaks in the succession; the one between the Lingula-flags and the Lower Tremadoc slates, and the other between the Upper Tremadoc slates and the Lower Llandeilo.

This conclusion is confirmed by the fact that there exists at each of these horizons a nearly complete paleontological break. The fauna of the Tremadoc slates is, according to Salter, almost entirely distinct from that of the Lingula-flags, and not less distinct from that of the so-called Lower Llandeilo or Arenig rocks, (the equivalents of the Skiddaw slates of Cumberland). Hence, says Ramsay, it is evident "that in these strata we have three perfectly distinct zones of organic remains, and therefore, in common terms, three distinct formations." The paleontological evidence is thus in complete accordance with that furnished by stratigraphy. We cannot leave this topic without citing the conclusion of Ramsay that "each of these two breaks necessarily implies a lost epoch, stratigraphically quite unrepresented in our area; the life of which is only feebly represented in some cases by the fossils common to the underlying and overlying formation." In connection with this remark, which we conceive to embody a truth of wide application, it may be said that stratigraphical breaks and discordances in a geological series, may, *à priori*, be expected to occur most frequently in regions where this series is represented by a large thickness of strata. The accumulation of such masses implies great movements of subsidence, which, in their nature, are limited, and are accompanied by elevations in adjacent areas, from which may result, over these areas, either interruptions in the process of sedimentation, or the removal, by sub-aerial or sub-marine denudation, of the sediments already formed. The conditions of succession and distribution, it may be conceived, would be very different in a region where the period corresponding to this same geological series was marked by comparatively small accumulations of sediment upon an ocean-floor subjected to no great movements.

This contrast is strikingly seen between the conformable series of less than 2,000 feet of strata which in Scandinavia are characterized by the first three paleozoic faunas (Cambrian and Silurian) and the repeatedly broken and discordant succession of more than 30,000 feet of sediments,* which in Wales are their paleontological equivalents. It must, however, be considered that in regions of small accumulation where, as in Scandinavia, the formations are thin, there may be lost or unrepresented zoological epochs whose place in the series is marked by no stratigraphical break. In such comparatively stable regions, movements of the surface sufficient to cause the exclusion, or the disappearance by removal, of the small thickness of strata corresponding to an epoch, may take place without any conspicuous marks of stratigraphical discordance.

The attempt to establish geological divisions or horizons upon stratigraphical or paleontological breaks must always prove fallacious. From the nature of things, these, whether due to non-deposition or to subsequent removal of deposits, must be local; and we can say, confidently, that there exists no break in life or in sedimentation which is not somewhere filled up and represented by a continuous and conformable succession. While we may define one period as characterized by the presence of a certain fauna, which, in a succeeding epoch, is replaced by a different one, there will always be found, in some part of their geographical distribution, a region where the two faunas commingle, and where the gradual disappearance of the old before the new may be studied. The division of our stratified rocks into systems is therefore unphilosophical, if we assign any definite or precise boundaries or limitations to these. It was long since said by Sedgwick with regard to the whole succession of life through geologic time, —that all belongs to one great *systema naturæ*. [Philos. Mag. IV. viii, 359.]

We have already noticed that Barrande, as early as 1852, gave the name of Primordial Silurian to the rocks which, in Bohemia, were marked by the first fauna; although he, at the

* The Longmynd rocks in Shropshire are alone estimated at 20,000 feet; but their supposed equivalents, the Harlech rocks of Pembrokeshire, have a measured thickness of 3,300, while the Llanberris and Harlech rocks together, in North Wales, equal from 4,000 to 7,000 feet, and the Lingula-flags and Tremadoc slates, united, about 7,000 feet. The Bala group in the Berwyns exceeds 12,000 feet, and the proper Silurian, from the base of the Upper Llandovery or May Hill sandstone, attains from 5,000 to 6,000 feet; so that the aggregate of 30,000 feet may be considered below the truth. [Mem. Geol. Survey, III, part 2, pages 72, 222, and Siluria, 4th ed. 185.]

same time, recognized this as distinct from and older than the second fauna, discovered in the Llandeilo rocks, which Murchison had declared to represent the dawn of organic life. Into the reasons which led Barrande to include the rocks of the first, second and third faunas in one Silurian system, (a view which was at once adopted by the British Geological Survey and by Murchison himself,) it is not our province to inquire, but we desire to call attention to the fact that the latter, by his own principles, was bound to reject such a classification. In his address before the Geological Society in 1842, (already quoted in the first part of this paper,) he declared that the discussion as to the value of the term Cambrian involved the question "whether there was any type of fossils in the mass of the Cambrian rocks different from those of the Lower Silurian series. If the appeal to nature should be answered in the negative, then it was clear that the Lower Silurian type must be considered the true base of what I had named the protozoic rocks; but if characteristic new forms were discovered, then would the Cambrian rocks, whose place was so well established in the descending series, have also their own fauna, and the paleozoic base would necessarily be removed to a lower horizon."

In the event of no distinct fauna being found in the Cambrian series, it was declared that "the term Cambrian must cease to be used in zoological classification, it being, in that sense, synonymous with Lower Silurian." [Proc. Geol. Soc. III, 641 et seq.] That such had been the result of paleontological inquiry Murchison then proceeded to show. Inasmuch as the only portion of Sedgwick's Cambrian which was then known to be fossiliferous, was really above and not below the Llandeilo rocks, which Murchison had taken for the base of his Lower Silurian, his reasoning with regard to the Cambrian nomenclature, based on a false datum, was itself fallacious; and it might have been expected that when the government surveyors had shown his stratigraphical error, Murchison would have rendered justice to the nomenclature of Sedgwick. But when, still later, a farther "appeal to nature" led to the discovery of "characteristic new forms," and established the existence of a "type of fossils in the mass of the Cambrian rocks, different from those of the Lower Silurian series," Murchison was bound by his own principles to recognize the name of Cambrian for the great Festiniog group, with its primordial fauna, even though Barrande and the government surveyors should unite in calling it Primordial Silurian.

He however chose the opposite course, and now attempted to claim for the Silurian system the whole of the Middle Cambrian or Festiniog group of Sedgwick, including the Tremadoc slates and the Lingula-flags. The grounds of this assumption, as set forth in the successive editions of Siluria from 1854 to 1867, and in various memoirs, may be included under three heads: first that the Lingula-flags have been found to exist in some parts of his original Silurian region; second, that no clearly-defined base had been assigned by him to his so-called system; and third, that there are no means of drawing a line of demarkation between these Middle Cambrian formations and the overlying Llandeilo.

With regard to the first of these reasons, it is to be said that the only known representatives of the Lingula-flags in the region described by Murchison in his *Silurian System* are the black slates of Malvern; and some scanty outliers which, in Shropshire, lie between the old Longmynd rocks and the base of the Stiper-stones. The former were then (as has already been shown) supposed by him to belong to the Llandeilo, or rather to the passage-beds between the Llandeilo and Cambrian (Bala); while with regard to the latter, Ramsay expressly tells us that they were not originally classed with the Silurian, but have since been included in it. [Mem. Geol. Sur. III, part 2, page 9; and 242, foot-note.]

The Llandeilo beds were by Murchison distinctly stated to be the base of the Silurian system [Sil. Sys. 222.]; and it was farther declared by him that in Shropshire, (unlike Caermarthenshire,) "there is no passage from the Cambrian to the Silurian strata," but a hiatus, marked by disturbances which excluded the passage-beds, and caused the Lower Silurian to rest unconformably upon the Longmynd rocks. [Ibid, 256; and plates 31, sections 3 and 6; 32, section 4.] But in *Siluria* [1st. ed. 47] the two are stated to be conformable; and in the subsequent sections of this region, made by Aveline, and published by the Geological Survey, the evidences of this want of conformity do not appear. Murchison at that time confounded the rocks of the Longmynd with the Cambrian (Bala) beds of Caermarthenshire and Brecon. [Sil. Sys. 416.] Hence it was that he gave the name of Cambrian to the former; and this mistake, moreover, led him to place the Cambrian of Caermarthenshire beneath the Llandeilo. It is clear that if he claimed no well-defined base to the Llandeilo rocks in this latter (their typical region), it was because he saw them passing into the overlying Bala beds. There was, in the error by which he placed *below* the Llandeilo, strata which were really *above* them, no ground whatever for afterwards including in his Silurian system, as a downward continuation of the Llandeilo rocks (which are the basal portion of the Bala group), the whole Festiniog group of Sedgwick; whose infra-position to the Bala had been shown by the latter long before it was known to be fossiliferous.

It was however claimed by Murchison that no line of separation can be drawn between these two groups. The results of Ramsay and of Salter, as set forth in the address of the former before the Geological Society in 1863, and more fully in the Memoirs of the Geological Survey [vol. III. part 2] published in 1866, with a preface by himself, as the director of the Survey, are completely ignored by Murchison. The reader familiar with these results, of which we have given a summary, finds with surprise that in the last edition of *Siluria*, that of 1867, they are noticed in part, but only to be repudiated. In the five pages of text which are there given to this great Middle Cambrian division, we are told that the distinction between the Lower Tremadoc and the Lingula-flags "is difficult to be drawn," and that the Upper Tremadoc slate passes into and forms the lower part of the Llandeilo, "into which it graduates conformably." (Siluria, 4th ed. p. 46.) In each of these cases, on the contrary, according to Ramsay, there is observed "a break very nearly complete both in genera and species, and probable unconformity;" the evidence of the paleontological break being furnished by the careful studies of Salter; while that of the stratigraphical break, as we have seen, leaves no reason for doubt. [Mem. Geol. Sur. III, part 2, pages 2, 161, 234.] The student of *Siluria* soon learns that in all cases where Murchison's pretensions were concerned, the book is only calculated to mislead.

The reader of this history will now be able to understand why, notwithstanding the support given by Barrande, by the Geological Survey of Great Britain, and by most American geologists to the Silurian nomenclature of Murchison, it is rejected, so far as the Lingula-flags and the Tremadoc slates are concerned, by Lyell, Phillips, Davidson, Harkness and Hicks in England, and by Linnarsson in Sweden. These authorities have, however, admitted the name of Lower Silurian for the Bala group or

Upper Cambrian of Sedgwick; a concession which can hardly be defended, but which apparently found its way into use at a time when the yet unravelled perplexities of the Welsh rocks led Sedgwick himself to propose, for a time, the name of Cambro-Silurian for the Bala group. This want of agreement among geologists as to the nomenclature of the lower paleozoic rocks, causes no little confusion to the learner. We have seen that Henry Darwin Rogers followed Sedgwick in giving the name of Cambrian to the whole paleozoic series up to the base of the May Hill sandstone; and the same view is adopted by Woodward in his Manual of the Mollusca. The student of this excellent book will find that in the tables giving the geological range of the mollusca, on pages 124, 125 and 127, the name of Cambrian is used in Sedgwick's sense, as including all the fossiliferous strata beneath the May Hill sandstone. On page 123 it is however explained that Lower Silurian is a synonym for Cambrian, and it is so used in the body of the work.

The distribution of the Lower and Middle Cambrian rocks in Great Britain may now be noticed. The former, or Bangor group, to which Murchison and the Geological Survey restrict the name of Cambrian, and which they sometimes call the Longmynd, bottom or basement rocks, occupy two adjacent areas in Caernarvon and Merionethshire; the one near Bangor, including Llanberris, to the north-east, and the other, including Harlech and Barmouth, to the south-east of Snowdon; this mountain lying in a synclinal between them, and rising 3571 feet above the sea. The great mass of grits or sandstones appears to be at the summit of the group, but in the lower part the blue roofing-slates of Llanberris are interstratified in a series of green and purple slates, grits and conglomerates. (Some of the Welsh roofing-slates are however supposed to belong to the Llandeilo). [Mem. Geol. Survey III, part 2, pages 54, 258.] The Harlech rocks in this north-western region are conformably overlaid by the Menevian, followed by the true Lingula-flags, or Olenus beds, of the Middle Cambrian. Upon these repose the Tremadoc slates, which are not known in the other parts of Wales. The third area of Lower Cambrian rocks is that already described at St. David's in Pembrokeshire, about 100 miles to the south-west; and the fourth, that of the Longmynd hills, about sixty miles to the south-east of Snowdon. The rocks of the Longmynd, like those of the other Lower Cambrian areas mentioned, consist principally of green and purple sandstones with conglomerates, shales and some clay-slates. They occasionally hold flakes of anthracite, and small portions of mineral pitch exude from them in some localities. The only evidence of animal life yet found in the rocks of the Longmynd are furnished by worm-burrows, the obscure remains of a crustacean, (the *Palæopyge Ramsayi*,) and a form like *Histioderma.* This latter organic relic, with worm-burrows, and the fossils named *Oldhamia*, is found on the coast of Ireland opposite Caernarvonshire, in the rocks of Bray Head; which resemble lithologically the Harlech beds, and are regarded as their equivalents.

Still another area of the older rocks is that of the Malvern hills, on the western flanks of which, as already mentioned, the Lingula-flags are represented by about 500 feet of black shales with Olenus, underlaid by 600 feet of greenish sandstones containing traces of fucoids, with Serpulites and an Obolella. It is not improbable, as suggested by Barrande and by Murchison, that these 1100 feet of strata represent, in this region, the great mass of the Lingula-flags,—and, we may add, perhaps the whole series of Lower Cambrian strata, which in Caernarvonshire and Pembrokeshire underlie them; since these sandstones of Malvern, like those of St. David's, rest upon crystalline schists, and are in part made up of their ruins.

These crystalline schists of Malvern, which are described by Phillips as the oldest rocks in England, and by Mr. Holl are conjectured to be Laurentian, seem from the descriptions of their lithological characters to resemble those of Caernarvon and Anglesea, with which they are, by Murchison, regarded as identical. The crystalline schists of these latter localities are, by Sedgwick, described as hypozoic strata, below the base of the Cambrian. Murchison however, in the first edition of his *Siluria*, adopted the suggestion of De la Beche that they themselves were altered Cambrian strata. In fact they directly underlie the Llandeilo rocks, and were apparently conceived by Murchison to represent the downward continuation of these, upon which he had insisted. This opinion is supported by ingenious arguments on the part of Ramsay. [Mem. Geol. Survey, III, part 2, passim.] I am however disposed to regard them, with Sedgwick and Phillips, as of pre-Cambrian age, and to compare them with the Huronian series of North America, which occupies a similar geological horizon, and with which, as seen in northern Michigan, and in the

Green Mountains, I have found the rocks of Anglesea to offer remarkable lithological resemblances.

It may here be noticed that the gold-bearing quartz veins in North Wales are found in the Menevian beds, and also, according to Selwyn, throughout the Lingula-flags. These fossiliferous strata at the gold-mine near Dolgelly appear in direct contact with diorites and chloritic and talcose schists, which are more or less cupriferous, and themselves also contain gold-bearing quartz veins. [Mem. Geol. Survey, part 2, pp. 42; 45, and Siluria, 4th ed., 450, 547.]

The Table on page 312 gives a view of the lower paleozoic rocks of Great Britain and North America, together with the various nomenclatures and classifications referred to in the preceding pages. In the second column, the horizontal black lines indicate the positions of the three important paleontological and stratigraphical breaks signalized by Ramsay in the British succession. [Mem. Geol. Survey, III, part 2, page 2.] In a table by Davidson in the *Geological Magazine* for 1868 [V. 305] showing the distribution of organic remains in these lower rocks, he gives, as the Festiniog group of Sedgwick, only the Dolgelly and Maentwrog beds of Belt (the Upper and Middle Lingula-flags); and makes of the two divisions of the Tremadoc rocks a separate group; the whole being described as the Upper Cambrian of Sedgwick. This however is not the present grouping and nomenclature of Sedgwick, nor was it his earlier one. So far as regards Middle and Upper Cambrian, this discrepancy is explained by the fact already stated, that in 1843 Sedgwick proposed, as a compromise, the name of Cambro-Silurian for his Bala group, previously called Upper Cambrian; by which change the Festiniog or Middle Cambrian became Upper Cambrian. When the true relation between the Lower Silurian of Murchison and the Bala group was made known, Sedgwick, as we have seen, re-claimed for the latter his former name of Upper Cambrian; but this had meanwhile been adopted for the Festiniog group, in which sense it is still used by Lyell, Phillips, Davidson, Harkness and Hicks. The Festiniog group, or Middle Cambrian, as defined by Sedgwick, however, included not only the whole of the Lingula-flags but the Upper and Lower Tremadoc rocks. [Philos. Mag. IV. viii. 362.]

The only change which I have made in the groupings of the British rocks adopted by Sedgwick and by Murchison, is in separating the Menevian or Lower Lingula-flags from the Festiniog, and uniting it with the Bangor group or Lower Cambrian. In this I follow, with Lyell and Davidson, the suggestion of Salter and Hicks.

In the third column, the sub-divisions are those of the New York and Canada Geological Surveys; in connection with which the reader is referred to a table published in 1863, in the *Geology of Canada*, page 932. Opposite the Menevian I have placed the names of its principal American localities; which are Braintree, Mass., St. John, New Brunswick, and St. John's, Newfoundland. The farther consideration of the American subdivisions is reserved for the third part of this paper. With regard to the classification of Angelin, it is to be remarked that although he designates II as *Regio Olenorum*, and III as *Regio Conocorypharum*, the position of these, according to Linnarsson, is to be reversed; the Conocoryphe beds with Paradoxides being below and not above those holding Olenus. The *Regio Fucoidarum* in Sweden has lately furnished a brachiopodous shell, *Lingula monilifera*, besides the curious plant-like fossil, *Eophyton Linnæanum*. [Linnarsson, Geol. Magazine, 1869, vi. 393.]

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(The third and concluding part of this paper will appear in the next number of the *Naturalist*.)

## Lower Paleozoic Rocks of Europe and North America.

| | *British sub-divisions.* | *North American sub-divisions.* | *Nomenclatures of Sedgwick and Murchison.* | *Barrande's classification.* | *Angelin's divisions.* |
|---|---|---|---|---|---|
| 14<br>13<br>12 | Ludlow.<br>Wenlock.<br>Upper Llandovery. | Lower Helderberg.<br>Niagara, Clinton,<br>Medina, Oneida. | Silurian, *Sedgwick.*<br>Upper Silurian, *Murchison.* | Third fauna including Etages H. G F. E. | VIII. VII. or Regiones E. and DE |
| 11<br>10<br>9<br>8 | Lower Llandovery.<br>Caradoc.<br>Upper Llandeilo.<br>Lower Llandeilo. | Hudson-River, Utica,<br>Trenton, Birdseye,<br>Black-River.<br>Chazy. | Upper Cambrian or Bala group, *Sedgwick.* Lower Silurian, *Murchison.* | Second fauna including Etage D. | VI. V. IV. or Regiones D. C. and BC. |
| 7<br>6<br>5<br>4 | Upper Tremadoc.<br>Lower Tremadoc.<br>Dolgelly.<br>Maentwrog. | Levis.<br>Calciferous.<br>Potsdam. | Middle Cambrian or Festiniog group, *Sedgwick.* Primordial Silurian, *Murchison* | First fauna or Primordial fauna, including Etage C, and probably also Etage B. | III. II. I. or Regiones B. and A. and Regio Fucoidarum. |
| 3<br>2<br>1 | Menevian.<br>Harlech.<br>Llanberris. | Braintree & St. John.<br>——— ?<br>——— ? | Lower Cambrian or Bangor group, *Sedgwick.* Cambrian, *Murchison.* | | |

# REMARKS ON THE TACONIC CONTROVERSY.

By E. Billings, F.G.S.

Table *of the Silurian formations of New York and Canada as recognized previously to* 1859.

| | |
|---|---|
| UPPER SILURIAN. | |
| 16 Lower Helderberg. | |
| 15 Onondaga. | |
| 14 Guelph. | |
| 13 Niagara. | |
| 12 Clinton. | The Red Sandrock of Vermont was originally placed about here by Dr. Emmons, followed by Adams, Rogers, and others. It was afterwards referred to a horizon near the Potsdam by Dr. Emmons and E. Billings. |
| 11 Medina. | |
| 10 Oneida. | |
| LOWER SILURIAN. | |
| 9 Grey sandstone. | Position of the Taconic rocks and Quebec group according to Prof. Hall and others. At first adopted, but rejected by the Canadian Survey in 1860. |
| 8 Hudson River. | |
| 7 Utica. | |
| 6 Trenton. | |
| 5 Black River. | |
| 4 Birdseye. | |
| 3 Chazy. | Approximate horizon of the Quebec group as decided by Sir W. E. Logan & E. Billings in 1860 |
| 2 Calciferous. | |
| 1 Potsdam. = | Position of the Red Sandrock of Vermont (nearly) according to Dr. Emmons & E. Billings |
| TACONIC SYSTEM. = | Position of the Taconic System according to Dr. Emmons. |

It frequently happens that a science, such for instance as that of geology, possesses a sort of an aristocracy, consisting of the most talented, learned, active and influential of its devotees. The views of this body of men, on any difficult problem that may present itself, are usually regarded as conclusive, and are quietly adopted by the less distinguished members. Indeed, the opinion of any one of these latter, would be scarcely listened to, provided it should happen to be contrary to the established creed of the dominant party. As a general rule the leading men are right, and yet it will sometimes happen that they are wrong. One of the most remarkable instances on record, is that of the great question in American Geology, relating to the age of the rocks which Dr. Emmons called "The Taconic System." Upon this question nearly all of the leading geologists of North America arranged themselves upon one side, and, as it turned out after more than twenty years discussion, *on the wrong side.* Although they were wrong, yet so overwhelming was the weight of their authority, that for nearly a quarter of a century, Dr. Emmons stood almost alone. He had a few followers, but they were not men who had made themselves sufficiently conspicuous and influential to contend successfully against an opinion that was supported by all the great geologists of the continent in one compact body. In consequence of this powerful opposition, the Taconic theory gradually sank so low in reputation, that it was at length considered to be scarcely worthy of the notice of a scientific man.

During the last thirteen years, a great revolution of opinion has occurred with regard to the views of Dr. Emmons. Although not entirely adopted, they are now considered to be, in a general way, well founded. The opposite theory, that all of those rocks which he placed in the Taconic System are above the Potsdam sandstone, instead of below it, as he maintained, is completely exploded. It is at this moment dead, more so than was the Taconic theory in 1859, the year in which the subject was re-opened. As I understand it at present, some of the Taconic rocks are certainly more ancient than the Potsdam, others may be of the same age, and perhaps some of them more recent. The details are not yet worked out, and judging from the manner in which the strata are folded, broken up and thrown out of their original position by almost every kind of geological disarrangement, I venture to say that no man, at present living, will ever see a perfect map of the Taconic region.

The theory, that the Taconic rocks belonged to the Hudson River group, was an enormous error, that originated in the Geological Survey of New York, and thence found its way into the Canadian Survey. No doubt the mistake was due, in the first instance, to the extraordinary arrangement of the rocks, the more ancient strata being elevated and often shoved over the more recent. Thus, without the aid of paleontology, it was impossible to assert positively that they were not, what they appeared to be, of the age of the Hudson River formation. The attitude of the strata, together with their numerous disturbances, might be explained physically, so as to meet either theory. If, for instance, the trilobites of Vermont and Point Levis, had turned out to be of the age of the fauna of the Hudson River group, the rocks would be to this day called Hudson River. There is no apparent physical arrangement to contradict this view, but rather to support it. I do not consider that originally either the physical geologists, or the paleontologists, were much to blame. With regard to the first, when a geologist finds one rock overlying another, he is obliged to accept that as the natural arrangement. Then as to the fossils, with all our increased knowledge, I doubt that any good paleontologist of the present day, would feel himself justified in deciding against physical appearances, on the few imperfect specimens figured in 1847, on pl. 67, Pal. N. Y., vol. I. Be this as it may the object of this note is to show that while the error originated in New York, it was corrected by the Geological Survey of Canada. Dr. Hunt, in his published Address to the American Association, in August last, indirectly associates Prof. Hall with me in the rectification of the mistake, whereas neither Prof. Hall nor Dr. Hunt contributed any aid whatever, but on the contrary, opposed the change that has been made to the utmost. In this paper I desire simply to claim what belongs to myself, and to do justice to some others, who assisted in the work. I shall discuss the subject under the following heads:

### 1.—*The Vermont Trilobites.*

In 1859, I had some correspondence with Col. E. Jewett, then residing at Albany, N.Y., on the subject of an exchange of fossils. This gentleman is widely known for the extensive collections he has made, and I have also found him to be a good sound geologist, although he has never published much on the science. It appears that, during the numerous excursions he had made over the disputed territory, he had arrived at the conclusion from his own observations that Dr. Emmons was, upon the whole, correct in his views. He had, on several occasions, urged me to take the matter up and investigate it, but this I could not do for want both of time and of facts. On the 5th of April, 1859, he wrote me a letter, in which he gave an account of what specimens he could send in exchange. After mentioning several species, he says:

"I can spare a good specimen of what Prof. Hall describes as *Olenus asaphoides*, which I got from the upturned slates of Vermont, twenty-five miles north of Burlington and four miles from Lake Champlain. Emmons declares it below the New York system. It is singular that no other fossils of any kind are found in the locality which has furnished several of this trilobite."

Shortly afterwards the trilobite was received by me at Montreal, and I was much surprised to find it a true primordial form, but not an *Olenus*. It seemed to me to be more nearly allied to *Paradoxides* and it appears also that I communicated this opinion to Col. Jewett, for I have a letter from him dated 11th of May, 1859, in which he says:

"Should you have any doubts of the trilobite sent you being a true *Paradoxides*, I will send you others which display more graphically the characters."

After studying the fossil for several days, I showed it to the officers of our Survey, and pointed out that its primordial aspect, indicated a horizon far below the Hudson River group, and perhaps even below the Potsdam sandstone. The subject was much discussed, and Sir W. E. Logan proceeded, soon afterwards, to examine the geological structure of the region in which the trilobite had been found. Thus the re-investigation of the Taconic question was commenced by the Canadian Survey in the spring of 1859. I consider this a very important step, because, for many years, the views of Dr. Emmons had been regarded as constituting a theory so utterly baseless, that none of the leading geologists could be brought to think it worth a single day's work in the field. Sir W. E. Logan, however, was not of that opinion, and after seeing the trilobite, took to the field at once. Although he did not, at first, find any good reason to depart from what had been considered, for more than twenty years, the true arrangement of the rocks in question, yet he continued the investigation, whenever his other duties would permit, until his final decision was given, on the last day of December, 1860, just twenty months after the trilobite was received by me.

Dr. Hunt, in his address, has omitted to make any allusion to my determination of the primordial character of this trilobite in the spring of 1869, or to the investigation which took place in consequence thereof. On the contrary he gives his readers to understand, as will be seen by a quotation further on, that this important point was first determined by Barrande in 1860. One whole year, during which the Canadian Survey was engaged in the investigation, is thus left out of his address.

The circumstances which led to Barrande's giving an opinion are the following. In the latter part of 1859, Prof. Hall described three species of trilobites from the Vermont locality, including the form I had received from Col. Jewett. He made no allusion to their primordial characters, but referred them, wrongly, to *Olenus*, a genus whose horizon he supposed to be at the summit of the Lower Silurian. He referred the rocks in which they had been found to the upper part of the Hudson River group. This is the position he had always assigned to the Taconic rocks of New-York. The Canadian Survey had long before adopted his opinion; and indeed before the discovery of these trilobites no good reasons had been given to prove that it was not correct. Dr. Emmon's views, although they turned out to be, in part, well founded, had never been supported by good clear evidence.

Previously to the month of April, 1860, I believe that the only palæontologists who had studied these trilobites, were Prof. Hall and myself. He considered them to belong to the summit of the Lower Silurian, while I maintained that they were primordial, and that the rocks in which they had been found, were either at the base of the Lower Silurian or perhaps below that horizon.

On the 25th of April, 1860, just one year after I had received the trilobite from Col. Jewett, I sent a copy of Prof. Hall's pamphlet, containing the figures and descriptions, to Barrande, then in Paris. He had previously written me several times requesting me to furnish him with any facts, within my knowledge, that might have a bearing upon his theory of Colonies. I referred him to these three trilobites, as an example of a group of primordial fossils, in rocks which were considered by American geologists to be of the age of the Hudson River formation. On the 28th of May he wrote me, acknowledging the receipt of the pamphlet and of my letter. He agreed with me that the trilobites were primordial forms, and expressed his doubts that the rocks in which they had been found were of the age of the Hudson River formation. On the 16th of July he addressed a letter to Prof. Bronn of Heidelberg, on the subject. In this letter he stated that he had received the pamphlet from me,—that the trilobites were primordial forms, and calls for "new researches and new studies, that may lead to a final and certain solution of this important question." (This letter was published in the Proceedings of the Boston N. H. Soc., Dec. 1860; in the Am. Jour. Sci., March 1861, and in the Can. Nat. Geol., in April, 1861.)

Thus Barrande did in 1860, exactly what I had done in 1859. He decided that the trilobites were primordial, and that there was reason to doubt that the rocks were of the age of the Hudson River formation. In quoting Barrande's opinion, Dr. Hunt first alludes to my description of the trilobites from Point-Levis in August, 1860, and then says:—

"Just previous to this time, in the Report of the Regents of the University of New-York for 1859, Professor Hall had described and figured by the name of Olenus, two species of trilobites from the Slates of Georgia, Vermont, which Emmons had wrongly referred to the genus Paradoxides. They were at once recognized by Barrande, who called attention to their primordial character, *and thus led to a knowledge of their true stratigraphical horizon*, and to the detection of the singular error in Hisinger's book, already noticed, by which American geologists had been misled."

Now it appears to me that any one reading this paragraph would arrive at the conclusion, that Barrande was the first to perceive that the trilobites were primordial forms. On the contrary, I pointed this out to the officers of our Survey one year previously, and my opinion led to the investigation above alluded to.

Barrande's opinion was given in 1860, and was founded on materials that I sent him. Mine was given and acted upon in 1859, and yet Dr. Hunt makes no allusion to it in any part of his Address, although it was well known to him.

## 2.—*The Point Levis Trilobites.*

In May and June, 1860, a large number of trilobites and other fossils, were discovered in the limestones of Point Levis. I decided that these belonged to a horizon about the age of the

Calciferous and Chazy. On the 12th July I wrote to Barrande on the subject, and informed him that I considered the fossils of the age of those of the base of his second fauna. In August I published figures and short descriptions of the principal species. In this paper the designation "*Hudson River group*" was first discontinued as the name of the formation, and I am happy to state that it has never since been applied to the rocks in question, in any of the publications of our Survey. I had a number of separate copies of my paper printed, and sent one with a letter to each of the following palæontologists and geologists:—M. J. Barrande, Paris; J. W. Salter, Geo. Sur. G. B., London; Dr. B. F. Shumard, St. Louis, Missouri; and Prof. J. M. Safford, Lebanon, Tennessee. All of them agreed with me without any reservation whatever.

Previously to the discovery of these fossils, Prof. Hall had examined the rocks at Point Levis, and had described a number of species of graptolites that had been collected there. In his report he says, "These strata belong to the Lower Silurian series, and are of that part of the Hudson River group which is sometimes designated as Eaton's sparry limestone, being near the summit of the group: they form also the rocks of Quebec."

Dr. Hunt in commenting upon the investigations of Prof. Hall and myself says:—

"The palæontological evidence thus obtained by Billings and by Hall, both from near Quebec and in Vermont, led to the conclusion that the strata of these regions, so much resembling the upper members of the Champlain division, were really a great developement, in a modified form, of some of its lower portions."

Now I object to this mode of stating the matter. It seems to associate Prof. Hall with me in the determination of the age of the rocks in question. Taking this passage, with others that precede it, the reader might suppose that Prof. Hall and I had studied the fossils together, and had arrived at the same conclusion. On the contrary we examined them separately and came to widely different conclusions. He placed them, incorrectly, at the summit of the Champlain group, and I, correctly, at the base.

During the years 1859 and 1860, Sir W. E. Logan made numerous excursions into the disputed territory, and examined a great number of localities, in order to find a clue to the true stratigraphical arrangement. I believe no other physical geologist worked at the problem. I conducted the palæontology throughout. Sir W. E. Logan's final decision was given on the last day of December, 1860, and from that date no one has referred either the Taconic or the Quebec rocks to the Hudson River group.

The Canadian Survey did not originate the Taconic theory, but it exposed and removed from American geology, the enormous error which placed the rocks at the summit of the Lower Silurian. The palæontologists who were consulted by me were, Barrande, Salter, Shumard and Safford, as above mentioned. The others who have made important discoveries bearing upon the subject are the following.

In 1861 Mr. J. Richardson of the Canadian Survey, discovered the Vermont trilobites, at the Straits of Belle Isle and at Bonne Bay, in Newfoundland, in rocks which lie below that part of the Potsdam which holds *Lingula acuminata.*

In the same year the Rev. J. B Perry and Dr. G. M. Hall discovered a new locality of the trilobites, about 1½ miles east of Swanton in Vermont.

Mr. T. C. Weston, of our Survey, collected a nearly perfect head of a species of the same genus at Bald Mountain in New York, in June, 1864.

In July, 1871, Mr. S. W. Ford of Troy, New York, published a short paper in the Am. Jour. Sci., entitled: "Notes on the primordial rocks in the vicinity of Troy, N. Y." This paper was re-published in the Can. Nat. in December 1872. Mr. Ford gave a good description of the rocks of the locality, and announced the discovery of 18 species of fossils, 15 of which were found on comparison to belong to the Taconic fauna. Mr. Ford's paper, with the exception of what Dr. Emmons himself had written, is the most important that has ever been published in the United States on this subject. It consists entirely of original observations, while a large number of the papers that have appeared in the scientific journals, relating to the Taconic rocks, are mere compilations, in which the question is misrepresented, many important facts suppressed, and others presented in a false light.

### 3.—*Determination of the age of the Red Sandrock of Vermont.*

Intimately connected with the Taconic question, is the determination of the Red Sandrock formation of Vermont. This group of rocks forms a chain of low hills, extending nearly the whole length of Lake Champlain, but, in general, situated several miles inland from the eastern shore of the lake. Dr. Emmons, about thirty years ago, referred this formation to the Medina sandstone. He was followed by other geologists, some of whom included in the formation the Oneida conglomerate and the Clinton. He afterwards came to the conclusion that the rocks in question were about the age of the Calciferous or Potsdam. In his American Geology, published in 1855, he sometimes refers it to the former and sometimes to the latter. The view that it was of the age of the Oneida, Medina and Clinton was, however, maintained by all others. The question was finally determined by the fossils, and to these I shall confine myself. A locality of trilobites had been discovered by the late Prof. Z. Thompson in Highgate, near the boundary line, sometime previously to 1847. He pointed out the place to Prof. C. B. Adams, State Geologist of Vermont, who referred some of the specimens to Prof. Hall. The following is his opinion upon them, as it appears in the "Third Annual Report on the Geology of Vermont," by Prof. C. B. Adams, 1847, p. 31:

"*Letter from* PROFESSOR JAMES HALL, *on certain Fossils in the Red Sandrock of Highgate.*

ALBANY, N. Y., September 17th, 1847.

"MY DEAR SIR,

I have only now received your letter of the 10th instant, on my return from a geological excursion. I examined the fossils and, as far as I can determine they are all of the central portion of the buckler of a Trilobite, with a prominent narrow lobed glabella. The cheeks have been separated at the facial section, so that we have not the entire form of the head. The course of the facial section indicates that it terminated on the posterior margin of the buckler, and the glabella is narrower in front than behind—these two characters are inconsistent with Calymene, Phacops or Asaphus, the common genera, (as well as with several other genera) of our strata, but they belong to Conocephalus and Olenus. I am inclined to regard this fragment as part of a Conocephalus, of which I have not before detected a fragment in our rock. From its isolated character, therefore, I am able to infer little regarding its real geological position. The form known to me most nearly like this one, is in the Clinton group of this State. I regret that more species could not have been found, or that some forms in the preceding strata could not be obtained to compare with others already known.

The meagre information of the two known species of Conocephalus is likewise an objection to any geological inference from the discovery of a species. All we know is that they are found in Graywacke, in Germany, or elsewhere, and the position of Graywacke is too dubious and ubiquitous to be of any importance in such a case.

I regret exceedingly that I am able to give only this meagre and unsatisfactory information, and also that I have not had the satisfaction of seeing the locality.

I shall see you in Boston next week, if I am able to go there, and will there reply more fully to the other part of your letter respecting N. Y. fossils.

I have prepared nothing for our meeting, but am coming to see what others do.

I am very sincerely, yours, &c.

Prof C. B. Adams. James Hall."

"[Two specimens only have been obtained of a shell, which resembles Atrypa Hemispherica, of the Clinton group of the New-York system. Prof. Hall informs me that he is disposed to assign both the Clinton group and the Medina sand-stone to one geological period.—C. B. A.]"

It is evident from the above that Prof. Hall did not consider the formation to belong to the Potsdam group, but rather to the Medina or Clinton. In 1861, I examined the locality and published the following note in the Am. Jour. Sci., 2nd series, Vol. XXXII, p. 232:

"*On the age of the Red Sandstone formation of Vermont.*
*By* E. Billings.

"I have lately been examining a tract of the Calciferous sandrock which lies on the boundary line between Canada and Vermont, on Missisquoi Bay. The rock is exposed here in long parallel ridges, over an area of eight or nine miles in length and from one to three in width. On the east side of the exposure there is a ridge of greyish sandstone which I traced south across the boundary line, after crossing which it soon becomes interstratified with thick beds of rock of a chocolate red or brown color. It is here the typical red sandrock formation of Prof. Adams. Hearing that Dr. G. M. Hall and Rev. J. B. Perry of Swanton had discovered trilobites near this place, I called upon them and they kindly conducted me to the locality. It is above two miles south of the line and one mile or a little more east of the Highgate Springs. The individual fossils are abundant in the red sandstone, but I could find only two species, a small *Theca* and a *Conocephalites*. Of the latter we found only the head, but the specimens are very numerous and some of them well preserved. The species resembles Bradley's *C. minutus*, but is a little larger, and I think quite distinct therefrom. It is a true primordial type, and if we are to be guided at all by palæontology we cannot regard this rock as lying at the top of the Lower Silurian but at the very base of Barrande's Second Fauna, if not indeed a little lower. It is therefore not the Medina sandstone, but a formation somewhere near the horizon of the Potsdam. This accords exactly with conclusions drawn from the evidence afforded by the fossils discovered by our survey at Quebec last year."

In this paper the formation was first referred to the base of the Lower Silurian on the palæontological evidence. The following notice from C. Hitchcock was published shortly afterwards. (See p. 454 of the vol. last cited):

"*Letter from* C. HITCHCOCK, Esq., *on the first observation of the Fossils of the Red Sandstone formation of Vermont.*

"Eds. Silliman's Journal: As a notice of the Conocephalites from the Red Sandrock series in Highgate, Vt., has appeared in your Journal (Second Series, vol. xxxii, p. 232), it is but just to the dead to state who were the original discoverers of this trilobite. By referring to the Third Annual Rept. Geol. Vt., 1847, pages 14 and 31, it will appear that Prof. Z. Thompson conducted Prof. C. B. Adams to Highgate, where both gentlemen procured a large number of these trilobites. They were sent to Prof. J. Hall in 1847 for determination, who gave them the name Conocephalus, the same genus to which Mr. Billings now refers them. At that time the precise position of the Conocephalus was not known. Nor was Prof. Hall able to give more definite information respecting them in 1858 when I showed him the specimens again.

These trilobites are noticed on pages 339 and 340 of our Third Report on the Geology of Vermont, which will be ready shortly for distribution.

Amherst, Mass., Oct. 23d, 1861."

From the above I think it will be evident that I was the first to decide the age of the red sandrock on palæontological grounds. The locality at Highgate is perhaps not exactly of the age of the typical Potsdam, but nearly of that age.]

## 4.—*Sir R. I. Murchison's Address.*

In a paper entitled "On some points in American Geology," published in the Am. Jour. Sci. 2nd series, vol. xxxi, and in the Can. Nat. & Geol., vol. 6, 1861, Dr. Hunt gave an account of the determination of the age of the Quebec group, and introduced Prof. Hall's researches in such a manner that Sir R. I. Murchison was led to make the following statement in his "Address to the Geological Section of the British Association, at Manchester, Sept. 1861 ":—

"In an able review of this subject, Mr. Sterry Hunt thus expresses himself:—"We regard the whole Quebec group, with its underlying primordial shales, as the greatly developed representatives of the Potsdam and Calciferous groups (with part of that of Chazy), and the true base of the Silurian system." "The Quebec group, with its underlying shales," this author adds (and he expresses the opinion of Sir W. Logan), "is no other than the Taconic system of Emmons;" which is thus, by these authors, as well as Mr. James Hall, shown to be the natural base of the Silurian rocks in America, as Barrande and De Verneuil have proved it to be on the continent of Europe."

The meaning of the above is simply this: that the age of the Quebec group was determined by Sir W. E. Logan, as physical geologist; Prof. Hall, as palæontologist, and by Dr. T. S. Hunt, as chemist and mineralogist, an arrangement very satisfactory to the latter two gentlemen, but not so to myself. Upon reading the address, I resolved to publish same remarks upon it, but on speaking to Sir W. E. Logan, he thought it best that the matter should be rectified by himself. Accordingly he addressed the following letter to the Editors of the Amer. Jour. Science:

"*Letter from* Sir Wm. E. Logan, *Director of the Canadian Geological Survey, on Sir Roderick Murchison's reference to the determination of the age of the Quebec Rocks.*

Montreal, November 27, 1861.

" *To the Editors of the American Journal of Science:*

*Dear Sirs,*—In his address to the Geological Section of the last meeting of the British Association, Sir Roderick Murchison has placed the name of my friend Prof. Hall in such a relation to the Quebec group of rocks, as might lead to the inference that to him was due the credit of having determined its horizon, as adopted by the Geological Survey of Canada. Nothing I am persuaded can be farther from the mind of this distinguished palæontologist than a wish to put forward any claim of this description, as the credit is wholly due to Mr. Billings the Palæontologist of the Canadian Survey.

In 1848 and 1849, founding myself upon the apparent superposition in Eastern Canada of what we now call the Quebec group, I enunciated the opinion that the whole series belonged to the Hudson River group and its immediately succeeding formation; a *Leptæna* very like *L. sericea*, and an *Orthis* very like *O. testudinaria*, and taken by me to be these species being then the only fossils found in the Canadian rocks in question. This view supported Professor Hall in placing, as he had already done, the Olenus rocks of New York in the Hudson River group, in accordance with Hisinger's list of Swedish rocks as given in his Lethæa Suecia in 1837, and not as he had previously given it. But the discovery in 1860 of the Point Lévis fossils enabled Mr. Billings to prove that the rocks of the Quebec group must be placed near the base of the Lower Silurian series instead of at its summit, and it thus became necessary to discover some other interpretation of the physical structure than the one suggested by the visible sequence of the strata.

Although there may be difficulties in regard to detail, the interpretation given in my letter to Mr. Barrande of the 31st December, 1860, will, I am persuaded, turn out to be the right one. Prof. Emmons long ago asserted that the rocks in question in Vermont were older than the Birdseye and Black River formation. In this I now agree with him; while however his interpretation of the structure would make them all older than the Potsdam sandstone, mine would not. But whatever the value of my present interpretation, it might have been some time before I should have been urged to look for it, had it not been for the palæontological skill which Mr. Billings brought to bear on the question. I am, dear Sirs, very truly and respecfully yours,

W. E. LOGAN.'

To the above I shall add two quotations from the last letter I received from Dr. Emmons on the subject of the Taconic system. He was, at the date of this letter, State Geologist of N. Carolina:

"RALEIGH, Feb. 5, 1861.

MR. E. BILLINGS:

"MY DEAR SIR,—I am much obliged to you for your favor of the 30th inst., and especially for the opinions and kind regards which you express. Be assured they are highly appreciated, and the more so seeing that they are rare. I had for years past looked upon the subject with a kind of indifference, until you had expressed to Col. Jewett, opinions favourable to the existence of the lower rocks I had contended for; not indeed that I had any misgivings of the truth of the position I had taken, for that would be impossible from all I had seen, provided there were truth in geology, and that the department were founded on principles. But the real difficulty has always been that geologists would not look at the question at all."

"Be assured that I fully appreciate your kind aid in the matter of the Taconic system, for I think I should have gone down to the grave before it had been acknowledged, except for your active, intelligent, and disinterested labours in the cause."

"Yours truly,

"E. EMMONS."

# ON THE GENUS OBOLELLINA.

By E. Billings, F.G.S.

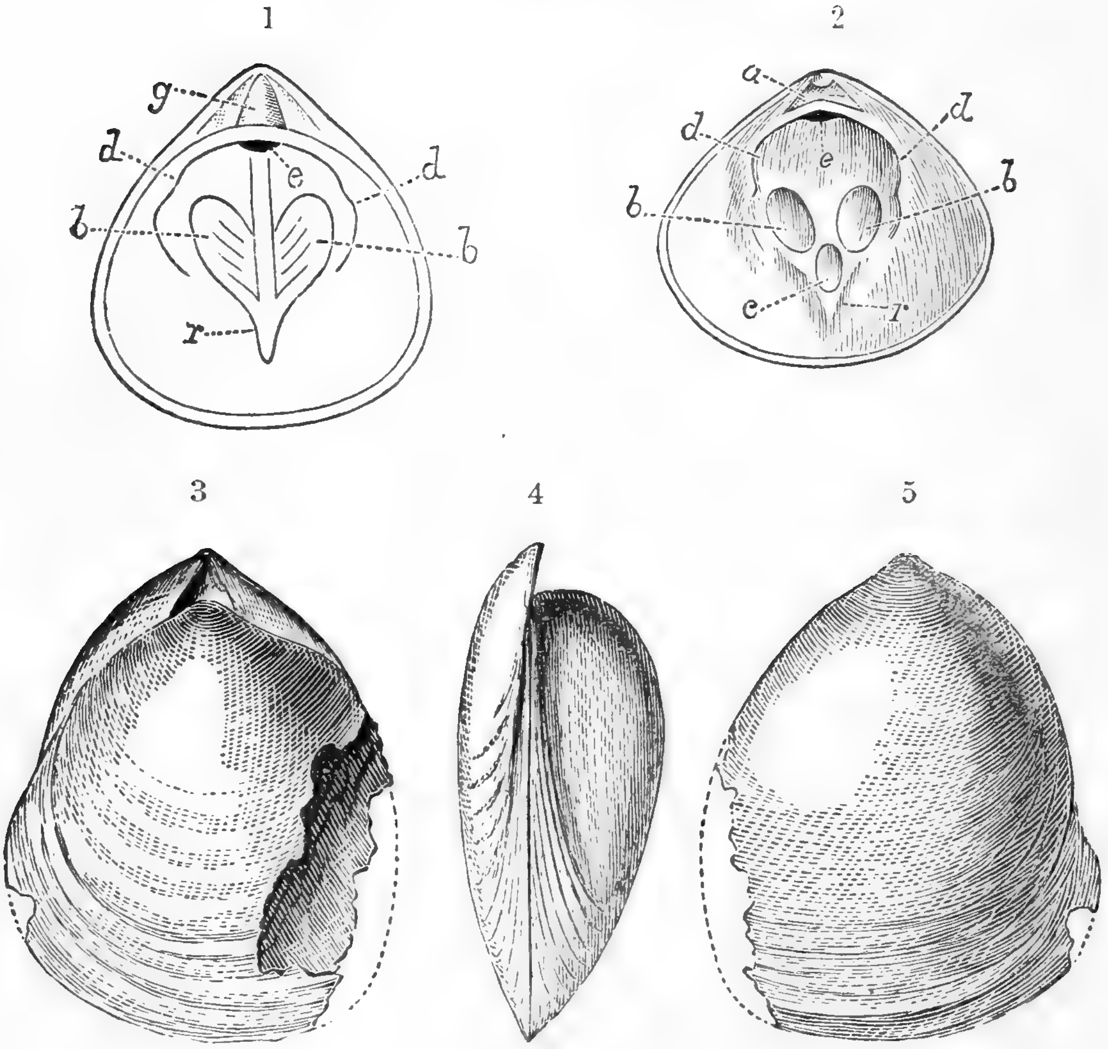


Fig. 1. Dragram of the interior of the ventral valve of a specimen, supposed to be a small individual of *O. Canadensis; bb*, the two large sub-central muscular impressions; *dd*, the groove under the area; *e*, enlargement of the same; *g*, the pedicel groove in the area, on each side of which is a smaller oblique furrow; *r*, the ridge in front of the muscular impressions.

2. Interior of a dorsal valve; *a*, the area; *c*, the pair of small scars in front of the two larger. The other letters, the same as in Fig. 1.

3. Dorsal view of the original specimen.

4. Side view of the same.

5. Ventral view of the same.

A short notice of this genus was published in the last number of this journal, Dec., 1871. I now propose to extend the description, so far as our present material will admit.

(All the figures in this paper are of the natural size.)

## Genus Obolellina, Billings.

*Generic characters.*—Shell, unarticulated, ovate or orbicular, smooth or concentrically striated. Area of the ventral valve with a median groove, on each side of which there is, sometimes, an additional furrow. In the interior of this valve there are two large, ovate, or sub-rhomboidal muscular impressions. They are situated near the centre, but usually (for the greater part) in the posterior half of the shell. They are sometimes obliquely striated or grooved, or obscurely reticulated by both transverse and longitudinal striae. Close under the area there is a fine, but distinctly impressed groove, which curves outwards and forwards, outside of the muscular scars for a greater or less distance towards the front margin. There appears to be an enlargement of this groove, just under the peduncular groove of the area, on the median line, as if for the attachment of a muscle. The large scars are bordered anteriorly, by an elevated margin, which is prolonged forwards, along the median line, in a more or less prominent ridge; this ridge varies greatly in the amount of its developement, in different individuals of the same species, being sometimes almost obsolete.

The area of the dorsal valve varies greatly in size in the different species, and is either flat or with a triangular elevation under the beak like a pseudo-deltidium. Beneath the area there is a fine groove, which curves outwards and forwards, as in the ventral valve, with a similar enlargement in front of the beak. There are two large, ovate, sub-central muscular impressions, with a smaller pair in front of, or between them. These latter are situated on or close to the median line, and usually appear as a single scar, but in some specimens are distinctly divided into two, by a longitudinal ridge. Their form varies in different individuals of the same species. The muscular impressions are margined, anteriorly, by an elevated border, which is extended forwards as an obscure ridge, a greater or less distance towards the front.

In the original notice it is stated, that this genus has no cavities in either valve. This holds good for all the specimens of *O. Canadensis* of which the interior has been seen. In *O. Galtensis*, however, while some of the specimens have no cavities, in others, as is shown by the casts of the interior, there is a small one extending a short distance under the larger muscular scar on each side in the ventral valve. In one of our specimens there is a short cone, half-a-line in length, on the edge of the cast of the cavity. No cavities have yet been observed in the dorsal valve. It thus becomes evident, that the existence or non-existence of these cavities, is not always a character of generic value. Whether it be so or not, in any particular instance, depends upon the extent to which the cavities are developed. They may be so small and rudimentary, as not to be even of specific value. Or they may be so large, as to constitute good sub-generic characters. I have some specimens which seem to show that small cavities also exist in species that, with our present knowledge, can only be referred to the genus *Monomerella*. In a general way, therefore, it may be said that these genera are destitute of cavities, but that, exceptionally, they do occur, and that where such is the case, an approach to the genus *Trimerella* is indicated.

I consider that *Obolellina*, *Monomerella* and *Trimerella*, are merely sub genera of a single great genus, of which the first, as it is the most ancient, and the least specialized, should be regarded as the type. They gradually pass into each other, and no doubt as the number of species increases, it will become more and more difficult to draw lines between them.

The Canadian species are *O. Canadensis*, *O. Galtensis* and *O. magnifica*. The second of these, has the muscular impressions in the dorsal valve of the same form and arrangement as those of the first named. The beak of the ventral valve is very large, its length being one-half that of the body of the shell. It is slightly incurved. The area has three furrows, the peduncular and the two lateral grooves. The muscular impressions are rhomboidal rather than ovate, and confined to the central portion of the shell. There are no cavities under the area.

I am informed that it is now proposed to place *O. Galtensis* in one of Prof. Hall's unpublished genera, presently to be noticed, along with the species described in the 20th N. Y. Reg. Rep. p. 368, under the name of *Obolus Conradi*. It seems to me however, that this latter is a *Trimerella*, or rather one of those forms whose position is near the dividing line between *Trimerella* and *Obolellina*. Prof. Hall has figured the cast of the interior of a ventral valve in Pl. 13, fig. 2, of the work cited. Close to the area there are two short obtuse cones, which are continued towards the front, as two rounded ridges, one on each side of the muscular impressions. The latter extend nearly up to the area, and are separated by a small rounded ridge. These characters are all seen in the cast of the ventral valve of *Trimerella*. They do not occur at all in either of the three species of *Obolellina*.

Prof. Hall's fig. 1 represents the cast of the interior of the dorsal valve of his *Obolus Conradi*, showing that the three muscular impressions are completely concealed by two sub-conical projections, just as they are concealed by the cones in *Trimerella.* I have lying before me fifteen casts of the interior of *O. Galtensis*, and in all of them the three scars are entirely exposed as in fig. 6, below. With all due deference, therefore, I think that *O. Conradi* should be classified in *Trimerella* rather than in the same genus with *O. Galtensis.*

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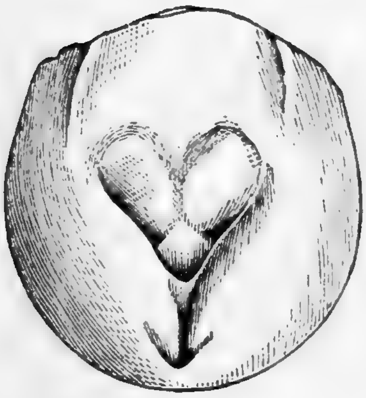

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FIG. 6. The original figure of *O. Galtensis* showing the cast of the interior of the dorsal valve. Compare with Fig. 2. The specimen is imperfect but it shows the casts of the groove *dd*, the two large ovate scars, *bb*, and the smaller pair, *c*, of fig. 2.

8. Dorsal valve of *Obolellina? magnifica.* This was figured in the Report of the Geological Survey of Canada for 1857, published in 1858 as a dorsal valve of *O. Canadensis.* It is, however, a distinct species. The following is the description.

O ? MAGNIFICA, n. sp. Dorsal valve transversely broad ovate; width about one-fourth greater than the length; uniformly and moderately convex; apical angle about 120 degrees; cardinal edges nearly straight, or gently convex for about one-third the length of the shell; sides and front rounded, the latter more broadly than the former. The area seems to be obsolete altogether or merely linear.

The ventral valve is depressed convex with a large beak slightly incurved. Area with a wide triangular peduncular groove; no lateral furrows. Surfaces of both valves concentrically marked with imbricating lines of growth.

In a specimen, which appears to have been about 20 lines in length, the height of the area is nearly 3 lines.

I place this species doubtfully in this genus, because there is in the interior of the dorsal valve, a distinct muscular pit about one line in front of the beak, which does not occur in either of the other two species. In one well preserved specimen this scar is distinctly seen to be divided into two, by a longitudinal ridge. It may be that it represents the small anterior scar (c. fig. 2,) which is certainly variable in form and perhaps, also, in position. In *O. Canadensis*, for instance, the scar, *c*, is sometimes a distinct ovate pit, as shown in fig. 2, entirely separated from the two larger scars, *bb*. In others all three are confluent, or at least in contact, while in one specimen, *c*, is represented by two elongated grooves, separated by a rounded ridge, extending backwards between, *bb*. Some of the figures of the English species *O. Davidsoni*, seem to show that a pit, like that of *O. magnifica*, occurs in one of the valves of that species.

*O. magnifica* occurs in the Black River formation, along with *O. Canadensis*.

## A Question of Priority.

About three weeks after the above genus was published, I received a letter from Thos. Davidson, Esqr., F.R.S. Brighton, England, informing me that it had been previously named, by Prof. Hall in a pamphlet of 5 pages, dated March, 1871. On this subject I beg to make a few remarks.

When I was appointed to the office I now hold, in 1856, Prof. Hall was engaged on his 3rd vol, Pal. N.Y., which relates altogether to the Upper Silurian fossils of the State of New York. Sir W. E. Logan gave me to understand that I was not to describe any Upper Silurian fossils until Prof. Hall should have completed his volume. It was also understood, that I should not describe any species which might occur in New York and not in Canada. To do so was thought to be in the highest degree discourteous and un fair. Species that were found in Canada I could describe, although they might be known to occur in New York also. I have never once transgressed these rules for sixteen years. I have compared a number of collections for parties living in New York but have always declined to describe new species, although frequently urged to do so. There is a person at this present time at work on N. Y. fossils, and I have declined to give him any assistance.

It appears that many years ago, Prof. Hall obtained from Galt, a single specimen of the ventral valve of *O. Galtensis*. This species does not occur at all in New York. In the beginning of 1871, Prof. Hall applied to Mr. Selwyn for the loan of the original specimens of *Trimerella grandis*, stating that he wanted them to elucidate some points in the structure of his *Obolus Conradi*. I consented to the loan of them, and Prof. Hall was informed by Mr. Selwyn that the genus was then under investigation by Mr. Davidson, Mr. Dall and myself. Shortly afterwards he applied for specimens of *Kutorgina* and *O. Canadensis*. I declined to lend the latter as I was then using it. In reply he intimated that he had no desire to take any advantage of me, but only to fortify his own position. It turns out, however, that he was then actually working at *O. Galtensis*, intending to make a new genus on a Canadian specimen. He did not inform Mr. Selwyn of this fact. Ten months afterwards, I heard from Mr. Davidson that Prof. Hall had proposed a new genus *Rhynobolus*, on the Canadian specimen before mentioned, and it then became apparent why he wished to borrow *O. Canadensis*. A question now arises, whether or not his pamphlet was regularly published, previously to the 29th Dec. 1871, the date of the publication of my genus.

I have made extensive enquiries in the United States and Canada, among those who would have been the first to have received it, had it been regularly published, and cannot find one who had ever seen it previously to the 29th December, 1871. I have heard from the Directors of six Geological Surveys, from the Smithsonian Institution, the Academy of Natural Sciences of Philadelphia, the New York Lyceum of Natural History, the Boston Natural History Society, McGill College and the Nat. Hist. Soc. of Montreal, besides a number of geologists and professors in colleges where geology is taught. The general opinion is that it was not published in the United States at all.

Then as to foreign countries, the only copy I have any certain account of, is the one sent to Mr. Davidson. Another is noticed in the Journal of the Geological Society for February, 1872, but the exact date of its reception is not mentioned. The case stands thus.

It is admitted by all that the only test of priority is publication. By this term we must understand the placing of a book or pamphlet on sale, so that it may be accessible to the public by way of purchase.

On the other hand, when an author only gives away several copies of his work to his private friends, this is not publication, but private distribution. Should he even send one to a learned society, whose library is private, it would still not be publication. The work would not be accessible to the public.

My genus was openly and fairly published, on the 29th Dec., 1871, in a scientific journal of good standing, and at all times obtainable by purchase.

Prof. Hall's pamphlet was not published, but only privately distributed to a very few parties.

Although the law (that publication in the true sense of the term is the only test of priority,) should, in general, be rigidly enforced, yet in peculiar cases it admits of a considerable amount of flexibility. It should not always be carried out with a strong hand. Circumstances may render it necessary, in order to do justice, that it should be very strictly adhered to as against one of the parties, and more leniently as regards the other. When one of the disputants has proceeded in an irregular manner; has not published his paper in the ordinary way, in a scientific journal or book obtainable by purchase; and when, in consequence of such irregularity, the difficulty to be settled has arisen, he is to blame, and the law should be strictly enforced. If Prof. Hall had brought out his descriptions of *Rhynobolus* and *Dinobolus*, in any of the scientific journals of this continent, in March, 1871, I would almost certainly have seen it before the month of December, and would not have published my genus. This unfortunate collision would not then have occurred. But instead of following the regular mode of publication he resorted to private distribution, on a most limited scale; not in America but in England. In consequence of this I knew nothing of his genera, until I was informed of them by Mr. Davidson, in a letter which only reached me on the 17th of Jan., 1872, three weeks after my paper was published. It is not, therefore, my fault but his, that a controversy has arisen. Then as regards the Canadian specimen of *O. Galtensis*, he should, before he instituted a genus upon it, have given Mr. Selwyn notice; but instead of this, although he was informed that I was working at the group of fossils to which it belongs, he said nothing about it. It is not my fault that he concealed this from us. If the species occurred in New-York, as well as in Canada, he would not have been under any obligation to give notice, but as it does not occur in that State the case is quite different. It is said that shortly after his paper was printed a part of the edition was destroyed by fire. That is his misfortune, not mine. He should have had it immediately reprinted. I am informed that it could have been done in less than half a day, and at an expense of only four dollars. Surely the rich State of New York could have afforded that amount. A great deal more might be said upon this subject, but the above is quite sufficient to show that it is not my fault that this difficulty has arisen.

In this case I do not desire that the law of publication should be harshly administered, but I insist that the circumstances are such that it should be strictly carried out. Prof. Hall's pamphlet was not regularly published, according to the strict meaning of the law, and as it is altogether his fault, and not mine, the consequences should fall upon him and not upon me. In the common law, when a loss has accrued, which must be sustained by one out of two individuals, it falls upon the one by whose misconduct or neglect of duty it has been occasioned. The same rule holds good in scientific matters, as well as in the ordinary affairs of every-day life. I bestowed a great deal of investigation on my genus, and no doubt Prof. Hall did the same upon his. As matters have turned out, either his work or mine must be lost. On whom must the loss fall? On the party who is to blame, or or on the party who is not to blame? I do not ask to have the law stretched or executed leniently in my favor. I require no such extension in order to obtain justice. I only desire that it should be strictly adhered to, and not distorted in order to favour the party who has been the cause of all this difficulty.

# METEOROLOGICAL RESULTS FOR MONTREAL FOR THE YEAR 1871.

By Charles Smallwood, M.D., LL.D., D.C.L.,
Professor of Meteorology in the University McGill College, Montreal.

The following observations extend over the past year, 1871, and are reduced from the records of the Montreal Observatory, Lat. 45° 36$^{m}$ 17.41$^{s}$ Long. 4$^{h}$ 54$^{m}$ 17$^{s}$ west of Greenwich. The cisterns of the Barometer are 182 feet above mean sea level. The whole of the readings are corrected for any instrumental errors, and the observations of the Barometer are corrected and reduced to 32° F.

*Atmospheric pressure.*—The highest reading of the Barometer occurred at 10$^{h}$ 30$^{m}$ p.m., on the 25th day of January, and indicated 30,985 inches; the lowest reading was at 2$^{h}$ 25$^{m}$ p.m., on the 18th day of February, and was 29,050 inches, giving a range during the year of 1.935 inches.

The following table has been compiled to show the highest and lowest readings, also the monthly mean and monthly range in inches and decimals of an inch:

| *Months.* | *Highest.* | *Lowest.* | *Mean.* | *Range.* |
|---|---|---|---|---|
| January | 30.985 | 29.475 | 30.157 | 1.510 |
| February | 30.549 | 29.050 | 29.882 | 1.499 |
| March | 30.422 | 29.424 | 29.950 | 0.998 |
| April | 30.346 | 29.451 | 29.712 | 0.895 |
| May | 30.261 | 29.460 | 29.937 | 0.801 |
| June | 30.149 | 29.402 | 29.875 | 0.747 |
| July | 30.267 | 29.501 | 29.770 | 0.766 |
| August | 30.301 | 29.642 | 29.976 | 0.659 |
| September | 30.386 | 29.500 | 30.068 | 0.886 |
| October | 30.504 | 29.463 | 29.781 | 1.041 |
| November | 30.456 | 29.382 | 29.936 | 1.074 |
| December | 30.462 | 29.132 | 29.885 | 1.330 |

*Temperature of the Air* F°.—The highest reading of the Thermometer during the year was on the 13th July and was 95°. The lowest was on the 5th February and was 28° (below zero), giving a yearly range or climatic difference of 123°. The mean temperature for the year was 44.53, which is 2.23 degrees higher than the *Isothem* for Montreal deduced from observations extending over a long series of years.

The first frost of autumn occurred on the 8th September.

The warmest month during the year was the month of July, and the coldest February. The mean temperature of the warmest day was 81.70 on the 13th July, and the mean temperature of the coldest day was 13.73 (below zero) on the 5th February.

The following table shows the monthly mean temperature for 1871, with the amount of rain and snow; the snow in this case is not reduced by melting into water, but is the observed depth in inches on the surface:

| *Months.* | *Mean Temp. in F°* | *Highest Temperat'e.* | *Lowest Temperat'e.* | *Rain in inches.* | *Snow in inches.* |
|---|---|---|---|---|---|
| January ..... | 11°04 | 40°1 | – 26°8 | 0.427 | 16.53 |
| February .... | 18°70 | 46°2 | – 28°0 | 0.509 | 8.36 |
| March ....... | 35°25 | 61°6 | 17°0 | 3.059 | 13.49 |
| April ........ | 44°41 | 68°0 | 27°1 | 3.085 | |
| May ......... | 58°59 | 94°5 | 35°4 | 1.570 | |
| June ........ | 67°52 | 92°2 | 48°1 | 1.298 | |
| July ......... | 70°58 | 95°0 | 54°1 | 7.144 | |
| August ...... | 70°67 | 89°6 | 56°7 | 3.066 | |
| September ... | 57°00 | 91°0 | 38°4 | 1.253 | |
| October. ..... | 50°50 | 83°0 | 29°7 | 3.014 | 0.16 |
| November.... | 31°60 | 52°3 | – 6°6 | 1.669 | 9.20 |
| December .... | 18°50 | 46°0 | – 22°9 | 0.413 | 26.79 |

The following table shows the quarterly mean temperature, also the amount of rain and snow in inches for each quarter:

| | *Months.* | *Mean Temp.* | *Rain.* | *Snow.* |
|---|---|---|---|---|
| Winter Quarter. | December.. | 24°35 | 0.203 | 21.95 |
| | January.... | 11°04 | 0.427 | 16.54 |
| | February... | 18°70 | 0.509 | 8.36 |
| *Quarterly mean.* .......... | | 18°03 | 1.139 | 46.84 |
| Spring Quarter. | March ..... | 35°25 | 3.059 | 13.49 |
| | April ...... | 44°41 | 3.085 | |
| | May. ...... | 58°59 | 1.570 | |
| *Quarterly mean.* .......... | | 46°08 | 7.714 | 13.49 |
| Summer Quarter. | June ...... | 67°52 | 1.298 | |
| | July. ...... | 70°58 | 7.144 | |
| | August .... | 70°67 | 3.066 | |
| *Quarterly mean.* .......... | | 69°59 | 11.507 | |
| Autumn Quarter. | September . | 57°00 | 1.253 | |
| | October ... | 50°50 | 3.014 | 0.16 |
| | November . | 31°60 | 1.669 | 9.20 |
| *Quarterly mean.* .......... | | 46°36 | 5.936 | 9.36 |

There were three *cold terms* during the year, one in January, the second in February, and the third in December.

The first was somewhat remarkable for its duration and severity. The temperature was 101$^{h}$ and 20 below zero, and it attained a minimum of 26°8, and the Barometer attained a maximum of 30.985 inches.

The following table will show the variations in temperature and its duration :

*22nd January,* 1871.

| | | | |
|---|---|---|---|
| 7 a.m. | +7°4 | 5 p.m. | — 9°0 |
| 8 " | —4°1 | 6 " | — 9°9 |
| 10 " | —2°6 | 7 " | —10°1 |
| 12 noon | 0°0 | 8 " | —12°3 |
| 2 p.m. | —1°8 | 9 " | —13°1 |
| 3 " | —3°7 | 10 " | —16°0 |
| 4 " | —6°2 | 12 midnight | —18°4 |

*23rd January,* 1871.

| | | | |
|---|---|---|---|
| 2 a.m. | —19°8 | 3 p.m. | —11°7 |
| 4 " | —21°2 | 4 " | —13°3 |
| 6 " | —23°8 | 5 " | —16°7 |
| 7 " | —23°2 | 6 " | —18°0 |
| 8 " | —22°8 | 7 " | —20°0 |
| 9 " | —21°6 | 8 " | —21°1 |
| 10 " | —19°0 | 9 " | —21°9 |
| 12 noon | — 9°2 | 10 " | —22°1 |
| 1 p.m. | — 8°3 | 11 " | —22°8 |
| 2 " | — 7°2 | 12 midnight | —23°2 |

*24th January,* 1871.

| | | | |
|---|---|---|---|
| 2 a.m. | —24°6 | 12 noon | —14°6 |
| 4 " | —25°2 | 2 p.m. | —13°4 |
| 6 " | —26°8 | 4 " | —10°9 |
| 7 " | —25°4 | 6 " | — 9°0 |
| 8 " | —23°3 | 8 " | — 9°0 |
| 9 " | —21°8 | 9 " | — 9°0 |
| 10 " | —19°8 | | |

*25th January,* 1871.

| | | | |
|---|---|---|---|
| 10 p.m. | —14°2 | 12 midnight | —16°0 |

*26th January,* 1871.

| | | | |
|---|---|---|---|
| 2 a.m. | —17°1 | 2 p.m. | —14°0 |
| 4 " | —19°3 | 4 " | —14°2 |
| 6 " | —22°7 | 6 " | —15°0 |
| 7 " | —22°0 | 8 " | —13°6 |
| 8 " | —21°0 | 9 " | —12°4 |
| 10 " | —17°1 | 10 " | —11°0 |
| 12 noon | —15°1 | 12 midnight | —10°2 |

*27th January,* 1871.

| | | | |
|---|---|---|---|
| 2 a.m. | —10°6 | 8 a.m. | — 6°0 |
| 4 " | — 8°0 | 10 " | — 3°8 |
| 6 " | — 7°0 | 12.40 " | — 0°0 |
| 7 " | — 6°6 | | |

The second cold term occurred on the 4th of February and attained a temperature of —28°. The Thermometer was 52h 45m below zero.

The following table contains a record of the observations:

*4th February*, 1871.

| | | | |
|---|---|---|---|
| 12.15 a.m. | —0°0 | 2 p.m. | —5°2 |
| 1 " | —2°1 | 2 40 " | —0°0 |
| 2 " | —8°0 | 4 " | —8°0 |
| 4 " | —11°6 | 6 " | —9°6 |
| 6 " | —15°0 | 8 " | —12°4 |
| 7 " | —14°1 | 9 " | —13°4 |
| 8 " | —13°0 | 10 " | —15°2 |
| 9 " | —12°0 | 11 " | —16°3 |
| 10 " | —8°0 | 12 midnight | —20°6 |
| 12 noon | —4°0 | | |

*5th February*, 1871.

| | | | |
|---|---|---|---|
| 2 a.m. | —22°7 | 2 p.m. | —2°1 |
| 4 " | —26°2 | 3 " | —1°4 |
| 6 " | —28°0 | 4 " | —5°9 |
| 7 " | —27°1 | 5 " | —7°0 |
| 8 " | —25°1 | 6 " | —8°0 |
| 9 " | —22°3 | 8 " | —11°4 |
| 10 " | —19°2 | 9 " | —12°0 |
| 11 " | —17°0 | 10 " | —12°2 |
| 12 noon | —9°2 | 11 " | —11°0 |
| 1 p.m. | —5°3 | 12 midnight | —11°0 |

*6th February*, 1871.

| | | | |
|---|---|---|---|
| 2 a.m. | —10°4 | 8 a.m. | —7°7 |
| 4 " | —10°0 | 9 " | —6°0 |
| 6 " | —9°0 | 10 " | —4°0 |
| 7 " | —8°0 | 11 " | —0°0 |

The third cold term of the 21st December set in with somewhat unusual rapidity. The early part of the evening was bright and moonlight, with but light wind from the N. W. The Thermometer attained its zero point at 8.5 p.m. and at 9 p.m. stood at —1°6. Wind N. W.; velocity 4 miles per hour. Barometer 29.632. At midnight the wind freshened and veered to the W., velocity 12 miles per hour, the Barometer slowly rising, and at 11.49 p.m. (one of the signal hours of the War Department at Washington) it stood at —5°5; at 2 a.m. it stood at —10°6; and from that time it fell rapidly and attained a minimum of —22°9. The Thermometer was 34h below zero.

Below is a table of the observations recorded :

*21st December*, 1871.

| | | | |
|---|---|---|---|
| 8.05 p.m. | — 0°0 | 12 noon | — 8°0 |
| 9 " | — 1°6 | 1 p.m. | — 5°1 |
| 12 midnight | — 5°5 | 2 " | — 2°2 |
| 2 a.m. | —10°6 | 4 " | —12°2 |
| 4 " | —18°4 | 6 " | —12°4 |
| 6 " | —22°9 | 8 " | —12°6 |
| 7 " | —22°4 | 9 " | —12°9 |
| 8 " | —21°0 | 10 " | —12°0 |
| 9 " | —18°4 | 12 midnight | —10°0 |

*22nd December*, 1871.

| | | | |
|---|---|---|---|
| 2 a.m. | — 5°1 | 6 a.m. | — 1°0 |
| 4 " | — 3°4 | 7 " | — 0°0 |

The following table has been compiled to show the number of days in each month on which rain or snow fell, also the number of days without either rain or snow.

| *Months.* | *Days of Rain.* | *Accompanied with Thunder and Lightning* | *Days of Snow.* | *Days without Rain or Snow.* |
|---|---|---|---|---|
| January | 5 | .. | 12 | 14 |
| February | 5 | .. | 10 | 13 |
| March | 8 | .. | 4 | 19 |
| April | 13 | .. | .. | 17 |
| May | 10 | 1 | .. | 21 |
| June | 13 | 3 | .. | 17 |
| July | 18 | 5 | .. | 13 |
| August | 11 | 8 | .. | 20 |
| September | 7 | 1 | .. | 23 |
| October | 10 | .. | 1 | 20 |
| November | 6 | .. | 8 | 16 |
| December | 3 | .. | 21 | 7 |
| Total | 109 | 18 | 56 | 200 |

*Rain* fell on 109 days; it amounted to 26.507 inches, was accompanied by thunder and lightning in 18 days, and shows a large decrease in the usual annnal rain fall.

*Snow* fell on 56 days, amounting to 74.53 inches on the surface, which is equivalent to about 7.450 inches of rain.

The first snow of autumn fell on the 18th October, and the winter fairly set in on the 29th November, with unusual severity, and somewhat earlier than the usual period, causing severe losses to shipping from foreign ports as also to the river navigation.

The Thermometer first attained its zero point on the 29th November.

The ice left the front of the city on the 8th of April, and the first steamer arrived in port on the 10th day. The last frost of spring was on the 26th of April.

*Winds.*—The most prevalent wind during the year was the West, the next in frequency the N. E. The most windy month in the year was May, and the least windy month July.

Below is a table showing the direction of the wind for each month and its mean velocity in miles, irrespective of its direction :

| *Months.* | N | NE | E | SE | S | SW | W | NW | *Calm.* | *Veloc'y* |
|---|---|---|---|---|---|---|---|---|---|---|
| January ..... | 0 | 61 | 0 | 0 | 0 | 6 | 19 | 5 | 0 | 4.82 |
| February..... | 3 | 9 | 0 | 0 | 0 | 19 | 52 | 1 | 0 | 5.77 |
| March....... | 0 | 26 | 0 | 5 | 4 | 7 | 38 | 7 | 6 | 2.86 |
| April......... | 1 | 22 | 0 | 5 | 3 | 14 | 43 | 0 | 2 | 5.04 |
| May .......... | 0 | 39 | 0 | 3 | 0 | 12 | 36 | 0 | 1 | 6.89 |
| June ........ | 0 | 20 | 0 | 0 | 3 | 13 | 54 | 0 | 0 | 1.84 |
| July ........ | 0 | 17 | 2 | 1 | 0 | 16 | 54 | 2 | 1 | 1.84 |
| August ...... | 0 | 23 | 0 | 0 | 9 | 10 | 46 | 5 | 0 | 4.55 |
| September... | 4 | 5 | 1 | 0 | 14 | 7 | 53 | 5 | 1 | 4.34 |
| October ..... | 2 | 13 | 1 | 2 | 12 | 23 | 34 | 6 | 0 | 4.07 |
| November ... | 12 | 19 | 2 | 6 | 5 | 0 | 41 | 4 | 1 | 3.84 |
| December ... | 0 | 13 | 0 | 1 | 0 | 23 | 48 | 7 | 1 | 4.84 |

Mean monthly amount of clouds in decimals, a cloudy sky being represented by a whole number (1.00.)

| *Months.* | *Amount.* | *Months.* | *Amount.* |
|---|---|---|---|
| January ........ | 0.40 | July ............ | 0.40 |
| February ....... | 0.30 | August ......... | 0.30 |
| March .......... | 0.40 | September ...... | 0.30 |
| April ........... | 0.50 | October......... | 0.60 |
| May............ | 0.30 | November....... | 0.60 |
| June ........... | 0.30 | December....... | 0.70 |

There were 138 nights suitable for astronomical purposes during the year.

The aurora borealis was visible at observation hours on 26 nights, and exhibited some grand displays on the 10th and 11th of February, 17th March, 9th of April, 7th of August, 7th of September and the 9th of November.

MONTREAL OBSERVATORY, 30th Jan., 1872.

## PROCEEDINGS OF THE
# NATURAL HISTORY SOCIETY,
*Session* 1871–72.

## MONTHLY MEETINGS.

1st Monthly Meeting, October 30th, 1871,—Principal Dawson presiding.

A donation of a large collection of fossils from Sir G. Duncan Gibb, Bart., M.A., M.D., F.G.S., &c., &c., having been announced by the Recording Secretary, a special vote of thanks to the donor was passed.

Prof. J. B. Edwards made a communication on an insect larva (?) which he stated perforated filters made of silicated carbon.

Mr. J. F. Whiteaves read a paper entitled "Log of a Deep-Sea Dredging Cruise round the Island of Anticosti." This forms the first part of a report submitted by the author to the Hon. the Minister of Marine and Fisheries for publication, the whole of which it is hoped will appear, with the writer's latest corrections, in an early number of this journal.

A paper by Dr. Anderson, entitled "The Whale of the St. Lawrence," was read by the Rec. Secretary. This will be found at pages 203–208 of the present volume.

The following resolutions having been moved by Dr. Smallwood and seconded by G. L. Marler, were unanimously adopted:

"That this Society desires to convey to the Hon. the Minister of Marine its grateful acknowledgments for the aid afforded to its Scientific Curator in the prosecution of his researches into the fauna of the deeper parts of the Gulf of St. Lawrence during the past summer, and to express its confidence that the results will be found to be useful and creditable to Canada, both in a practical and scientific point of view, and such as to encourage a continuation and extension of similar investigations."

"That this resolution be communicated to the Hon. the Minister of Marine, with the assurance that the Society will do all in its power to enable the important scientific results of the expedition to be worked out, and published as extensively as possible."

A copy of the above resolutions was duly forwarded to the Hon. Mr. Mitchell, to which the following reply was returned:

OTTAWA, Nov. 25, 1871.

SIR,—I have to acknowledge the receipt of your letter of the 3rd instant, informing me that at a meeting of the Natural History Society of Montreal, held on the 30th September last, a resolution of thanks was unanimously carried to myself, for the aid which I had afforded the Scientific Curator of the Society in the prosecution of his researches into the fauna of the deeper parts of the St. Lawrence Gulf during the past summer, and I am gratified to find in the second resolution that the Society have confidence "that the results will be found to be useful and creditable to Canada, both in a practical and scientific point of view, and such as to encourage a continuation and extension of similar investigations." I am gratified also to learn that it is the intention of tho Society to "do all in its power to enable the important scientific results of the expedition to be worked out and published as extensively as possible."

While this action of the Natural History Society is personally very gratifying to me, it is also satisfactory to me to be able to state that the Government, in granting the facilities which your Society asked for during the past season, performed an act which, I believe, commended itself to the intelligence of the country, and I have no doubt that the action of the researches of the Society in the future, directed as they are by intelligence and scientific skill, will always command the use of similar facilities such as those referred to at the command of the Government. It will afford me much pleasure to notice the result of your labours, if furnished therewith, in the annual report of my Department.

I have the honor to be,
Yours, &c.,

P. MITCHELL.

J. F. WHITEAVES, Esq., F.G.S.,
Montreal.

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2nd Monthly Meeting, Nov. 29th, 1871.

The Most Rev. the Bishop of Montreal and Metropolitan, Rev. Charles Chapman, M.A., Drs. Eneas, Leprohon, Wilkins and McEachran, and Messrs. T. Wright, W. S. Walker, Alexander Robertson, Thomas Curry, S. B. Scott, H. Mott, N. Mercer, F. W. Hicks, M.A., and J. Dey, B.A., were elected Members of the Society.

Prof. Nicholson's paper "On the Colonies of M. Barrande," was presented; and Mr. Billings gave a popular exposition of Prof. Barrande's views. The article referred to will be found on page 188. Dr. T. Sterry Hunt then made a communication "On the Geological Structure of Mont Blanc." An article on this subject, by Dr. Hunt, entitled "On Arctic Geology," will be found in the American Journal of Science and Arts, for January, 1872.

3rd Monthly Meeting, Jan. 29th, 1872.

The Secretary announced a donation of more than 120 volumes of the Zoological Catalogues of the British Museum, from the Trustees of that Institution, to whom a special vote of thanks was unanimously voted.

Prof. G. F. Armstrong, M.A., F.G.S., and Dr. B. J. Harrington were elected ordinary members, and Sir G. Duncan Gibb, Bart., M.A., M.D., LL.D., &c., a corresponding member of the Society.

Principal Dawson made a communication on the Physical Geography of Prince Edward Island. The paper commenced with noticing the form and geographical position of the Island as a crescent-shaped and much indented expanse of undulating and fertile land, more than 100 miles in length, lying in the almost semicircular bend formed by the southern side of the Gulf of St. Lawrence, and separated from the neighbouring coasts of Nova Scotia and New Brunswick by Northumberland Strait. The principal geological formations are the Triassic red sandstones, the almost equally red sandstones of the Upper Carboniferous rocks, which extend across from Nova Scotia and New Brunswick, and appear in limited areas on the West Coast and in Hillsborough Bay. The soil of the Island is almost throughout a fertile red loam, and the beautifully undulating surface, bright green fields contrasting with the red soil, frequent groves and belts of trees, and neat homesteads, give an appearance of beauty and rural comfort not surpassed by any portion of America. The Island is said to be more thickly peopled and more highly cultivated than any other portion of British America of equal extent. Its climate is much more mild and equable than that of Eastern Canada. In July last the horse-mowing machines, which are almost universally used, were to be seen everywhere laying down a crop of hay not to be surpassed in any country, and the wide fields of clean and tall oats presented a magnificent appearance. The potato and turnip are largely cultivated, and wheat to a less extent. In the end of July, however, the author visited a field on the estate of the Hon. Mr. Pope, where a very heavy crop of winter wheat was being cut. The natural fertility of the soil is largely aided by the application to it of mussel or oyster mud obtained in inexhaustible quantities from the old oyster beds of the bays and creeks, by means of dredging machines mounted on rafts in summer and on the ice in winter.

Prince Edward Island possesses excellent sandstone for building, abundance of brick clay, and large deposits of valuable peat. The Coal Formation rocks underlie the whole of the Island, but are probably at a depth too great to permit their profitable exploration at present. Iron, copper, and manganese ores in small quantities occur, but are insufficient for mining purposes. There are beds of useful though impure limestone. Fossil plants, as trunks of coniferous trees and leaves of ferns, occur in great abundance in the beds of the Upper Coal formation, and a few fossil plants occur in the Trias, among them a stem of a cycad, the first discovered in these Provinces. The most remarkable fossil of the latter formation is the large and formidable reptile *Bathygnathus borealis*, an ancient inhabitant of Prince Edward Island, comparable with the great Saurians, which have left their remains in rocks of similar age in the old world. The boulder formation occurs in Prince Edward Island, and in its upper portion includes boulders which must have been drifted from Labrador on the one hand and New Brunswick on the other. Another very remarkable feature of the modern geology is the great extent of sand dunes or hills of blown sand, along the northern coast. For further details the author referred to a report recently prepared by himself and Dr. Harrington, on the geology of this ineres ting and important Province.

After the reading of this paper, Dr. T. Sterry Hunt made some commendatory remarks on its general scope and scientific aspect, and pointed out that in this Island we have an example of two rock formations resting conformably the one on the other, between which a "lost epoch" (the Permian formation) should have intervened, if the succession of rocks had been unbroken. Dr. B. J. Harrington also gave an account of the peat formations of the Island.

Mr. E. Billings read a paper "On some supposed fossils from the Huronian Rocks of Newfoundland."

These supposed organisms, as they are provisionally regarded, belong to two species, or at any rate present two kinds of appearances, but their affinities are at present exceedingly doubtful. A discussion ensued as to the age of the rocks in which these supposed fossils were found, Mr. Billings maintaining (with Mr. A. Murray, the Director of the Geological Survey of Newfoundland), that they are of Huronian age, and Dr. T. Sterry Hunt, that they are of a newer horizon, and belong to the base of the Primordial zone.

4th Monthly Meeting, Feb. 26th, 1872.

Prof. H. A. Nicholson, of Toronto, was elected a corresponding member of the Society.

A paper by Prof. H. A. Nicholson, entitled Sexual Selection in Man, was presented, and Mr. Darwin's views on that subject, with Prof. Nicholson's comments thereon, were explained and illustrated by Principal Dawson. Prof. Nicholson's paper will appear in the next No. of this journal.

A paper entitled "On the Cultivation of Chenopodium Quinoa," was read by Principal Dawson. This we hope to print also in our next number.

Dr. P. P. Carpenter made a communication "On the present condition and causes of the Montreal Death Rate."

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## SOMERVILLE LECTURES.

The six Annual Lectures of the Somerville Course were duly delivered as follows:

1. Feb. 8th, 1872.—On Mont Blanc, by Dr. T. Sterry Hunt, F.R.S.

2. Feb. 15th, 1872.—A New England Clam-Bake, by Dr. P. P. Carpenter.

3. Feb. 22nd, 1872.—Applied science as illustrated in the processes of Chromo and Photo-Lithography, by Prof. J. B. Edwards, Ph. D., D.C.L., &c.

4. March 7th, 1872.—The elementary principles of Spectrum Analysis, by Prof. G. F. Armstrong, M.A., F.G.S.

5. March 14th, 1872.—On Thermometers and other measures of Heat, by Dr. G. P. Girdwood.

6. March 21st, 1872.—On Fossil Foot-prints, by Principal Dawson, LL.D., F.R.S., &c.

# GEOLOGY AND MINERALOGY.

On the Structure of the Palæozoic Crinoids.—The best known living representatives of the Echinoderm class Crinoidea are the genera *Antedon* and *Pentacrinus*—the former the feather stars, tolerably common in all seas; the latter the stalked sea-lilies, whose only ascertained habitat, until lately, was the deeper portion of the sea of the Antilles, whence they were rarely recovered by being accidentally entangled on fishing-lines. Within the last few years Mr. Robert Damon, the well-known dealer in natural history objects in Weymouth, has procured a considerable number of specimens of the two West Indian *Pentacrini*, and Dr. Carpenter and the author had an opportunity of making very detailed observations both on the hard and the soft parts. These observations will shortly be published.

The genera *Antedon* and *Pentacrinus* resemble one another in all essential particulars of internal structure. The great distinction between them is, that while *Antedon* swims freely in the water, and anchors itself at will by means of a set of "dorsal cirri," *Pentacrinus* is attached to a jointed stem, which is either permanently fixed to some foreign body, or, as in the case of a fine species procured off the coast of Portugal during the cruise of the *Porcupine* in the summer of 1870, loosely rooted by a whorl of terminal cirri in soft mud. Setting aside the stalk, in *Antedon* and *Pentacrinus* the body consists of a rounded central disc and ten or more pinnated arms. A ciliated groove runs along the "oral" or "ventral" surface of the pinnules and arms, and these tributary brachial grooves gradually coalescing, terminate in five radial grooves, which end in an oral opening, usually subcentral, sometimes very excentric. The œsophagus, stomach, and intestine coil round a central axis, formed of dense connective tissue, apparently continuous with the stroma of the ovary, and of involutions of the perivisceral membrane; and the intestine ends in an anal tube, which opens excentrically in one of the inter-radial spaces, and usually projects considerably above the surface of the disc. The contents of the stomach are found uniformly to consist of a pulp composed of particles of organic matter, the shields of diatoms, and the shells of minute foraminifera. The mode of nutrition may be readily observed in *Antedon*, which will live for months in a tank. The animal rests attached by its dorsal cirri, with its arms expanded like the petals of a full-blown flower. A current of sea water, bearing organic particles, is carried by the cilia along the brachial grooves into the mouth, the water is exhausted of its assimilable matter in the alimentary canal, and is finally ejected at the anal orifice. The length and direction of the anal tube prevent the exhausted water and the fœcal matter from returning at once into the ciliated passages.

In the probably extinct family Cyathocrinidæ, and notably in the genus *Cyathocrinus*, which the author took as the type of the Palæozoic group, the so-called Crinoidea Tessellata, the arrangement, up to a certain point, is much the same. There is a widely-expanded crown of branching arms, deeply grooved, which doubtless performed the same functions as the grooved arms of *Pentacrinus*; but the grooves stop short at the edge of the disc, and there is no central opening, the only visible apertures being a tube, sometimes of extreme length, rising from the surface of the disc in one of the inter-radial spaces, which is usually greatly enlarged for its accommodation by the intercalation of additional perisomatic plates, and a small tunnel-like opening through the perisom of the edge of the disc opposite the base of each of the arms, in continuation of the groove of the arm. The functions of these openings, and the mode of nutrition of the crinoid having this structure, have been the subject of much controversy.

The author had lately had an opportunity of examining some very remarkable specimens of *Cyathocrinus arthriticus*, procured by Mr. Charles Ketley from the Upper Silurians of Wenlock, and a number of wonderfully perfect examples of species of the genera *Actinocrinus*, *Platycrinus*, and others, for which he was indebted to the liberality of Mr. Charles Wachsmuth, of Burlington, Ohio, and Mr. Sydney Lyon, of Jeffersonville, Indiana; and he had also had the advantage of studying photographs of plates, showing the internal structure of fossil crinoids, about to be published by Messrs. Meek and Worthen, State Geologists for Illinois. A careful examination of all these, taken in connection with the description by Prof. Lovén, of *Hyponome Sarcii*, a recent crinoid lately procured from Torres Strait, had led him to the following general conclusions.

In accordance with the views of Dr. Schultze, Dr. Lütken, and Messrs. Meek and Worthen, he regarded the proboscis of the tesselated crinoids as the anal tube, corresponding in every respect with the anal tube in *Antedon* and *Pentacrinus*, and he maintained the opinion which he formerly published (Edin. New Phil. Jour. Jan. 1861), that the valvular "pyramid" of the Cystideans is also the anus. The true mouth in the tesselated crinoids is an internal opening vaulted over by the plates of perisom, and situated in the axis of the radial system more or less in advance of the anal tube, in the position assigned by Mr. Billings to his "ambulacral opening." Five, ten, or more openings round the edge of the disc lead into channels continuous with the grooves in the ventral surface of the arms, either covered over like the mouth by perisomatic plates, the inner surface of which they more or less impress, and supported beneath by chains of ossicles; or, in rare cases (*Amphoracrinus*), tunnelled in the substance of the greatly thickened walls of the vault. These internal passages, usually reduced in number to five by uniting with one another, pass into the internal mouth, into which they doubtless lead the current from the ciliated brachial grooves.

In connection with different species of *Platyceras* with various crinoids, over whose anal openings they fix themselves, moulding the edges of their shells to the form of shell of the crinoid, is a case of "commensualism," in which the mollusc takes advantage for nutrition and respiration of the current passing through the alimentary canal of the echinoderm. *Hyponome Sarsii* appears, from Prof. Lovén's description, to be a true crinoid, closely allied to *Antedon*, and does not seem in any way to resemble the Cystideans. It has, however, precisely the same arrangement as to its internal radial vessels and mouth which we find in the older crinoids. It bears the same structural relation to *Antedon* which *Extracrinus* bears to *Pentacrinus*.

Some examples of different tesselated crinoids from the Burlington limestone, most of them procured by Mr. Wachsmuth, and described by Messrs. Meek and Worthen, show a very remarkable convoluted plate, somewhat in form like the shell of a *Scaphander*, placed vertically in the centre of the cup, in the position occupied by the fibrous axis or columella in *Pentacrinus* and *Antedon*. Mr. Billings, the distinguished palæontologist to the Survey of Canada, in a very valuable paper on the structure of the Crinoidea, Cystidea, and Blastoidea (*Silliman's Journal*, January, 1870), advocates the view that the plate is connected with the apparatus of respiration, and that it is homologous with the pectinated rhombs of Cystideans, the tube apparatus of Pentremites, and the sand-canal of Asterids. Messrs Meek and Worthen and Dr. Lütken, on the other hand, regard it as associated in some way with the alimentary canal and the function of nutrition.

The author strongly supported the latter opinion. The perivisceral membrane in *Antedon* and *Pentacrinus* already alluded to, which lines the whole calyx, and whose involutions, supporting the coils of the alimentary canal, contribute to the formation of the central columella, is crowded with miliary grains and small plates of carbonate of line; and a very slight modification would convert the whole into a delicate fenestrated calcareous plate. Some of the specimens in Mr. Wachsmuth's collection show the open reticulated tissue of the central coil continuous over the whole of the interior of the calyx, and rising on the walls of the vault, thus following almost exactly the course of the perivisceral membrane in the recent forms. In all likelihood, therefore, the internal calcareous network in the crinoids, whether rising into a convoluted plate or lining the cavity of the crinoid head, is simply a calcified condition of the perivisceral sac.

The author was inclined to agree with Mr. Rofe and Mr. Billings in attributing the functions of respiration to the pectinated rhombs of the Cystideans and the tube apparatus of the Blastoids. He did not see, however, that any equivalent arrangement was either necessary or probable in the crinoids with expanded arm, in which the provisions for respiration, in the form of tubular tentacles and respiratory films and lobes over the whole extent of the arms and pinnules, are so elaborate and complete.—*Abstract of a paper read before the Royal Society of Edinburgh, by Prof. Wyville Thomson, April* 3, 1871. *From "Nature."*

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ON THE SUPPOSED LEGS OF THE TRILOBITE, ASAPHUS PLATYCEPHALUS. By JAMES D. DANA.—(Am. Jour. Sci. May, 1871.) * At the request of Mr. E. Billings of Montreal, I have recently examined the specimen of *Asaphus platycephalus* be-

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* In the last number of this Journal, p. 227, an abstract from the Report of the Committee of the Brit. Association on Fossil Crustacea was published, and this paper should have appeared at the same time. In the March number of the Am. Jour. Sci., Prof. Dana has given a second notice, in reply to Mr. Woodward. We shall publish them both together.

longing to the Canadian Geological Museum, which has been supposed to show remains of legs. Mr. Billings, while he has suspected the organs to be legs so far as to publish on the subject, * has done so with reserve, saying, in his paper, "that the first and all-important point to be decided, is whether or not the forms exhibited on its under side, were truly what they appeared to be, locomotive organs." On account of his doubts, the specimen was submitted by him during the past year to the Geological Society of London; and for the same reason, notwithstanding the corroboration there received, he offered to place the specimen in my hands for examination and report.

Besides giving the specimen an examination myself, I have submitted it also to Mr. A. E. Verrill, Prof. of Zoology in Yale College, who is well versed in the invertebrates, and to Mr. S. I Smith, assistant in the same department, and excellent in crustaceology and entomology. We have separately and together considered the character of the specimen, and while we have reached the same conclusion, we are to be regarded as independent judges. Our opinion has been submitted to Mr. Billings, and by his request it is here published.

The conclusion to which we have come is that the organs are not legs, but the semi-calcified arches in the membrane of the ventral surface to which the foliaceous appendages, or legs, were attached. Just such arches exist in the ventral surface of the Macroura, and to them the abdominal appendages are articulated.

This conclusion is sustained by the observation that in one part of the venter three consecutive parallel arches are distinctly connected by the intervening outer membrane of the venter, showing that the arches were plainly *in the membrane*, as only a calcified portion of it, and were not members moving free above it. This being the fact, it seems to set at rest the question as to the legs. We should add, however, that there is good reason for believing the supposed legs to have been such arches in their continuing of nearly uniform width almost or quite to the lateral margin of the animal; and in the additional fact, that, although curving forward in their course toward the margin, the successive arches are about equidistant or parallel, a regularity of position

* Q. J. Geol. Soc., No. 104, p. 479, 1870, with a plate giving a full-sized view of the under surface of the trilobite, a species that was over four inches in length.

not to be looked for in free-moving legs. The curve in these arches, although it implies a forward ventral extension on either side of the leg-bearing segments of the body, does not appear to afford any good reason for doubting the above conclusion. It is probable that the two prominences on each arch nearest the median line of the body, which are rather marked, were points of muscular attachment for the foliaceous appendage it supported.

With the exception of these arches, the under surface of the venter must have been delicately membranous, like that of the abdomen of a lobster or other macrouran. Unless the under surface were in the main fleshy, trilobites could not have rolled into a ball.

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Supposed Legs of Trilobites.—Mr. Henry Woodward, of the British Museum, in a reply to the paper by the writer in volume i, p. 320, of the present series of this Journal, supports the view that the supposed legs are real legs. He says that the remark that the calcified arches were plainly a calcified portion of the membrane or skin of the under surface is "an error, arising from the supposition that the matrix represented a part of the organism." But Prof. Verrill, Mr. Smith and myself are confident that there is on the specimen an impression of the skin of the under surface, and that this surface extended and connected with the arches, so that all belonged distinctly together.

Moreover the arches are exceedingly slender, far too much so for the free legs of so large an animal; *the diameter of the joints is hardly more than a sixteenth of an inch outside measure; and hence there is no room inside for the required muscles.* In fact, legs with such proportions do not belong to the class of Crustaceans. Moreover the shell (if it is the shell of a leg instead of a calcified arch) is relatively thick, and this makes the matter worse.

We still hold that the regular spacing of these arches along the under surface renders it very improbable that they were legs. Had they been closely crowded together, this argument would be of less weight; but while so very slender, they are a fourth of an inch apart. Mr, Wooward's comparison between the usual form of the arches in a Macrouran and that in the trilobite does not appear to us to prove anything. We therefore still believe that the specimen does not give us any knowledge of the actual legs of the trilobite. Mr. Woodward's paper is contained in vol. vii No. 7, of the Geological Magazine. J. D. D.

3. Note on the Discovery of Fossils in the "Winooski Marble" at Swanton, Vt.; by E. Billings, F.G.S., Palæontologist of the Geol. Surv. Canada.—A few days ago Mr. Solon M. Allis, of Burlington, Vt., visited our museum and informed me that he had a specimen of the Winooski marble of Swanton which contained some fossils. Since then he has sent it to me. It contains, abundantly, a species of *Salterella*, which I believe to be the *S. pulchella* described in my Pal. Foss., vol. i, p. 18. This marble, both at Swanton and St. Albans, seems to underlie the Geologia slates. It is generally of a reddish, mottled color, but sometimes gray or greenish. The limestone at the straits of Belle Isle, in which *S. pulchella* is found, is also red, gray and greenish; and is, I have no doubt, of the same age. At this latter locality it overlies a red or brownish sandstone, conformably, which holds *Scolithus linearis*. I consider the Belle Isle sandstone to be the "Quartz rock" of the Green mountains of Vermont. In that case, the limestone at Belle Isle occupies, stratigraphically, the position of the Stockbridge limestone as represented by Dr. Emmons in his American Geology, part 2, p. 19. On page 19 of the same work, Dr. E., speaking of the Stockbridge limestone, says: "It is reddish at Williamston and is intimately blended with silex." In his Report on the Second Geological District of New York, in 1838, page 232, he gives a section of the rocks at Burlington combined with one of the strata at Port Kent. He there notices a gray limestone (at Burlington) of which he says:—"It is a stratum, which in Berkshire county, and other parts of the country, has generally been placed among the primary rocks; it is identical with the limestone at the base of Saddle mountain, and which covers more or less of the western flank of the Green Mountains." If the limestone to which he alludes is one of the gray varieties of the Winooski marble, then he is most probably right. I believe Mr. Allis's fossils are the first that have been found in the Winooski marble.

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## ZOOLOGY AND BOTANY.

Deep-Sea Dredging in the Gulf of St. Lawrence.—The marine zoology of the deeper parts of the River and Gulf of the St. Lawrence has not been investigated until quite recently. This summer, under the auspices of the Natural History Society of

Montreal, and in consequence of the kindness of the Hon. Peter Mitchell, Minister of Marine and Fisheries for the Dominion (who not only gave me facilities for dredging or board Government vessels, but also caused sufficient rope to be provided for the purpose), depths of from 50 to 250 fathoms were successfully examined. The greatest depth in the Gulf, to the west of the Island of Newfoundland, as given in the Admiralty charts, is 313 fathoms.

The cruise lasted five weeks, the first three of which were spent on board the Government shooner *La Canadienne,* and the remaining two on the *Stella Maris.* The area examined includes an entire circuit round the Island of Anticosti, and extends from Point des Monts (on the north shore of the St. Lawrence) to a spot about half way between the east end of Anticosti and the Bird Rocks. As these investigations were almost necessarily subordinate to the special duties on which the schooners were engaged, in several cases the same ground was gone over twice.

The bottom at great depths generally consists of a tough clayey mud, the surface of which is occasionally dotted with large stones. So far as I could judge, using an ordinary thermometer, the average temperature of this mud was about 37° to 38° Fahrenheit, at least on the north shore. In the deepest parts of the river, on the south shore, between Anticosti and part of the Gaspe Peninsula, the thermometer registered a few degrees higher. Sand dredged on the north shore in 25 fathoms also made the mercury sink to 37° to 38°.

Many interesting Foraminifera and Sponges were obtained, but as yet only a few of these have been examined with any care. A number of Pennatulæ were dredged south of Anticosti; the genus has not been previously recorded, so far as I am aware, as inhabiting the Atlantic coast of America. They were found in mud, at depths of 160 and 200 fathoms, and it seems probable that this species, at least, is sedentary, and that it lives with a portion of the base of the stem rooted in the soft mud. *Actinia dianthus* and *Tealia crassicornis* were frequent in 200 to 250 fathoms. The Echinoderms characteristic of the greater depths are a *Spatangus* (specifically distinct from the common British species), *Ctenodicus crispatus, Ophioglypha Sarcii* (very large), *Ophiacantha spinulosa,* and *Amphiura Holbollii.* Marine worms, of many genera and species, were both numerous and fine. Among the more interesting of the Crustacea were *Nymphon grossipes* (?)

and a species of *Pycnogonum*. Several of the last-named crustaceans were taken at a depth of 250 fathoms, entangled on a swab, fastened in front of a deep-sea lead, which was attached to the rope, a few feet from the mouth of the dredge. This circumstance tends to show that the genus is not always parasitic in its habits. The Decapods, Amphipods, &c., at least those of greatest interest, have not yet been identified. Among the most noticeable of the marine Polyzoa are *Defrancia truncata*, and what appears to be a *Retepora*. Not many species in this group were obtained in very deep water, and those procured were, for the most part, of small size. About six species of Tunicates were collected. Being anxious to have Mr. J. Gwyn Jeffreys' opinion upon the various species of Mollusca during his visit to Montreal, I studied these carefully first, and submitted the whole of them to him for examination. Twenty-four species of Testaceous Mollusca were obtained at depths of from 90 to 250 fathoms. Nearly all of these are Arctic forms, and eleven of them are new to the continent of America.

The following are some of the most interesting of the deep-water Lamellibranchiata :—*Pecta grœnlandicus* of Chemnitz, but not of Sowerby ; * *Arca pectunculoides* Scacchi ; *Yoldia lucida* Loven ; *Y. frigida* * Torell ; *Neœra artica* * Sars ; *N. Obesa** Loven. Among the novelties in the Gasteropoda of the same zone are the subjoined :—*Dentalium abyssorum* Sars ; *Siphonodentalium vitreum* Sars ; *Eulima stenostoma* Jeffreys ; *Bela Trevelyana* Turton*; *Chrysodomus* (*Sipho*) *Sarsii* Jeffreys.* Three Brachiopods occur in the Gulf, of which *Rhynchonella psittacea* and *Terebratella Spitzbergensis* are found in about 20—50 fathoms, and *Terebratula septentrionalis* in from 100—250. A few rare shells were obtained in comparatively shallow water; among them an undescribed *Tellina* (of the section *Macoma*), a new *Odostomia*, and *Chrysodomus* (*Sipho*) *Spitzbergensis** Reeve. Nor were even the Vertebrata unrepresented; from a depth of 96 fathoms off Trinity Bay, a young living example of the " Norway Haddock " (*Sebastes Norvegicus*) was brought up in the dredge. And off Charleton Point, Anticosti, in 112 fathoms, on a stony bottom, two small fishes were also taken; one, a juvenile wolf-fish

* I am indebted to Mr. Jeffreys for the identification of species to which an asterisk is attached. He corroborates also my determination of the remainder.

(*Anarrhicas lupus*) the other a small gurnard, a species of *Agonus*, probably *A. hexagonus* Schneid.

The similarity of the deep-sea fauna of the St. Lawrence to that of the quaternary deposits of Norway, as described by the late Dr. Sars, is somewhat noticeable. *Pennatulæ*, *Ophiura Sarsii*, *Ctenodiscus crispatus*, several Mollusca, &c., are common to both; but on the other hand, the absence of so many characteristic European invertebrates on the American side of the Atlantic should be taken into consideration. The resemblance between the recent fauna of the deeper parts of the St. Lawrence, and that of the Post-pliocene deposits of Canada, does not seem very close, but our knowledge of each is so limited that any generalisations would be premature.—J. F. Whiteaves in "Nature."

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Fish-Nest in the Sea-Weed of the Sargasso Sea.—Extracts from a letter from Professor Agassiz to Prof. Peirce, Superintendent U. S. Coast Survey, dated Hassler Expedition, St. Thomas, Dec. 15, 1871.— * * * The most interesting discovery of the voyage thus far is the finding of a nest built by a fish, floating on the broad ocean with its live freight. On the 13th of the month, Mr. Mansfield, one of the officers of the Hassler, brought me a ball of Gulf weed which he had just picked up, and which excited my curiosity to the utmost. It was a round mass of sargassum about the size of two fists, rolled up together. The whole consisted, to all appearance, of nothing but Gulf weed, the branches and leaves of which were, however, evidently knit together, and not merely balled into a roundish mass; for, though some of the leaves and branches hung loose from the rest, it became at once visible that the bulk of the ball was held together by threads trending in every direction, among the sea-weed, as if a couple of handfuls of branches of sargassum had been rolled up together with elastic threads trending in every direction. Put back into a large bowl of water, it became apparent that this mass of sea-weed was a nest, the central part of which was more closely bound up together in the form of a ball, with several loose branches extending in various directions, by which the whole was kept floating.

A more careful examination very soon revealed the fact that the elastic threads which held the Gulf weed together were beaded at intervals, sometimes two or three beads being close together, or a bunch of them hanging from the same cluster of threads, or they were, more rarely, scattered at a greater distance one from the other. Nowhere was there much regularity observable in the distribution of the beads, and they were found scattered throughout the whole ball of sea-weeds pretty uniformly. The beads themselves were about the size of an ordinary pin's head. We had, no doubt, a nest before us, of the most curious kind; full of eggs too; the eggs scattered throughout the mass of the nest and not placed together in a cavity of the whole structure. What animal could have built this singular nest, was the next question. It did not take much time to ascertain the class of the animal kingdom to which it belongs. A common pocket lens at once revealed two large eyes upon the side of the head, and a tail bent over the back of the body, as the embryo uniformly appears in ordinary fishes shortly before the period of hatching. The many empty egg-cases observed in the nest gave promise of an early opportunity of seeing some embryos freeing themselves from their envelope. Meanwhile a number of these eggs with live embryos were cut out of the nest and placed in separate glass jars to multiply the chances of preserving them, while the nest as a whole was secured in alcohol, as a memorial of our unexpected discovery. The next day I found two embryos in one of my glass jars; they occasionally moved in jerks, and then rested for a long while motionless upon the bottom of the jar. On the third day I had over a dozen of these young fishes in my rack, the oldest of which began to be more active, and promised to afford further opportunities for study.

* * * But what kind of fish was this? About the time of hatching, the fins of this class of animals differ too much from those of the adult, and the general form exhibits too few peculiarities, to afford any clue to this problem. I could suppose only that it would probably prove to be one of the pelagic species of the Atlantic, and of these the most common are Exocœtus, Naucratus, Scopelus, Chironectes, Syngnathus, Monacanthus, Tetraodon and Diodon. Was there a way to come nearer to a correct solution of my doubts?

As I had in former years made a somewhat extensive study of the pigment cells of the skin, in a variety of young fishes, I now resorted to this method to identify my embryos. Happily we had on board several pelagic fishes alive, which could afford means of comparison, but unfortunately the steamer was shaking too much and rolling too heavily, for microscopic observation of even moderately high power. Nothing however, should be left untried, and the very first comparison I made secured the desired result. The pigment cells of a young *Chironectes pictus* proved identical with those of our little embryos.

It thus stands as a well authenticated fact that the common pelagic Chironectes of the Atlantic (named *Chironectes pictus* by Cuvier), builds a nest for its eggs in which the progeny is wrapped up with the materials of which the nest itself is composed; and as these materials are living Gulf weed, the fish-cradle, rocking upon the deep ocean, is carried along as an undying arbor, affording at the same time protection and afterward food for its living freight.

This marvelous story acquires additional interest if we now take into consideration what are the characteristic peculiarities of the Chironectes. As its name indicates, it has fins like hands; that is to say, the pectoral fins are supported by a kind of prolonged, wrist-like appendages, and the rays of the ventrals are not unlike rude fingers. With these limbs these fishes have long been known to attach themselves to sea-weed, and rather to walk than to swim in their natural element. But now that we have become acquainted with their mode of reproduction, it may fairly be asked if the most important use to which their peculiarly constructed fins are put is not probably in building their nest.—*Silliman's Journal.*

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PROF. AGASSIZ'S EXPEDITION.—It is probable that I may have been anticipated, as regards part of the present communication. If not, I believe that many of your readers will be glad to learn the objects with which Prof. Agassiz has started, with Count Pourtales and a distinguished band of skilled observers, on a scientific expedition in the United States' surveying ship *Hassler*, and to receive a brief account of what he has already done at St. Thomas and Barbados, at which places he was obliged to touch, in consequence of defects in the vessel or her machinery.

The Expedition was detained some days at St. Thomas, and the time of the Professor and his assistants was devoted chiefly to the collection and preparation of fishes, with a view to the study of the brain, and the breathing and digestive organs. Several boxes full, preserved in alcohol, were at once shipped to the United States, as the first-fruits of the Expedition.

The party arrived at Barbados on December 26, and spent four days there. The first two were devoted by the Professor to examining and studying the large collection of West Indian shells, marine and terrestrial, of corals, sponges, crustacea, semi-fossil shells of the island, made by the Governor, Mr. Rawson. Of the marine series he wrote in the following terms to Mr. J. G. Anthony, the Curator of the Harvard Museum:—"I am having high carnival. I have found here what I did not expect to find anywhere in the world—a collection of shells in which the young are put up with as much care as the adult, and extensive series of specimens show the whole range of changes of the species, from the formation of the nucleus to the adult." He was particularly struck with the now unique specimen of *Holopus*, lately procured by Mr. Rawson, which was described by Dr. J. E. Gray in the December number of the "Annals of Natural History," and named by him, from a drawing, *H. Rawsoni*, but which Agassiz, who had seen the specimen of D'Orbigny in Paris, before it disappeared, considers to be a normal specimen of *H. Ranzii*, which had only four, instead of five arms. Count Pourtales recognised among the corals several similar to those which he had obtained by dredging in or near the Gulf Stream, and described in the latest No. (4) of the "Illustrated Catalogue of the Museum of Comparative Zoology at Harvard College," the presence of which on the coast of Barbados serves to indicate the close similarity of submarine life in those two distant localities.

The next two days, or rather the night of the next, and the greater part of the following day, were spent in dredging in the neighbourhood, in a depth of 60 to 120 fathoms, about a mile from the shore, whence Mr. Rawson has procured his fine specimens of *Pentacrinus Mülleri*. The *Holopus* was found on the opposite side of the island. The results were beyond the expectations, or even the hopes, of the most sanguine of the party. Only dead fragments of the *Pentacrinus* were obtained, but among the abundant spoils were four specimens of a new genus of Crinoid, without arms on the stem, (like *Rhizocrinus ?*) which remained alive, with the arms in motion, until noon on the following day, under the excited observation of the party. A number of deep-sea corals, alive, crustacea, sea urchins of new species, star fish, sponges (crutaceous, jurassic,) and corallines, &c., and a rich harvest of shells, were obtained. Among these was a splendid live specimen of *Pleurotomaria Quoyana*, F and B, of which genus Chenu writes that only one living species, and of that only one specimen, is known. The animal exhibited remarkable affinities, and the artist accompanying the expedition was able to take several sketches of it. A large *Oniscia*, shaped like *O. cancellata* Sow., but with an orange inner lip (*O. Dennisoni?*), some specimens of *Phorus Indicus* Gmel., a magnificent new species of *Latiaxis*, with many exquisite specimens of *Pleurotoma*, *Fusus*, *Murex*, *Scalaria*, and three or four of *Pedicularia sicula* Sw., with innumerable Pteropods and Terebratulinæ, rewarded these "burglars of the deep." The Professor was delighted, and it was with reluctance he abandoned so rich a field in order to secure his passing through the Straits of Magellan at a right season.

Barbados, January 26. —*From "Nature."*

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AGASSIZ'S DEEP-SEA EXPLORATIONS.—*More about the trilobites.*—The following letter has been received by Prof. Peirce of Harvard College from Prof. Agassiz, giving interesting details respecting some of the results of the researches of the Hassler Expedition:

"RIO, ON BOARD THE HASSLER, Feb. 12, 1872.

"MY DEAR PEIRCE,—On January 18, Pourtales dredged to a very late hour during the night, the weather being more favorable for this kind of work than it had been at any previous time since we left Boston. As I did not dare to remain exposed to the dew, I missed the most interesting part of the proceedings, about which Pourtales will report himself. The next morning, however, I had an opportunity of overhauling the specimens brought up by the dredge, and to my great delight I discovered among them another of those types of past ages, only found nowadays in deep water. The case is entirely new, as the specimen in question belongs to the Pectinidal, a family the relations of which to earlier geological formations have thus far presented nothing especially interesting or instructive, except perhaps the fact that the type of neither is exclusively cretaceous. I wish had within my reach the means of making a full statement of the facts; but I have not the necessary books of reference, and must in this case trust entirely to my memory.

Among the most remarkable species of Pecten, there is a very small one, figured in Goldfuss under the name of Pecten paradoxus, if I remember rightly, and found in the Lias of Germany, which I have always been inclined to consider as the type of a distinct genus on account of its structural peculiarities. As yet nothing like it has been made known among the living shells. Now among the few specimens dredged on this occasion in 500 fathoms depth, off the mouth of the Rio Doce, there was one living specimen of the same type as the Pecten paradoxus, showing particularly, and very distinctly, the prominent radiating ribs rising on the inner surface of the shallow valve to which the fossil is indebted for its specific name. Like the fossil, the living species is of small dimensions, measuring hardly two-thirds of an inch. I hope I may be able to dissect the animal at some future time, and work out the anatomical character of this exceptional type. With it a few other shells, already known to us, from deep waters, were also found; among them, two beautiful species of Pleurotoma, identical with species found in Florida, off Barbados.

In my first letter to you concerning deep-sea dredging, you may have noticed the paragraph concerning crustacea, in which it is stated that among these animals we may expect "genera reminding us of some Amphipods and Isopods aping still more closely the Trilobites than Serolis." A specimen answering fully to this statement has actually been dredged in 45 fathoms, about 40 miles east of Cape Frio. It is a most curious animal. At first sight it looks like an ordinary Isopod, with a broad, short, flat body. Tested by the characters assigned to the leading groups of crustacea, whether we follow Milne Edwards, or Dana's classification, it can, however, be referred to no one of their orders or families. As I have not the works of the authors before me, I shall have to verify more carefully these statements hereafter, but I believe I can trust my first inspection. The general appearance of my new crustacean is very like that of Serolis, with this marked difference, however, that the thoracic rings are much more numerous and the abdomen or pygidium is much smaller. It cannot be referred to the Podopthalmians of Milne Edwards (which corresponds to the Decapods of Dana) because it has neither the structure of the mouth, nor the gills, nor the legs, nor the pedunculated eyes of this highest type of the crustacea; nor can it be referred to the Tetradecapods of Dana (which embrace Milne Edwards's Amphipods and Isopods), because it has more than seven pairs of thoracic limbs; it cannot be referred to the Entomostraca, because the thoracic are all provided with locomotive appendages of the same kind. But it has a very striking resemblance to the Trilobites; it is in fact, like the latter, one of those types, combining the characteristic structural features of other independent groups which I have first distinguished under the name of synthetic types. Its resemblance to the Trilobites is unmistakable, and very striking. In the first place the head stands out distinct from the thoracic regions, as the buckler of Trilobites; and the large, kidney-shaped facetted eyes recall those of Calymene; moreover, there is a facial suture across the cheeks, as in Trilobites, so that, were it not for the presence of the antennæ, which project from the lower side of the anterior margin of the buckler, in two unequal pairs, these resemblances would amount to an absolute identity of structure. As it is, the presence of an hypostome, in the same position as that piece of the mouth is found in Trilobites, renders the similarity to this extinct type of crustacea still more striking, while the antennæ exhibit an unmistakable resemblance to the Isopods.

In view of the synthetic character of these structural features it should not be overlooked that the buckler of our new crustacean, for which I propose the name of Tomocaris Peircei, extends sideways into a tapering point, curved backward over the first thoracic ring, as is the case with a great many Trilobites. The thorax consists of nine rings, seven of which have prominent lateral points, curved backward, like the pleuræ of Olenus, Lichas, &c. The sixth ring is almost concealed between the fifth and seventh, and is destitute of lateral projections, as is also the ninth. These rings are distinctly divided into three nearly equal lobes by a fold or bend on each side of the middle region, so that the thorax has the characteristic appearance of that of the Trilobites, to which the latter owes its name. The legs are very slender, and resemble more those of the Copepods and Ostracoids than those of any other crustacea. There are nine pairs of them, all alike in structure, six of which, however, the anterior ones, are larger than the three last, which are also more approximated to each other. Besides the legs, there is a pair of maxillipeds attached to that part of the buckler which extends back of the facial suture. These maxillipeds resemble the claw of a Cyclops. All these appendages are inserted in that part of the rings corresponding to the bend of the thoracic lobes; so that, if there exists a real affinity between the Trilobites and our little crustacean, and their resemblance is not simply a case of analogy, we ought hereafter to look to a corresponding position for the insertion of the limbs of Trilobites. I do not remember with sufficient precision what Billings, Dana, and Verrill have lately published concerning the limbs of Trilobites, to say now what bearing the facts described above may have upon the subject, as lately discussed in *The Journal of Science.* But of one thing I am satisfied, since I have examined the Tomocaris Peircei—that Trilobites are not any more closely related to the Phyllopods than to any other Entomostracæ, or to the Isopods. In reality, the Trilobites are, like Tomocaris, a synthetic type, in which structural feature of the Tetradecapods are combined with characters of Entomostracæ and other peculiarities essentially their own.

The pygidium or abdomen of Tomocaris is very like the abdomen of the ordinary Isopods with an articulated oar attached sideways and leaf-like respiratory organs upon the under side. The whole pygidium is embraced between the last curved points of the side of the thorax. Owing to these various combinations, I would expect in Trilobites phyllopod-like respiratory appendages under the pygidium only, and slender, articulated legs, with lateral bristles under the thorax, so thin and articulated by so narrow a joint as easily to break off without leaving more than a puncture as an indication of their former presence. It is impossible to study carefully the synthetic types without casting a side glance at those natural groups, which, without being strictly synthetic themselves, have nevertheless characters capable of throwing light upon the whole subject. And in this connection I would say a few words of Apus and Limulus. If I remember rightly, Milne Edwards considers the shield of Limulus as a cephalothorax in which the function of chewing is devolved upon the legs, while he regards the middle region as an abdomen, and the sword-like tail as an appendage *sui generis.* In the light of what proceeds, I am rather inclined to consider the cephalic shield of Limulus as a buckler homologous to that of the Trilobites, and the middle region as a thorax in which the ring show unquestionably signs of a division into lobes as in Trilobites. The tail would then answer to the pygidium. Apus should be compared with the other crustacea, upon the same assumptions as Limulus.—Ever truly your friend,

L. Agassiz.

—*From the New York Tribune.*

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Dredging in Lake Superior under the direction of the U. S. Lake Survey.—Extensive dredgings were undertaken the past season in Lake Superior, from the U. S. steamer

Search, under the direction of Gen. C. B. Comstock, Superintendent of the Lake Survey. Dredging was carried on from the shallow waters, especially along the north shore, down to 169 fathoms, the deepest point known in the lake. In all the deeper parts of the lake, the bottom, as shown both by the dredging and by the soundings executed by the Survey, is covered with an uniform deposit of clay, or clayey mud, usually very soft and bluish or drab in color. Water brought from the bottom at many points was perfectly fresh; that from 169 fathoms gave no precipitate with nitrate of silver. The temperature, everywhere below 30 or 40 fathoms, varied very little from 39°, while at surface (at the time of the observations, during August) it varied from 50° to 55°. The fauna of the bottom corresponds with these physical conditions. In the shallow waters, the species vary with the varying character of the bottom, while below 30 to 40 fathoms, where the deep-water fauna properly begins, the species seem to be everywhere very uniformly distributed. The deep-water fauna, as might be expected from the unfavorable character of the bottom, is meager, and seems to be characterized rather by the absence of many of the shore species than by forms peculiar to itself. Some of the more interesting species occurring in deep water were: *Mysis relicta* Lovén, at various depths from 4 to 159 fathoms; *Pontoporeia affinis* Lindst., at nearly every haul from the shallowest to the deepest; a small undescribed species of *Pisidium*, down to 159 fathoms; several forms of dipterous larvæ, allied to *Chironomus*, down to the same depth; several species of Lumbricoid worms, of the genera *Tubifex*, *Scœnuris*, and an allied genus; and a species of *Hydra*, which was found from the shore down to 159 fathoms. Of these, the *Mysis*, *Pontoporeia*, and *Pisidium* are identical with species found by Dr. Stimpson in his dredging in Lake Michigan, a short account of which was published in the American Naturalist for September, 1870. The species of *Mysis* and *Pontoporeia* I am unable to distinguish from specimens from the Lake Wetter in Sweden. In the Swedish lakes, these species were associated with *Idotœa entomon* and *Gammaracanthus loricatus*, marine species, and were supposed by Lovén to have been derived from ancient marine species left in the lake basins by the recession of the ocean. The occurrence of these forms in Lake Superior, so far removed from the ocean, is certainly a very interesting fact in the geographical distribution of species, but one which I will not attempt to discuss in this brief notice. In the shallow waters many interesting species were obtained. Among these was a new species of *Crangonyx*, a genus closely allied to *Gammarus*, and heretofore known only from a few species found in the fresh waters of the old world, which occurred in 8 to 13 fathoms; and at the same depth, species of *Lumbricus*, *Nephelis*, *Procotyla*, *Gammarus*, *Asellus*, *Limnœa*, *Physa*, *Planorbis*, *Valvata*, *Sphœrium*, *Pisidium*, etc. A full report will soon be published.

S. I. Smith in Silliman's Journal.

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## MISCELLANEOUS.

Award of the Wollaston Medal to Prof. J. D. Dana.—Geological Society, February 16.—Mr. Joseph Prestwich, F. R.S., president, in the chair.—The Secretary read the reports of the council, of the Library and Museum Committee, and of the auditors. The general position of the society was decribed as satisfactory, although, owing to the number of deaths which had taken place among the fellows during the year 1871, the society did not show the same increase which has characterised former years. In presenting the Wollaston gold medal to the Secretary, Mr. David Forbes, for transmission to Prof. Dana, of Yale college, Connecticut, the President said :—"I have the pleasure to announce that the Wollaston Medal has been conferred on Prof. Dana, of Yale College, Newhaven, U.S.; and in handing it to you for transmission to our Foreign Member, I beg to express the great gratification it affords me that the award of the Council ha fallen on so distingnished and veteran a geologist. Prof. Dana's works have a world-wide reputation. Few branches of geology but have received his attention. An able naturalist and a skilful mineralogist, he has studied our science with advantages of which few of us can boast. His contributions to our science embrace cosmical questions of primary importance—palæontological questions of special interest—recent phenomena in their bearings on geology, and mineralogical investigations so essential to the right study of rocks, especially of volcanic phenomena. The wide range of knowledge he brought to bear in the production of his excellent treatise on Geology, one of the best of our class books, embracing the elements as well as the principles of geology, is well known. His treatise on Mineralogy exhibits a like skill in arrangement and knowledge in selection. In conveying this testimonial of the high estimationin which we hold his researches to Prof. Dana, may I beg also that it may be accompanied by an expression how strongly we feel that the bonds of friendship and brotherhood are connected amongst all civilised nations of the world by the one common, the one universal, and the one kindred pursuit of truth in the various branches of science."—Mr. David Forbes, in reply, said that it was to him a great pleasure to have, in the name of Prof. Dana, to return thanks to the society for their highest honour, and for this mark of the appreciation in which his labours are held in England. It had rarely if ever occurred in the history of the society that the Wollaston medal had been awarded to any geologist who had made himself so well known in such widely different departments of the science, for not only was Prof. Dana pre-eminent as a mineralogist, but his numerous memoirs on the Crustaceans, Zoophytes, coral islands, volcanic formations, and other allied subjects, as well as his admirable treatise on general Geology, fully testify to the extensive range and great depth of his scientific researches.—The President then presented the balance of the proceeds of the Wollaston donation fund to Prof. Ramsay, F.R.S., for transmission to Mr. James Croll, and addressed him as follows :—" The Wollaston fund has been awarded to Mr. James Croll, of Edinburgh, for his many valuable researches on the glacial phenomena of Scotland, and to aid in the prosecution of the same. Mr. Croll is also well known to all of us by his investigation of oceanic currents and their bearing on geological questions, and of many questions of great theoretical interest connected with some of the great problems in Geology. Will you, Prof. Ramsay, in handing this token of the interest with which we follow his researches, inform Mr. Croll of the additional value his labours have in our estimation, from the difficulties under which they have been pursued, and the limited time and opportunities he has had at his command."—Prof. Ramsay thanked the president and council in the name of Mr. Croll for the honour bestowed on him. He remarked that Mr. Croll's merits as an original thinker are of a very high kind, and that he is all the more deserving of this honour from the circumstance that he has risen to have a well-recognised place among men of science without any of the advantages of early scientific training; and the position he now occupies has been won by his own unassisted exertions. The

President then proceeded to read his Anniversary Address, in which he discussed the bearings upon theoretical Geology of the results obtained by the Royal Commision on Water-Supply and the Royal Coal Commission. The Address was prefaced by biographical notices of deceased Fellows, including Sir Roderick I. Murchison, Mr. William Lonsdale, Sir Thomas Acland, Sir John Herschel, Mr. George Grote, Mr. Robert Chambers, and M. Lartet.—The ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—President —The Duke of Argyll, K.T., F.R.S. Vice-Presidents—Prof. P. Martin Duncan, F.R.S., Prof. A. C. Ramsay, F.R.S., Warington W. Smyth, F.R.S., Prof. John Morris. Secretaries—John Evans, F.R.S., David Forbes. F.R.S. Foreign Secretary, Prof. T. D. Ansted, F.R.S. Treasurer—J. Gwyn Jeffreys, F.R.S. Council—Prof. T. D. Ansted, F.R.S., the Duke of Argyll, F.R.S., W. Carruthers, F.R.S., W. Boyd Dawkins, F.R.S., Prof. P. Martin Duncan, F.R.S., R. Etheridge, F.R.S., John Evans, F.R.S., Jas. Fergusson, F.R.S., J. Wickham Flower, David Forbes, F.R.S., Capt. Douglass Galton, C.B.,F,R.S., Rev. John Gunn, M.A., J. Whitaker Hulke, F.R.S., J. Gwyn Jeffreys, F.R.S., Sir Chas. Lyell, Bart, F.R.S., C. J. Meyer, Prof. John Morris, Joseph Prestwich, F.R.S., Prof. A. C. Ramsay, F.R.S., R. H. Scott, F. R.S., W. W. Smyth, F.R.S., Prof. J. Tennant, Henry Woodward.

"Nature," 29th Feb. 1872.

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ADDITIONAL NOTE ON OBOLELLINA, &c.—Since the sheet containing my remarks on this genus was printed I have received a letter in which it is stated that Prof. Hall says his paper "was in reality printed in March, 1871, and that he received from twenty-five to thirty copies, from the printer, at that time."—"That he distributed these copies to some learned societies and individuals, having reserved three copies only, and that he sent one to the Geological Society of London, and to other parties whose names he can produce." I do not admit the whole of this statement. I have made extensive enquiries, among the most active and best geologists and naturalists in the United Ststes—men who keep themselves fully informed, as to all books and papers on geology and palæontology published in the country. With a single exception not one of them ever saw, or even heard of the paper until I wrote to them about it. One gentleman, only, sent me a copy on the 12th Feb., 1872, but he did not state when he received it, perhaps, because he did not wish to interfere in the matter. It was probably sent to him after Prof. Hall had seen my paper. The general opinion is that it was not circulated in the United States at all. There is some evidence, of a circumstantial character, to show that the two copies sent to England in September were printed after the month of July with important alterations. The principal objects of requiring a Naturalist to publish, are that others may obtain notice of what species or genera have been named and described; and, also, to afford the public a means of deciding questions of priority without depending upon the word of the author, who is always an interested party. Private distribution is not sufficient for either of these purposes. In this instance all of the six genera, noticed in Prof. Hall's pamphlet, might have been described and published, by as many different authors in the United States in perfect good faith, and without the least suspicion that they had been previously named by any one. Indeed, as he was aware that several were working at the same group, he seems to have concealed his pamphlet from them in order to give them annoyance. How otherwise can we account for the fact, that no copies were sent either to the Smithsonian Institution or to the Canadian Survey?

I am informed that Prof. Hall's genera are to be sustained by two distinguished authors in England. One of them having received a copy of the paper in October, 1871, and knowing that another copy had been sent to the Geological Society of London, about the same time, neither can realize that it was not published. But let us place them in Prof. Hall's position. Suppose that the paper on which they are now engaged relates to a peculiar group of Wenlock fossils. They borrow specimens from the Geological Survey, and are notified by the Director that the palæontologist of the Survey is at work on the same group. Instead of publishing their paper in the Journal of the Geological Society, or in any other scientific journal, they resort to the following extraordinary proceeding. They prepare an abstract of five pages. They send no copies to the Survey, to the Geological Society, to the Royal Society or to any other learned institution in England. They conceal it from the English scientific public altogether. About six months afterwards they send one copy privately to a friend in Russia, and one to the Mineralogical Society there. In consequence of this course, for ten months afterwards not one single member of the Geological Survey, or of the Geological Society, ever hears of the existence of their pamphlet. In the meantime the palæontologist of the British Survey publishes his genus openly and fairly, in the Journal of the Geological Society. Several weeks afterwards he hears from Russia, that it had been previously published in London by the very two gentlemen to whom he had lent the specimens. I cannot believe that British Naturalists in general would consider it right to suppress his work.

I am informed also that Prof. Hall says I have violated the agreement relating to New York fossils, by publishing species found in the United States. This is simply a misrepresentation of the statement of the case. The different Surveys in the United States are quite independant of each other. The Director of any Survey can consult any palæontologist he thinks proper. I have never described a single fossil from any one of the States where Prof. Hall was, at the time, in any way employed. But I have examined a number of species for those Surveys with which he has no connection.

In one of the letters I have received, it is stated with reference to publication, that "No determined rules or laws have been hitherto settled or followed." With the highest respect for the author of this opinion, I cannot agree with him. There are laws which result from the very nature of the circumstances to which they relate. These laws exist perpetually, although not established by legislative enactment, and although they may be disregarded and transgressed by any number of persons. The law of publication is one of these. Every true naturalist feels that such a law does exist, and that it is his duty to observe it. We can scarcely imagine a reason for its non-observance. The loss by fire, urged in this case, is surely not a sufficient excuse, because any scientific journal on the continent would have re-published the pamphlet for Prof. Hall, free of charge. On the other hand, there can be no law in favor of private distribution, for the simple reason that it affords so many facilities for the performance of unfair transactions. If distributed so widely that the requirements of science are satisfied, a book becomes of authority, but this has not been done in the case of Prof. Hall's pamphlet. On the contrary, he seems to have shunned publicity. I am well aware that the law of publication is not always followed. All that I contend for is, that owing to the extraordinary circumstances of the instance under discussion, it should be strictly adhered to.

*Waldheimia septigera and Terebratella septata, identical.*— To the Editor of the American Naturalist.—Sir,—Having in the course of a too short visit to North America been honored by remarkable kindness and attention on the part of my brother naturalists in this great hemisphere, I am rather disappointed at seeing in your excellent periodical a notice of the Report submitted to the Royal Society of London by my colleagues and myself, on the deep-sea exploration of parts of the North Atlantic, in H. M. S. "Porcupine," during the summer of 1869. The writer of that notice, Mr. W. H. Dall, criticises in what I cannot help considering over severe terms my views "in regard of the specific and generic limits of animals;" and he gives as an instance, "*Waldheimia septigera*" and "*Terebratella septata*," which he states belong to different genera, although I have included both under the same specific name. I do not agree with Mr. Dall in his statement. Having had opportunities of examining the types or original specimens of *Terebratula septigera* (Lovén) at Stockholm, and of *Terebratula septata* (Philippi) at Berlin, and having carefully compared these specimens with the published descriptions and figures, I am convinced that both belong not only to the same genus but to the same species. What seems to have been in the mind of Mr. Dall when he penned his hasty critique was that Professor Seguenza of Messina had referred a species of *Terebratella* from the Sicilian tertiaries to Philippi's species and a species of *Terebratula* found in the same formation to Lovén's species. The former may be the *Terebratella Mariæ* of Mr. Arthur Adams from the Japanese seas; the latter I have ascertained to be rather widely distributed in the North Atlantic.

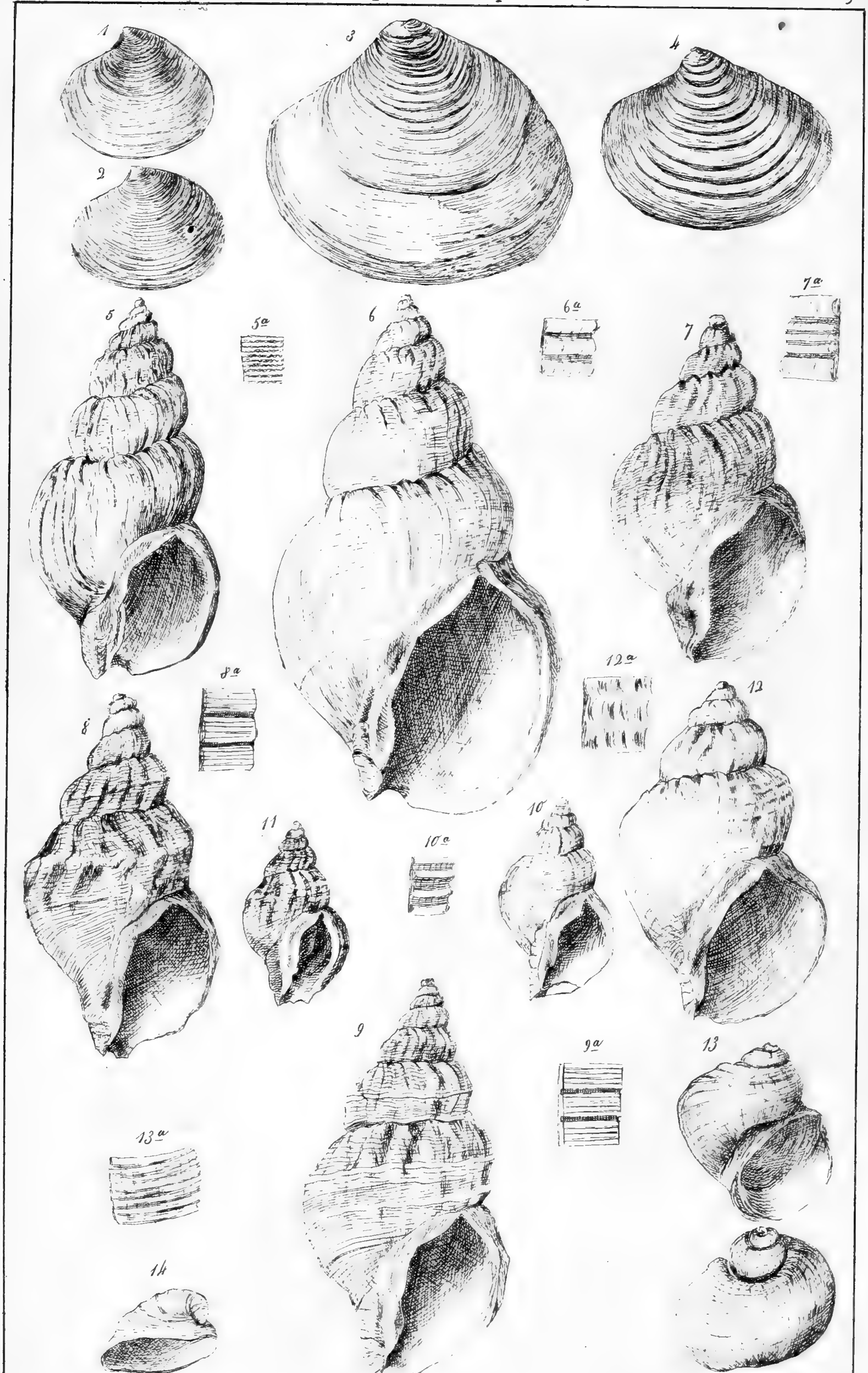
I have the honour to be, Sir,
Your very obedient servant,

J. Gwyn Jeffreys.

Montreal, 6th October, 1871.

Published April, 1872.

Pl. VII. Critical and Rare Post-pliocene Species. (Canadian Naturalist.)




Drawn on Stone, by A.L.D. LEGGO & C^o Lith., Montreal.

## IV. POLYZOON, BRACHIOPODS, AND LAMELLIBRANCHIATES

(Post-pliocene—Canada.)

Fig. 1.

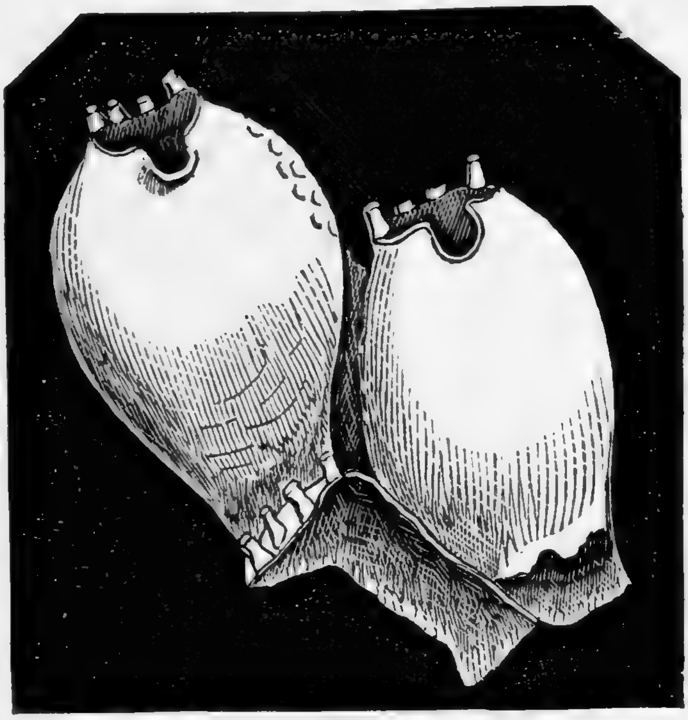


Fig. 2.

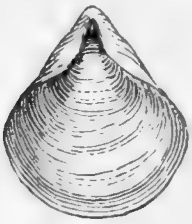


Fig. 3.

Fig. 4.

Fig. 6.

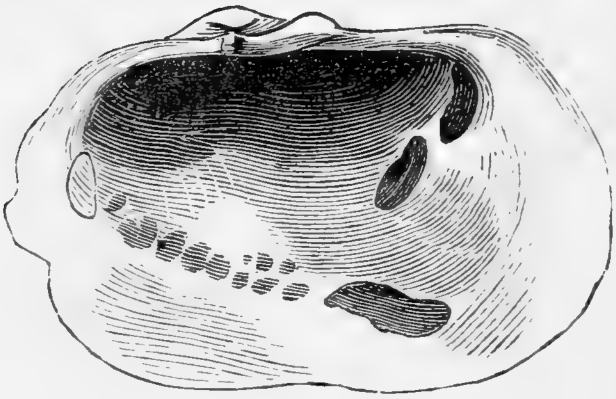


Fig. 5.

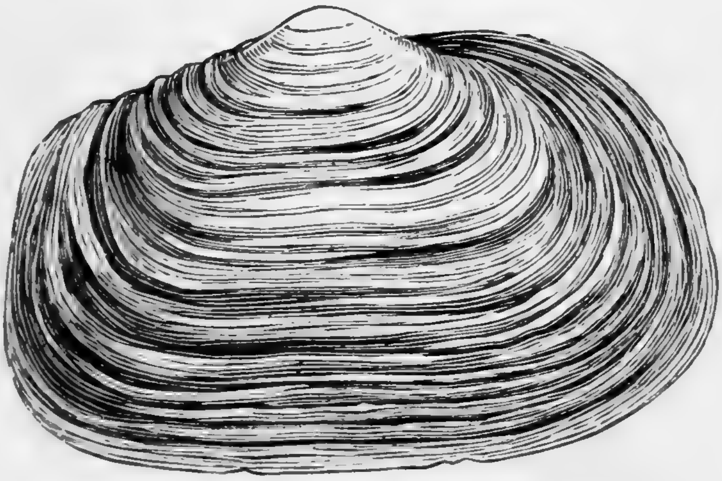


Fig. 7.

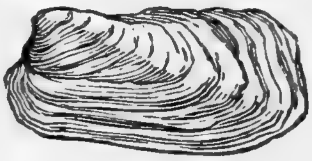


Fig. 8.

Fig. 1. *Lepralia quadricornuta*, Montreal (magnified).
Fig. 2. *Rhynchonella psittacea*, Riviere-du-Loup.
Fig. 3. *Terebratella Spitzbergensis*, Riviere-du-Loup.
Fig. 4. *Mya truncata*—Var. *Uddevallensis*—Montreal.
Fig. 5. *Mya truncata*—Var. *communis*—Portland.
Fig. 6. *Panopea Norvgica*, Riviere-du-Loup.
Fig. 7. *Saxicava rugosa*—Var. *Arctica*—Montreal.
Fig. 8. *Astarte Laurentiana*, Montreal.

Fig. 1.

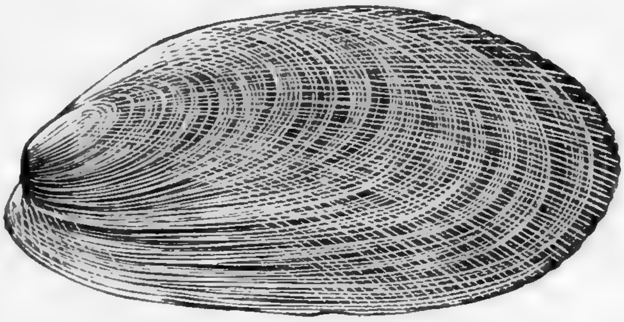
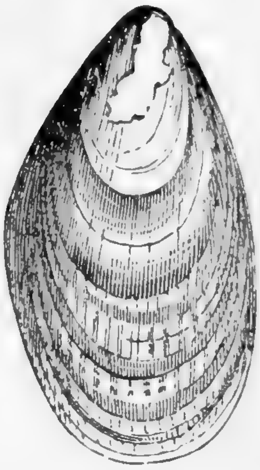


Fig. 2.



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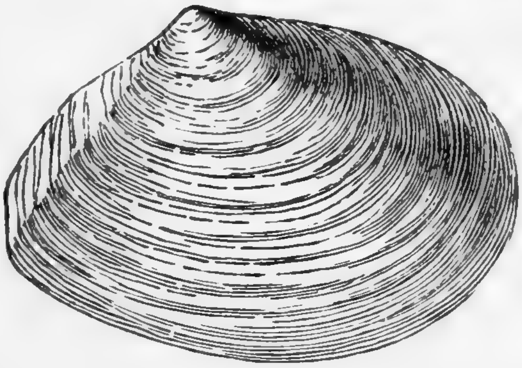
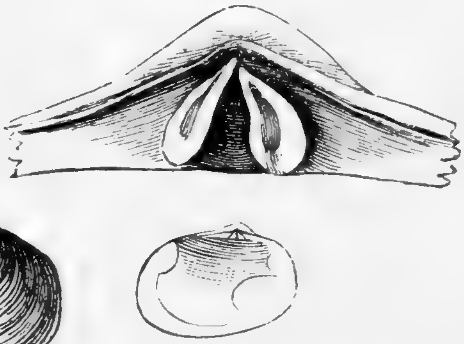


Fig. 5.



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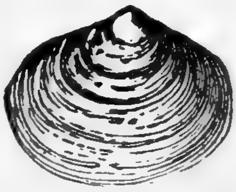

Fig. 6.

Fig. 9.

Fig. 10.

Fig. 7.

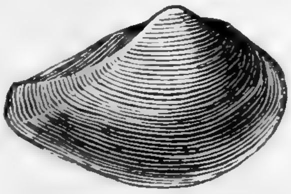

Fig. 11.

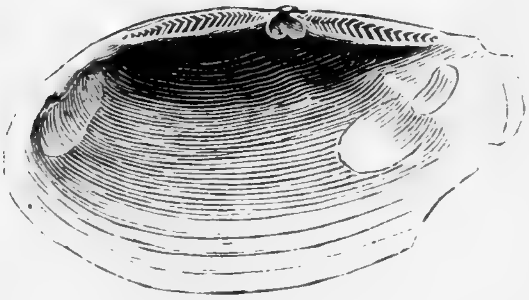

Fig. 8.

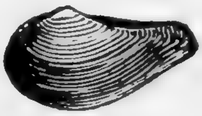

Fig. 1. *Modiolaria nigra*, Portland.
Fig. 2. *Mytilus edulis*—(Var. *elegans*)—Montreal.
Fig. 3. *Macoma calcarea*, Riviere-du-Loup.
Fig. 4. *Macoma Grœnlandica*, Riviere-du-Loup.
Fig. 5. *Macoma inflata*, Riviere-du-Loup.
Fig. 6. *Leda pernula*—(Var. *tenuisculata*)—Riviere-du-Loup.
Fig. 7. *Leda pernula*—(Var. *buccata*)—Riviere-du-Loup.
Fig. 8. *Leda minuta*, Riviere-du-Loup.
Fig. 9. *Leda* (*Portlandia*) *glacialis*, Montreal.
Fig. 10. *Nucula expansa*, Riviere-du-Loup.
Fig. 11. *Leda* (*Yoldia*) *limatula*, Riviere-du-Loup.

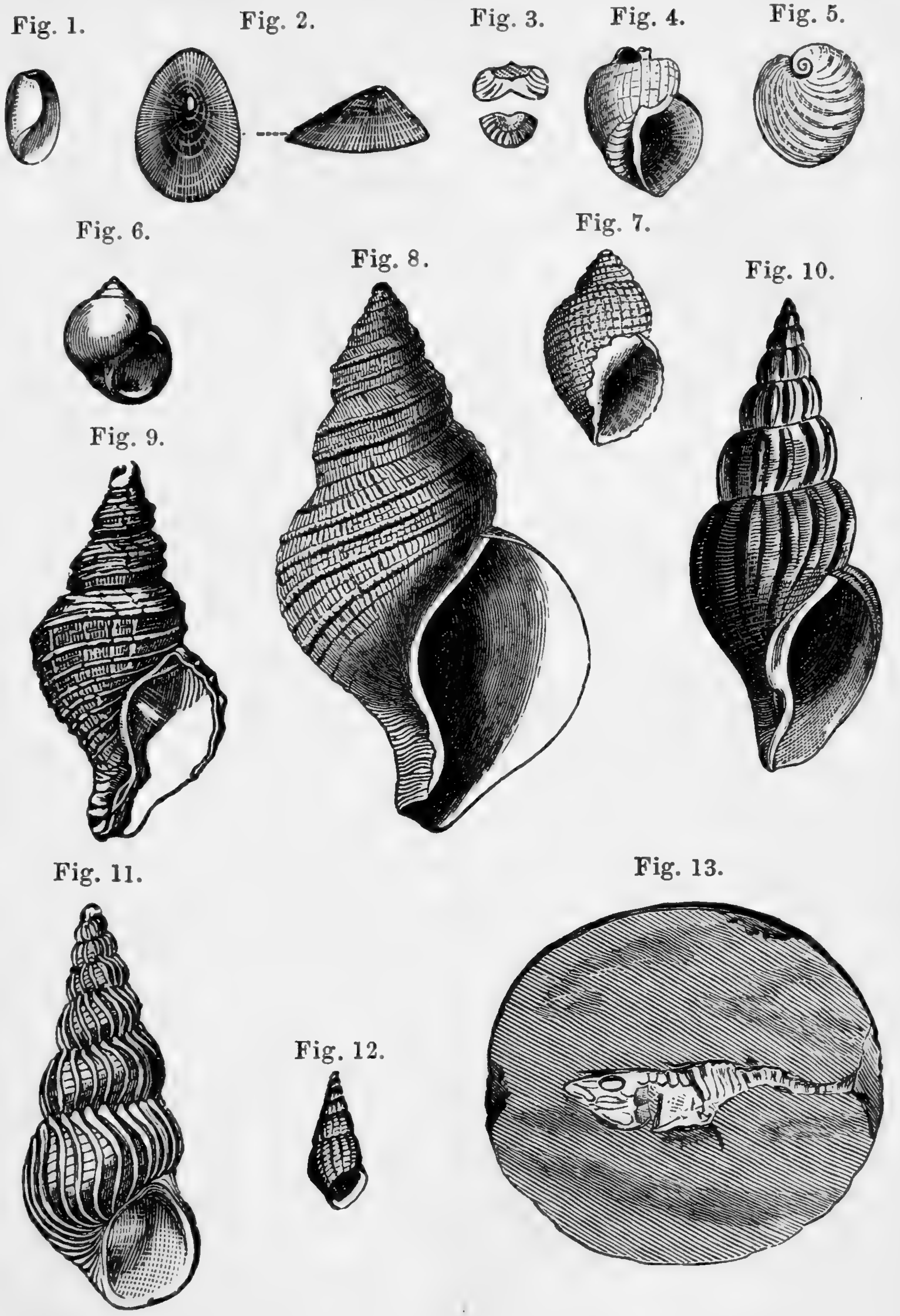


FIG.

1. *Haminea solitaria*, Montreal.
2. *Lepeta cæca*, Montreal.
3. Plates of *Amicula Emersonii*, Montreal.
4. *Trichotropis arctica?* Montreal.
5. *Velutina zonata*, Montreal.
6. *Natica clausa*, Montreal.
7. *Admete viridula*, Montreal.

FIG.

8. *Fusus tornatus*, Montreal.
9. *Fusus tornatus* (Var.), Quebec.
10. *Sipho Kroyeri* (recent specimen, after Packard).
11. *Scalaria Grœnlandica*, Riviere-du-Loup.
12. *Acirsa Eschrichtii*, Quebec.
13. *Gasterosteus*, Green's Creek, Ottawa

## EXPLANATION OF PLATE VII.

This plate, drawn on stone under my own direction, is intended to present, as faithfully as possible, the characters of some of the more rare and critical shells of the Canadian Post-pliocene.

Fig. 1. *Astarte Banksii*—A full-grown specimen of the ordinary type. Riviere-du-Loup.

Fig. 2. *Astarte Laurentiana*—An average full-grown specimen. Montreal.

Fig. 3. *Astarte lactea*—Ordinary type. Portland, Maine.

Fig. 4. *Astarte Elliptica*—A specimen with the ribs extending nearer to the ventral margin than usual. Portland, Maine.

Fig. 5. *Buccinum tenue*—Full-grown specimen. Riviere-du-Loup. 5*a*—Sculpture enlarged.

Fig. 6. *Buccinum cyaneum*—Full-grown specimen. Riviere-du-Loup. 6*a*—Sculpture enlarged.

Fig. 7. *Buccinum undulatum*—(Var. of *undatum*)—Immature shell, broken at lip. Riviere-du-Loup. 7*a*—Sculpture enlarged.

Fig. 8. *Buccinum glaciale*—Tuberculated variety. Riviere-du-Loup. 8*a*—Sculpture enlarged.

Fig. 9. *Buccinum glaciale*—Smooth variety. Riviere-du-Loup. 9*a*—Sculpture enlarged.

Fig. 10. *Buccinum ciliatum*—(Fabricius, not Gould)—Smooth variety, somewhat decorticated. Montreal. 10*a*—Sculpture enlarged.

Fig. 11. *Buccinum ciliatum*—(Fabricius, not Gould)—Small but mature specimen. Recent Murray Bay.

Fig. 12. *Buccinum Grœnlandicum*—Adult specimen. St. Nicholas. 12*a*—Sculpture enlarged.

Fig. 13. *Choristes elegans*—(Carpenter)—Adult specimen. Montreal. 13*a*—Sculpture enlarged.

Fig. 14. *Capulus commodus*—Pt. Levi, Quebec.

THE

# CANADIAN NATURALIST

AND

# Quarterly Journal of Science.

## THE POST-PLIOCENE GEOLOGY OF CANADA.

By J. W. Dawson, LL.D., F.R.S., F.G.S.

### SUB-KINGDOM MOLLUSCA.

*Introductory.*—In preparing this, the largest and most important part of my catalogue, I have to acknowledge my obligations to Dr. P. P. Carpenter, for his kind aid in comparing all the more critical species of shells, and in giving me his valuable judgment as to their relations and synonymy, which I have in nearly every case accepted as final. I am also indebted to Dr. Carpenter for all the notices of West-coast shells.

To Mr. J. F. Whiteaves, F.G.S., I am indebted for reviewing the Polyzoa and comparing them with Smitt's Norwegian catalogues, and also for many valuable facts as to shells obtained in his recent dredgings in the Gulf of St. Lawrence.

To Mr. J. Gwyn Jeffreys, F.R.S., and Mr. R. McAndrew, F.R.S., of London, my grateful acknowledgments are due for aid and information, and also for the opportunity of comparing my specimens with those in their collections.

My comparisons with recent species have been made to a great extent with specimens dredged by myself, in the Gulf of St. Lawrence, and especially at Murray Bay, where the marine fauna seems to be more nearly related to that of the Post-pliocene than in any part of the Gulf of St. Lawrence with which I am acquainted. I have also to acknowledge the use of specimens from Greenland, from Prof. Morch; from Norway from Mr. McAndrew; from Nova Scotia from Mr. Willis; as well as the use of the large and valuable collections of Dr. Carpenter and Mr. Whiteaves.

All the references in the following pages, except where authors are quoted, and many of these last, have been verified by myself by actual comparison of specimens.

The principal works to which I have referred in the publication of the catalogue are the following:

Beechey's Voyage, Natural History Appendix.
Belcher's Last of the Arctic Voyages, do.
Bell, Report on Invertebrata of Gulf of St. Lawrence.
Busk, Polyzoa of the Crag.
Crosskey on Post-pliocene of Scotland.
Fabricius, Fauna Grœnlandica.
Forbes and Hanley, British Mollusca.
Gould, Invertebrata of Massachusetts, edited by Binney.
Jeffreys' British Conchology.
Lyell on Shells collected by Capt. Bayfield; and Travels in North America.
Matthew on Post-pliocene of New Brunswick.
Middendorff, Shells of Siberia.
Packard on the Glacial Phenomena of Labrador and Maine.
Prestwich on the English Crag.
Sars on the Quaternary of Norway.
Stimpson, Shells of Hayes' Expedition, &c.
Whiteaves, Lists of Shells from Gulf of St. Lawrence, Canadian Naturalist.
Wood, Crag Mollusca.
Willis, Lists of Shells of Nova Scotia.

## Class I.—Heterobranchiata.

### Sub-Class I.—*Polyzoa.*

*Hippothoa catenularia*, Jameson.
Fossil—Beauport; Labrador; Rivière-du-Loup.
Recent—Gaspé*; Labrador (Packard).

* The references to Gaspé are from my list contributed to the Rept. Geol. Survey, 1858—Bell and Richardson, collectors; and from subsequent dredgings by myself and Mr. Whiteaves.

*Hippothoa expansa*, Dawson.
Fossil—Beauport; Rivière-du-Loup.
Recent—Gaspé; Labrador, Maine (Packard).

*Tubulipora flabellaris*, Johnston.
Fossil—Beauport; Rivière-du-Loup.
Recent—Gaspé, Labrador (Packard) (= *T. palmata*, Wood).

*Lepralia hyalina*, Johnston.
Fossil—Beauport; Rivière-du-Loup.
Recent—Gaspé.

*Lepralia pertusa*, Thomson.
Fossil—Beauport; Labrador; Rivière-du-Loup.
Recent—Gaspé, Labrador (Packard).

*Lepralia quadricornuta*, Dawson.
Fossil—Leda clay, Montreal.
Not yet found recent.

Mr. T. Curry, of Montreal, has recently found specimens in a very perfect state. They show that the cells are sculptured in a papillo-striate manner, and that the ovi-capsules are globular and granulate. Some cells have a projection for a vibraculum or avicularium at one side of the aperture. A few have two of these. Old colonies have a pitted calcareous deposit between the cells. The large size and narrow aperture with deep sulcas in front and four spines behind are as in the specimens formerly described.

*Lepralia spinifera?* Busk.
Fossil—Rivière-du-Loup.

*L. violacea?* Johnston.
Fossil—Rivière-du-Loup.

It wants the depression in front of the cell said to be characteristic of the species. (J. F. Whiteaves.)

*L. variolosa*, Johnston.
Fossil—Rivière-du-Loup.
Recent—Gaspé.

Dr. Smitt unites this with *L. trispinosa* of Johnston, and considers both as varieties of *L. Jacotini*, Audouin. *L. Jacotini*, Gray, is a very different species. (J. F. W.)

*Lepralia Belli*, Dawson.
Fossil—Rivière-du-Loup.
Recent—Gaspé; Labrador (Packard).

*L. producta*, Packard.
Fossil—Rivière-du-Loup.
Recent—Labrador (Packard); Gaspé; Murray Bay.

*L. globifera*, Packard.
Fossil—Riviére-du-Loup.
Recent—Labrador (Packard).

*L. punctata ?* Hassall.
Fossil—Rivière-du-Loup.
Recent—Gaspé.

The oral spines of this species cannot be made out in the fossil specimens I have seen. Smitt refers Hassall's species to D'Orbigny's sub-genus *Escharipora*. (J. F. W.)

*L. Peachii*, Johnston.
Fossil—Rivière-du-Loup.
Recent—Gaspé.

Rare in the Gulf of St. Lawrence. Smitt groups this species, together with *L. variolosa* (of Busk but *not* of Johnston) and *L. ventricosa*, as forms of *Discopora coccinea*. (J. F. W.)

*Lepralia trispinosa*, Johnston.
Fossil—Rivière-du-Loup.
Recent—Gaspé; Labrador (Packard).

*Lepralia ventricosa*, Hassall.
Fossil—Rivière-du-Loup.
Recent—Gulf St. Lawrence.

*Diastopora obelia*, Johnston.
Fossil—Rivière-du-Loup.
Recent—Gaspé.

*Eschara elegantula*, D'Orbigny.
Fossil—Rivière-du-Loup; Montreal (Curry).
Recent—Labrador (Packard); Gaspé.

Very fine and frequent in 10–30 fathoms opposite Cape Rosier Village. More abundant in the open river than in Gaspé and other bays. (J. F. W.)

*Celleporaria surcularis*, Packard.
Fossil—Rivière-du-Loup.
Recent—Labrador (Packard); Gaspé.

Smitt identifies this species with the *C. incrassata* of Lamarck. Abundant in 10–50 fathoms everywhere in the Gulf, and often drifted down to lower levels. (J. F. W.)

*Myriozoum sub-gracile*, D'Orbigny.

Fossil—Rivière-du-Loup.

Recent—Labrador (Packard); Gaspé.

*Idmonea atlantica*, Forbes.

Fossil—Rivière-du-Loup.

Recent—I believe this to be identical with a species found in the Gulf of St. Lawrence, and referred by Dr. Packard and Mr. Whiteaves to the above.

*Crisia eburnea*, Ellis.

Fossil—Montreal. A specimen collected by Mr. Curry is referred to this species by Mr. Whiteaves.

Recent—Labrador (Packard). In 96 fathoms, Trinity Bay, N. Shore St. Lawrence R. J. F. W.

*Alecto*, sp.

Fossil—Rivière-du-Loup.

*Membranipora Lacroixii*, Busk.

Fossil—Rivière-du-Loup.

Recent—Gaspé; Labrador (Packard).

Entirely agrees with recent examples from Gulf of St. Lawrence. One of the six forms referred by Smitt to *M. lineata* Linn. (J. F. W.)

*Membranipora lineata*, Linn.

Fossil—Rivière-du-Loup.

Recent—Gaspé.

*Discoporella hispida*, Johnston.

Fossil—Rivière-du-Loup. Patches on shells, somewhat worn, but referable to this common North Atlantic species.

## Sub-Class II.—*Brachiopoda.*

*Rhynchonella psittacea*, Gm.

Fossil—Montreal; Beauport; Rivière-du-Loup. Abundant.

Recent—Murray Bay and Gaspé. Abundant. Labrador (Packard); Gulf St. Lawrence. Generally on stony bottoms 10 fathoms and over. Arctic seas generally; also Crag of England and glacial beds.

In a bed of stony clay at Riviére-du-Loup, this shell is very abundant, with less abundant specimens of the next species. It occurs living in precisely the same relations and in great abundance at Murray Bay, in about 20 fathoms.

*Terebratella Spitzbergensis*, Davidson.

Fossil—Rivière-du-Loup.

Recent—Murray Bay; also deeper parts of Gulf of St. Lawrence (Whiteaves); Nova Scotia (Willis).

This species has been found in the Post-pliocene of Canada, hitherto only at Rivière-du-Loup, and is rare. It was called *T. Labradorensis*, Sowerby, in former lists, which seems to be a synonym. It appears to be a rare shell in every part of the Gulf where it has hitherto occurred, except at Murray Bay, where it is not uncommon, and is found attached to stones in 20 to 25 fathoms, associated with *Rhynchonella psittacea*.

### Class II.—Lamellibranchiata.

*Pholas (Zirphea) crispata*, Linn.

Fossil—Maine (Packard).

I have not found this species fossil in Canada, but it exists as a living shell on the New England coast generally, in Northumberland Strait; Gulf of St. Lawrence, and according to Bell as far to the north-west as Rimouski. Puget Sound (U. S. Expl. Exped.)

It has perhaps extended its northern limit to Canada since the glacial period. On the European coast it is a northern shell, reaching south to the Mediterranean.

*Saxicava rugosa*, Linn (and var. *Arctica*).

Fossil—Saxicava sand and top of Leda clay, Montreal; St. Nicholas; Ottawa; Quebec; Murray Bay; Rivière-du-Loup; Trois Pistoles; Tadousac; Labrador; Lawlor's Lake, New Brunswick; Maine, &c.

Recent—Gulf St. Lawrence; coast of Nova Scotia; and New England and northern seas generally; also west coast of America as far as Mazatlan. (P. P. Carpenter).

Very abundant in the more shallow portions of the Post-pliocene throughout Canada, and presenting all the numerous varietal forms of the species in great perfection. It is relatively much more abundant in the drift deposits than in the Gulf of St. Lawrence at present. Pieces of limestone which have been bored probably by this shell, are not rare in the drift at Montreal.

This is a widely distributed Arctic species, and is found in the Post-pliocene deposits of Europe, and as far back as the Miocene.

*Panopœa Norvegica*, Spengler.

Fossil—Leda clay; Rivière-du-Loup. Very rare.

Recent—Dredged in Gaspé Bay, 30 and 40 fathoms, by Mr. Whiteaves; Halifax (Willis); Grand Manan (Stimpson); Arctic and northern seas generally.

It is very rare in the Post-pliocene, a few valves only having been found at Rivière-du-Loup. The specimens are small, and much inferior to those found in the Scottish Clyde beds, of which I have a specimen from Rev. H. Crosskey.

*Mya truncata*, Linn. (and var. *Uddevallensis*).

Fossil—Saxicava sand and Leda clay; Montreal; Quebec; Rivière-du-Loup; Portland; New Brunswick (Matthew); Labrador (Packard); Greenland (Möller); also in the Post-pliocene of Europe.

Recent—Gulf St. Lawrence, but rare in comparison with its abundance in the drift. Generally distributed in the Arctic seas and North Atlantic, American coast as far south as Cape Cod; Puget Sound (=*preciosa*, Gould, P. P. C.)

The variety found in the Post-pliocene of Canada is the short or *Uddevallensis* variety, which is that occurring in the Arctic seas at present, while in the Gulf St. Lawrence the ordinary long variety is found almost exclusively. At Portland, Maine, however, the long variety lived in the Post-pliocene, and occasional specimens are found at Rivière-du-Loup. The form *Uddevallensis* occurs living in Labrador (Packard), and I have found it at Tadousac.

It is interesting to observe that while the present species is more abundant than the next in the Post-pliocene, it is much more rare in the Gulf at present. It also occurs in deeper water.

*Mya arenaria*, Linn.

Fossil—Leda clay and lower part of Saxicava sand; Montreal; Upton; Quebec; Murray Bay; Labrador; Duck cove and Lawlor's lake, New Brunswick; Portland, Maine; Greenland (Möller); also in the Post-pliocene of Europe.

Recent—Very abundant throughout the Gulf St. Lawrence and coast of Nova Scotia and New England, also Arctic seas generally. Mr. Jeffreys considers it identical with *M. Japonica*, Jay. Not found yet in W. America. (P. P. C.)

In the Gulf this species grows to a large size; I have a specimen five inches long from Gaspé; but in the Post-pliocene it is small and often of a short and rounded variety. This is especially the case inland, as at Montreal. At Rivière-du-Loup a small thin variety with a strong epidermis and attenuated posteriorly, is found *in situ* in its burrows in the Leda clay. It may be a deep-water variety. Some large specimens in collections from this place, I have reason to believe are from Kitchen-middens and not fossils.

*Kennerlia glacialis*, Leach.

Fossil—Leda clay; St. John, New Brunswick; Saco, Maine.

Recent—Gaspé (Whiteaves); Murray Bay; Labrador (Packard).

This species, which was at first confounded with *Pandora trilineata* by Dr. Packard, is evidently quite distinct, and on the evidence of the hinge would belong to a different genus. Much nearer to *Pandora pinna*, Mont.; = *P. obtusa* Forbes and Hanley. J. F. W.

*Lyonsia (Pandorina) arenosa*, Möller.

Fossil—Leda clay; Montreal (rare and small); Rivière-du-Loup, common; Duck Cove, N. B.; Saco, Maine; also in Greenland (Möller).

Recent—Murray Bay and Gaspé; Halifax (Willis); Greenland (Möller); Labrador (Packard).

Some specimens from Portland are much larger than those from Rivière-du-Loup and Montreal, and Mr. Whiteaves finds individuals an inch long, living at Gaspé.

*Thracia Conradi*, Couthuoy.

Fossil—Saco (Packard).

Not yet found fossil in Canada, but recent, though rare, in Nova Scotia (Willis); and at Gaspé. Also, though apparently rare, at Labrador (Packard).

Has probably extended its northern limit to Canada, since the glacial period.

*Macoma Grœnlandica*, Beck.

Fossil—Saxicava sand and Leda clay; Montreal; Ottawa; Perth, Ont.; Pakenham Mills, Cornwall; Clarenceville; Upton; Quebec; Murray Bay; Rivière-du-Loup; Labrador; Lawlor's lake, N.B.; Campbellton, P. E. I.; Westbeach, Maine; Greenland (Möller).

Recent—Everywhere on the coasts of the Gulf and River St. Lawrence, as a common littoral shell.

A thin and delicate variety with smooth epidermis is found in the Leda clay; coarser and more wrinkled varieties in the Saxicava sand. Larger specimens are found at Quebec and Rivière-du-Loup than more inland.

In the modern Gulf, the small and depauperated varieties are littoral and near the brackish water, the finer varieties passing into *Macoma fusca* of Say, which is a southern variety, are found on the coast of Nova Scotia and in the Bay of Fundy. This shell is represented in the European seas and Post-pliocene deposits by the closely allied species *M. solidula* or *Balthica*, which seems to pass through a corresponding series of varieties, but to be distinct. On the western American coast it is similarly represented by *M. inconspicua*. Mr. Tryon and Mr. Whiteaves believe the three forms to be conspecific. (P. P. C.)

It is said to be the *Tellina Fabricii* of Hanley, and I have specimens from Greenland from Morch labelled *T. tenera*. The *T. tenera* of Leach, however, is *proxima*, Brown, teste Hanley. It is apparently the *Venus fragilis* of Fabricius.

It is one of the most common and abundant shells of the Post-pliocene, as it is of the American coast from Greenland to New England.

*Macoma calcarea*, Chemnitz.

Fossil—Leda and Boulder clays; Montreal; Quebec; Murray Bay; Rivière-du-Loup; Duck Cove, St. John, N.B.; Maine; Labrador; Greenland (Möller); also European Post-pliocene.

Recent—Arctic seas generally, and on the American coast south to Massachusetts.

This shell is is extremely abundant in the Leda and Boulder clays, and often occurs in the clay with the valves attached. It is also of large size and in fine condition, especially at Rivière-du-Loup. It is *Tellina proxima*, Brown, *T. sabulosa*, Spengler, and *T. sordida* of Couthuoy. According to Hanley, the *T. lata* of Gmelin was founded on a figure of this shell.

*Macoma inflata*, Stimpson.

Fossil—Montreal; Rivière-du-Loup. Rare.

Recent—Murray Bay, and dredged in deeper parts of the Gulf of St. Lawrence by Mr. Whiteaves.

I am not aware where this little shell has been described, nor what is its range. It seems identical with a specimen in Jeffrey's collection labelled *Tellina fragilis* Leach, from Spitzbergen.

The Post-pliocene specimens are larger and better developed than the recent, except some dredged by Mr. Whiteaves on the north shore, and I would infer from this that the shell is Arctic. (See Figure.)

*Cyrtodaria siliqua*, Daudin.

Fossil—Rivière-du-Loup; Labrador (Packard); Greenland (Möller). I have seen in the Post-pliocene of Canada, only an imperfect and decorticated specimen of the young shell from Rivière-du-Loup.

Recent—Gulf of St. Lawrence, and coasts of Nova Scotia and New England.

*Mactra (Spisula) ovalis*, Gould.

*M. polynema*, Stimpson.

Fossil—Boulder clay; Cape Elizabeth, Maine.

Recent—Gaspé; Labrador (Packard); also coast of New England.

I found, many years ago, a few specimens of this shell at a cove where a number of species of marine shells occnr in Boulder-clay, and it was published in my list of shells from this place in my paper on the Post-pliocene of Labrador, Maine, &c. It is credited by Packard to "Zeeb's Cove," Cape Elizabeth, which may probably be the same place where I procured it. This species has not yet been found within the limits of Canada in the Post-pliocene, though this and the related species or variety, *M. solidissima*, are found living at Labrador. It has perhaps moved northward since the glacial period.

*Mesodesma (Ceronia) deaurata*, Turton.

Fossil—Matanne River (Bell.) I have not seen it in any other locality; and it occurs only on the lowest terrace, so that possibly it is modern.

Recent—Abundant at Tadousac and elsewhere in Gulf St. Lawrence; Labrador (Packard.)

This must be a modern species on our coasts; but according to Wood it is found in the Red Crag of England.

*Venericardia (Cardita) borealis*, Conrad.

Fossil—Labrador (Packard.)

Recent—Arctic seas to Long Island, and common throughout the Gulf of St. Lawrence. It would seem to have been much less generally distributed in the Post-pliocene. Western America as far south as Catalina Island. (P. P. C.)

*Astarte Laurentiana*, Lyell.

Fossil—Leda clay, Montreal, abundant; Beauport and Rivière-du-Loup, rare.

Recent—Greenland (Morch); Labrador (Packard); Murray Bay.

This shell may be a variety of the next species; but it is at least a very distinct varietal form. It is distinguished by its very fine and uniform concentric striation, passing to the ends of the valves and to the ventral margin. There are two varieties, a flatter, and more tumid. I have the former from Greenland named by Morch *A. Banksii*, and the latter named *A. striata*; but they are different from shells indicated by these names in Gould and elsewhere. The only recent specimens that I have seen from the Gulf of St. Lawrence, which can be referred to this species, are a few I dredged at Murray Bay. *A. Laurentiana* is very abundant at Montreal, but much more rare nearer the coast. It is evidently an Arctic form. (See Figure.)

*Astarte Banksii*, Leach.

Fossil—Leda clay, Rivière-du-Loup, abundant; Quebec, not infrequent; Montreal, very rare; Labrador (Packard); Portland, Maine, also Uddevalla, Clyde beds and Crag.

Recent—Abundant at Gaspé and elsewhere in Gulf of St. Lawrence, and also Arctic seas and coast of Nova Scotia.

This shell is that named *A Banksii*, in Gould's last edition, also in Beechey's voyages. It is easily distinguished from the last species by its coarser striation, fading toward the ends and also toward the margin of the shell. It is however about the same size, but less delicate and symmetrical in form. It is the common small Astarte of the Gulf St. Lawrence, and also of the Post-pliocene of Rivière-du-Loup; but becomes very rare at Montreal, where it is replaced by *A. Laurentiana*. This species was named *A. compressa* in my former lists, and it is certainly very near to European specimens of that species, especially to the fossils from the Clyde beds and the Crag. (See Figure.)

*Astarte Elliptica*, Brown.

Fossil—Labrador; Saguenay; Portland, Maine.

Recent—Labrador; Murray Bay; Gaspé; coast of Nova &c. Also Greenland; Norway (typical); Scotland.

Specimens from the Clyde beds are perfectly identical with ours. It is also found in the Post-pliocene of Norway and rarely in the Crag. It is a northern species meeting on the American coast the closely allied forms *A. Undata* and *A. lens*, into which however it does not seem to pass. The two latter species, being more southern forms, are not found in the Post-pliocene.

*A. Omalii* of S. Wood from the Crag, is very near to this species, but is at least a distinct variety.

*Astarte Arctica*, Möller, (var *Lactea.*)

Fossil—Labrador (Packard); Portland, Maine; also Greenland, (Möller).

Recent—Gaspé; also Arctic seas; Norway (typical).

This species has not yet been found in the Post-pliocene of Canada, except in Labrador; and it seems to be a rare shell in the Gulf of St. Lawrence. It is our largest Astarte and I believe it to be identical with *A. borealis*, Chem., *A. lactea*, Brod. and Sow., and *A Semisulcata*, Gray. Fossil specimens from Portland, are precisely similar to recent ones from Gaspé dredged by Mr. Whiteaves, and referred by him to *A. lactea*. Specimens from Norway (*A. Arctica*) and from Clyde beds (*A. Borealis*) are smoother and less ribbed than ours.

*Other species of Astarte.*

At Murray Bay, there occurs very rarely a transversely elongated and regularly striated Astarte with delicately wrinkled epidermis, which seems to be identical with *A. Richardsonii* from the Arctic seas as described but not as figured by Reeve. It is not improbably a young state of *Astarte Arctica*. A similar species or variety occurs, but very rarely, fossil at Rivière-du-Loup. *A. sulcata* (undata), *A. lens*, *A. crebricostata*, *A. castanea*, and *A. quadrans* have not yet been found fossil, though the three former at least live in the Gulf of St. Lawrence.*

*Cardium pinnulatum*, Conrad.

Fossil—Leda clay, Lawlor's Lake, N.B.

Recent—Gulf St. Lawrence, and coast of Nova Scotia and New England.

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* *A. undata* Gould and *A. quadrans*, Gould, certainly occur in the Gulf of St. Lawrence N. of the Bay of Chaleurs. A shell dredged in deep water N. of Anticosti may be *A. crebricostata*. *A. lens*, Stimpson, and *A. castanea*, Say, have not yet occurred to me in dredgings from more than 60 localities N. of New Brunswick. J. F. W.

*Cardium Islandicum*, Linn.

Fossil—Rivière-du-Loup; Murray Bay; Saguenay; Portland, Maine; Lawlor's Lake, N.B.; Greenland, Möller).

Recent—From Greenland to New England.

Our fossil specimens are mostly small, and similar to the northern variety or sub-species named by Stimpson *C. Hayseii*, and which also occurs living as far south as Nova Scotia, and seems to be the *C. ciliatum* of Fabricius. Decorticated specimens are not distinguishable from *C. Dawsonii* of Stimpson, from the Post-pliocene of Hudson's Bay; of which I have seen only specimens in this state.

*Serripes Grœnlandica*, Chemnitz.

Fossil—Leda clay, and Boulder clay, Quebec; Rivière-du-Loup; Murray Bay; Lawlor's Lake, N.B.; Cape Elizabeth, Maine; Labrador, (Packard); Greenland (Möller).

Recent—Gulf St. Lawrence, sometimes of large size, Arctic seas, and Greenland to Cape Cod.

This shell is somewhat rare and of small size in the Post-pliocene, and has not yet been found higher up the St. Lawrence than Quebec. Specimens of good size occur at Portland.

*Cryptodon Gouldii*, Philippi.

Fossil—Montreal, rare.

Recent—Murray Bay; Gaspé (Whiteaves); Greenland to New England.

The European form *C. flexuosa* is usually regarded as distinct, and is found as far north as Spitzbergen, and in the Crag, the Clyde beds, and the Norway Post-pliocene. Jeffreys, however, considers the difference merely varietal, and it certainly seems to diminish or disappear in the northern and glacial specimens.

According to Mr. Whiteaves this species has a great range in depth in the Gulf St. Lawrence, being found, living, from 20 to 300 fathoms.

*Sphaerium?*

Fossil—Pakenham Mills, with fresh-water bivalves and *Tellina Grœnlandica*. The specimens were too imperfect for certain determination.

*Unio rectus*, Lamarck.

Fossil—Clarenceville, Lake Champlain (Dickson), with *Mya arenaria, Tellina Grœnlandica*, &c.

Recent—River St. Lawrence.

*Unio Cardium?* Rafinesque.

Fossil—With the preceding. This and the preceding species were represented by large and thick shells better developed than those of the River St. Lawrence at present. It is probably the same with *U. ventricosus*, Say.

*Mytilus edulis* Linn.

Fossil—Montreal; Acton; Rivière-du-Loup; Quebec; Labrador (Packard); Lawlor's Lake, N.B. (Matthew); Greenland (Möller).

Recent—North Atlantic and Arctic seas generally; North Pacific (= *trossulus*, Gould) as far south as Monterey.

The variety most commonly found in the Post-pliocene is a small, oval, tumid form, allied to variety *elegans* of British writers (see figure). This variety still lives at Tadoussac; and is apparently characteristic of situations where the water is cold and exposed to intermixture of fresh water. The ordinary variety occurs at Portland, and also in some of the upper beds at Rivière-du-Loup. At Montreal only the small oval variety occurs. This variety is also found in the Clyde beds and in the crag.

*Modiola modiolus*, Linn.

Fossil—Montreal, very rare.

Recent—Labrador to New England; very common on the coasts of Nova Scotia and New England; North Pacific; found sparingly along the Vancouver and Californian coasts till it is replaced in the Gulf fauna by *M. capax*, Conrad.

This species becomes rare to the northward; and this, as well as its being proper to rocky shores rather than to clays and sands, may account for its rarity in the Canadian Post-pliocene. It is, however, common in the glacial beds of Europe.

*Modiolaria nigra*, Gray.

Fossil—Montreal; Rivière-du-Loup (small variety *nexa*; also large and fine); very large and well preserved in nodules at Kennebeck, Maine; Labrador (Packard of his *M. discrepans* as I suppose.)

Recent—Gulf of St. Lawrence (Whiteaves). Very large and fine on coast of Nova Scotia (Willis), and as far north as Greenland (*M. discors*, Fabricius).

*Modiolaria corrugata*, Stimpson.

Fossil—Rivière-du-Loup.

Recent—Murray Bay and Cacouna; precisely similar to the shells from the Post-pliocene. Also Greenland (Moller); Labrador (Packard); and south to Cape Cod.

*Modiolaria discors*, Leach.

Fossil—Beauport, of good size; Greenland (Möller).

Recent—Labrador to New England. Specimens from Gaspé are precisely similar to the fossil. This shell is no doubt identical with *M. lævigata* of Gray, and possibly with the *M. discrepans* of some other authors. It is however the same with that figured in Binney's Gould as *M. discors*.

*Crenella glandula*, Totten.

This species, which is at present quite common in the Gulf St. Lawrence, is indicated in my formerly published lists as a Montreal fossil; but I have mislaid the specimens, and cannot therefore now repeat the comparisons with the recent shells.

According to Mr. Whiteaves this is quite distinct from *C. decussata*, Montagu, both being found living in Gaspé.

*Nucula tenuis*, Montagu.

Fossil—Leda clay, Montreal; Saco (var. *inflata*); Rivière-du-Loup?

Recent—North shore Gulf St. Lawrence to Gaspé (Whiteaves) type and var. *inflata*; also European coasts.

*N. expansa*, Reeve.

Fossil—Leda clay and Boulder clay, Rivière-du-Loup; Saco; Duck Cove, St. John, N.B.

Recent—Labrador (Packard); Murray Bay; Arctic seas.

I doubt if this is not a large and well-developed northern form of *N. tenuis*.

*N. antiqua*, Mörch, from Leda clay of Maine, seems to be a variety.

*Leda pernula*, Muller.

Fossil—Leda clay, Rivière-du-Loup; Portland; Saco; Lawlor's Lake, N.B. (Matthew).

Recent—Arctic seas and south to New England.

This shell occurs very abundantly at Rivière-du-Loup; and the specimens found there show that no specific line can be drawn between the forms known as *pernula*, *buccata* (Steenst.), *tenuisulcata*, Gould, and *Jacksonii*, Gould. Slender and flattened varieties are *pernula* and *tenuisulcata*, shorter and more tumid forms are *buccata;* and specimens decorticated so as to show the origin of the hinge teeth are *Portlandica*. Comparison of specimens from Greenland, Norway, Labrador, the Gulf St. Lawrence, and New England, confirms this conclusion. (See Figure.)

*Leda minuta*, Fabricius.

Fossil—Leda clay, Montreal; Rivière-du-Loup; Greenland (Möller); Labrador (Packard).

Recent—Arctic seas, Gulf St. Lawrence; coast of Nova Scotia.

The fossil specimens occur abundantly with the last species at Riviére-du-Loup, and are quite similar to those dredged at Murray Bay. This was called *L. caudata* in my former lists.

*Lyda pygmæa*, Munster.

Fossil—Leda clay. Green's Creek, Ottawa; Saco; Maine; also English Crag and other Glacial beds.

Recent—North European seas; but not yet recognized on the American coast. According to Mr. Jeffreys and Dr. Carpenter, our drift shells are referable to the variety or species *Yoldia abyssicola* of Torell.

*Leda (Portlandia) glacialis*, Gray; *truncata*, Brown.

Fossil—Leda clay and Boulder clay, Montreal; Quebec; Ottawa River; Rivière-du-Loup; St. John, N.B.; Portland and Saco, Maine; also in Post-pliocene of Norway (Sars), and of Scotland (Crosskey).

Recent—Arctic seas.

This shell is most abundant, and generally diffused in the Leda clay; and the variety ordinarily found at Montreal and Rivière-du-Loup is precisely identical with the ordinary Arctic form. A long variety, called *L. intermedia* by Sars, is also found at Montreal, though rarely. A short variety, common in the Post-pliocene at Murray Bay, is similar to the *L. siliqua* of Reeve from the Arctic seas; and young and depauperated varieties resemble *L. sulcifera* of the same author. The abundant material from the Post-pliocene shows that these are all varietal forms.

This shell is *Yoldia Arctica* of Sars, but not of Möller and Morch. It is *Y. truncata* of Brown. It is *Portlandia glacialis* of Gray, and *Leda Portlandica* of Hitchcock.

*Yoldia lucida*, Lovén (which is abundant living in the deeper parts of the Gulf of St. Lawrence) closely resembles the young, smooth form of this species, but I think the two may be distinct. J. F. W.

*Leda (Yoldia) limatula*, Say.

Fossil—Leda clay, Rivière-du-Loup.

Recent—Gulf St. Lawrence to Long Island.

This shell has been found as yet only at Rivière-du-Loup, where the specimens however are as good as those now living in the Gulf. (See Figure.) It will be observed, however, that though they have the number of teeth of *Y. limatula*, they approach in form to the allied species or variety *Y. sapotilla*, a shell which occurs in Greenland and thence to New England, and which I strongly suspect is merely a short variety bearing a similar relation to *Y. limatula* to that which *Mya Uddevallensis* bears to the ordinary *M. truncata*. *Y. sapotilla* is, I may mention, the *Y. Arctica* of Morch, as proved by a specimen from his collection now in my possession.

*Leda (Yoldia) myalis*, Couthuoy.

Fossil—Labrador (Packard).

Recent—Gaspé (Whiteaves) to south of Cape Cod. This shell is supposed to be identical with *N. hyperborea*, Lovén, from Spitzbergen.

*Pecten Grœnlandicus*, Chemnitz.

Fossil—Leda clay, Portland and Saco, Maine; not yet found in Canada.

Recent—Gulf St. Lawrence (Whiteaves) in deep water 200 to 300 fathoms.

This species is found in the Clyde beds and in Greenland; and if, as Jeffreys supposes, identical with *P. similis* (Laskey), it is a shell of very wide distribution in the Atlantic, as well as in geological time. Though not yet found in Canada as a Post-pliocene fossil, its occurrence as a fossil in Maine and recent in the Gulf St. Lawrence, renders it probable that it may yet occur in our Leda clays.

*Pecten tenuicostatus*, Mighels.

Fossil—Leda clay, St. John, N.B. (Matthew).

Recent—Labrador to Cape Cod.

This shell has not yet been found in the Post-pliocene of the

St. Lawrence valley; but since, according to Packard, it is common in Labrador, there is nothing remarkable in its occurrence in the Post-pliocene of St. John.

*Pecten Islandicus*, Chemnitz.

Fossil—Rivière du-Loup; Quebec; Labrador (Packard); St. John, N.B. (Matthew); Portland, Maine; Greenland (Möller); also Crag, Clyde beds, and Post-pliocene of Norway.

Recent—Gulf St. Lawrence, and from Greenland to Connecticut.

This is a shell which is very durable, and retains even its colour when imbedded in the clays. In this it excels the Tellinas, Astartes, Saxicava and Ledas; though these in turn are always much better preserved than the Mytili and Modiolæ.

## Class III.—Gasteropoda.

*Philine lineolata*, Couthuoy.

Fossil*—Montreal, rare.

Recent—Gaspé; Grand Manan (Stimpson); Nova Scotia (Willis). It is *Philine lima*, Brown, according to Jeffreys.

*Cylichna alba*, Brown.

Fossil—Montreal; Rivière-du-Loup; also in the Clyde beds.

Recent—Gaspé; Labrador (Packard); Gulf St. Lawrence, common (Whiteaves); Arctic seas generally. Same or similar on West Coast at Sitka (P.P.C.)

*Cylichna oryza*, Totten.

Fossil—Montreal.

Recent—Coast of New England.

*Cylichna nucleola*, Reeve.

Fossil—Montreal; rare, and perhaps doubtful.

Recent—Arctic seas.

*Cylichna occulta*, Mighels and Adams.

Fossil—Montreal; Murray Bay; Maine.

Recent—Greenland to New England.

*Cylichna striata*, Brown.

Fossil—Rivière-du-Loup and Clyde beds.

Recent—Arctic seas.

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* Except when otherwise stated, all the Gasteropods are found in the Leda clay, or at its junction with the Saxicava sand.

*Bulla (Haminea) solitaria*, Say.

Fossil—Montreal; rather common.

Recent—New England and northward.

If this species is rightly determined, it furnishes a curious instance of a somewhat southern species occurring in the drift of Montreal. The *Hamineæ*, however, can scarcely be identified by weathered or fossil specimens, so that this may possibly be a northern form distinct from *solitaria*.

*Bulla (Diaphana) debilis*, Gould.

Fossil—Montreal.

Recent—Gulf St. Lawrence (Whiteaves); Greenland to New England.

Jeffreys considers it the same with *B. hyalina*, Turton. If so, it is a shell of the Clyde beds and of the Arctic seas generally.

*Bulla (Utriculus) pertenuis*, Mighels.

Fossil—Montreal.

Recent—Labrador (Whiteaves); Gulf St. Lawrence, and south to Cape Cod. According to Jeffreys it is *U. turritus*, Möller, Greenland.

*Helix striatella*, Anthony.

Fossil—Pakenham, Saxicava sand.

*Lymnea umbrosa*, Say.

Fossil—Montreal.

*Lymnea caperata*, Say.

Fossil—Montreal.

*Lymnea elodes*, Say.

Fossil—Pakenham Mills, Saxicava sand.

*Planorbis bicarinatus*, Say.

Fossil—Pakenham Mills, Saxicava sand.

*Planorbis trivolvis*, Say.

Fossil—Pakenham Mills, Saxicava sand.

*Planorbis parvus*, Say.

Fossil—Pakenham Mills, Saxicava sand.

All of the above pulmonates are modern Canadian species, and seem to have been drifted by some fresh-water stream into the sea of the Saxicava sand and Leda clay.

*Siphono-dentalium vitreum*, Sars.

Fossil—Leda clay, Murray Bay; also Norway (Sars).

Recent—Gulf of St. Lawrence (Whiteaves); coast of Norway (Sars.) It is a rare deep-water shell.

*Amicula Emersonii*, Couthuoy.

Fossil—Montreal.

Recent—Murray Bay; Halifax; coast of New England.

My specimens are merely detached valves. They indicate an animal quite similar to specimens from Halifax referred to this species, but differ slightly from specimens from Murray Bay. Dr. Carpenter has labelled the drift form var. "*altior*." The differences among the recent specimens, as well as the fossil valves, will be discussed in the "Contributions to a Monograph of the Chitonidæ," about to be printed by the Smithsonian Institution.

*Puncturella (Cemoria) Noachina*, Linn.

Fossil—Quebec; Rivière-du-Loup; Clyde beds.

Recent—Gulf St. Lawrence generally; and throughout the Arctic seas and North Atlantic.

*Acmœa testudinalis*, Möller.

Fossil—Labrador.

Recent—Gulf St. Lawrence generally; and throughout the Arctic seas and North Atlantic.

My only fossil specimen, obtained from Dr. Packard, is of the small, elevated and depauperated variety so common at Murray Bay and the north shore of the Gulf. It is curious that this common modern species is so very rare in the Post-pliocene.

*Lepeta cœca*, Möller.

Fossil—Montreal; Riviére-du-Loup; Quebec; Labrador; European Post-pliocene.

Recent—Gaspé; Labrador; Arctic seas generally; and coast of New England rarely.

This shell is not at all rare, living at Gaspé, and fossil at Rivière-du-Loup. Carpenter remarks that some of my Montreal specimens have the characters of variety *striata* of Middendorff from Siberia.

*Capulus commodus*, Middendorff.

Fossil—Point Levi, near Quebec. One specimen only, found by Mr. Gunn and communicated by Dr. W. J. Anderson.

Recent—Scotland (Jeffreys).

This species is fossil at Uddevalla, and is supposed to be the same with *C. fallax* and *C. obliquatus* of Wood from the English Crag. It has not yet been recognized on the American coast. (See Figure.)

*Margarita helicina*, Fabricius.

Fossil—Montreal; Murray Bay.

Young specimens resemble *M. acuminata* of Mighels. Broad specimens resemble *M. campanulata*, Morse.

Recent—Arctic seas; Gulf of St. Lawrence; and coast of New England. It is *M. Arctica*, Leach.

*Margarita argentata*, Gould.

Fossil—Montreal, rare.

Recent—Labrador and Gulf St. Lawrence (Whiteaves); Murray Bay; Gaspé; coast of New England and Nova Scotia? Possibly the same with *M. glauca*, Möll., from Greenland.

*Margarita cinerea*, Couthuoy.

Fossil—Rivière-du-Loup, Portland.

Recent—Gaspé; Labrador; Greenland to New England; var. *striata*, Dall, Sitka.

*Cyclostrema* (*Mölleria*) *costulata*, Möller.

Fossil—Montreal; Clyde beds; Uddevalla.

Recent—Gaspé; Arctic seas to New England.

*Cyclostrema Cutleriana*, Clark.

Fossil—Montreal, rare.

This is an Arctic and British shell, as yet recognized only at Montreal.

*Turritella erosa*, Couthuoy.

Fossil—Labrador; Rivière-du-Loup; Montreal?

Recent—Greenland to New England.

*Turritella reticulata*, Mighels.

Fossil—Labrador (Packard).

Recent—Labrador to Gulf St. Lawrence; also fishing banks, Nova Scotia (Willis).

My specimens received from Dr. Packard are marked *T. costulata*, but seem rather to be the above species.

*Turritella acicula*, Stimpson.
Fossil—Rivière-du-Loup; Labrador (Packard).
Recent—Murray Bay; coast of New England.

There may be some reason to donbt whether this is not a variety of *T. erosa*. It is quite possible that the above species should be regarded as *Mesaliæ*.

*Paludina (Melantho) decisa*, Say.
Fossil—Pakenham Mills, Saxicava sand.
Recent—Eastern America generally.

*Valvata tricarinata*, Say.
Fossil—Pakenham Mills, with the preceding.
Recent—Eastern America generally.

*Amnicola limosa*. Say.
Fossil—Pakenham Mills, with the preceding.
Recent—Hudson's Bay to Virginia.
This was *A. porata* of the previous lists.

*Littorina rudis*, Donovan.
Fossil—Rivière-du-Loup; also Clyde beds and Uddevalla.
Recent—Arctic seas to New England and European coasts.

*L. tenebrosa*, which may be regarded as a variety, is also found at Rivière-du-Loup.

*Rissoa castanea*, Möller.
Fossil—Montreal.
Recent—Gaspe; Labrador; Trinity Bay (Whiteaves).

*Rissoa exarata*, Stimpson.
Fossil—Montreal.
Recent—New England.

*Rissoa scrobiculata*, Möller.
Fossil—Montreal.
Recent—Greenland; Gulf St. Lawrence, 200 to 300 fathoms, large; and small, Gaspé, 30 fathoms (Whiteaves).

*Bela harpularia*, Couthuoy.
Fossil—Montreal; Quebec; Murray Bay; Rivière-du-Loup (large specimens).
Recent—Gulf St. Lawrence; very fine at Murray Bay, and similar to large specimens from Rivière-du-Loup; coast of New England. It is *B. Woodiana*, Möller (J. F. W.)

*Bela elegans*, Möller.

Fossil—Montreal.

Recent—Greenland and Norway ; closely allied to next species.

*Bela pyramidalis*, Ström.

Fossil—Montreal ; also Crag, Clyde beds and Uddevalla.

Recent—Labrador (Packard) ; Gulf St. Lawrence (Whiteaves) ; Murray Bay, and south to Cape Cod ; Arctic seas generally. It is the *B. pleurotomaria* of Couthouy. and *B. Vahlii* of Beck.

*Bela turricula*, Montagu.

Fossil—Montreal ; Rivière-du-Loup ; Labrador ; also Red Crag and Uddevalla (Jeffreys).

Recent—Gulf of St. Lawrence and coast of Nova Scotia and New England.

I include under this name *B. nobilis* of Möller ; *B. Americana*, Packard ; *B. scalaris*, Möller ; *B. exarata*, Muller, Morch ; and *B. angulata*, Reeve. The var. *nobilis* is found at Montreal and Gaspé ; also young shells not distinguishable from *exarata*. Var. *scalaris*, occurs at Rivière-du-Loup and Labrador. This shell is a widely diffused and somewhat variable northern species. Mr. Whiteaves, hewever, regards *B. nobilis*, *B. exarata*, and *B. scalaris* as distinct.

*Bela Trevelliana*, Turton.

Fossil—Rivière-du-Loup ; Labrador ; also Clyde beds and Norway (Jeffreys).

Recent—Murray Bay ; Arctic seas, and Greenland to Massachusetts. It is probably *B. decussata* of Couthuoy. *B. excurvata* from Puget Sound, may prove another variety.

*Bela violacea*, Mighels and Adams.

Fossil—Montreal.

Recent—Murray Bay ; Labrador (Packard) ; Gaspé (Whiteaves ; Fishing banks Nova Scotia (Willis) ; Massachusetts (Stimpson).

*Bela cancellata*, Mighels and Adams.

Fossil—Murray Bay ; Labrador (Packard) ; Casco Bay (Gould). This shell may be *B. impressa*, Beck. In any case the fossils are identical with the modern Murray Bay specimens. It also occurs living in Gaspé Bay (Whiteaves).

*Natica affinis*, Gmelin.

(*Natica clausa*, Brod. and Sowerby.)

Fossil—Montreal; Quebec; Rivière-du-Loup; Labrador; Portland, Maine.

Recent—Greenland to Cape Cod.

Common and extensively distributed in the Post-pliocene of Europe, from Norway to Sicily, and found at an elevation of 1330 to 1360 feet in Moel Tryfaen, Wales. (Darbyshire).

*Lunatia heros*, Say.

Fossil—Beauport, a single specimen only, and this of small size.

Recent—Labrador and southward.

This species is as old as the Miocene Tertiary; and in the Post-pliocene, Canada was probably its extreme northern limit.

*Lunatia Grœnlandica*, Beck.

Fossil—Montreal; Quebec; Rivière-du-Loup; Maine; also Post-pliocene of England, Scotland, and Norway.

Recent—Arctic seas generally; and extending to Britain and New England.

*L. pallida* is the representative of this species on the west coast of America.

*Choristes elegans*, Cpr.

Fossil—Saxicava sand, Montreal, rare.

This shell was identified in my former papers with *Natica helicoides;* but it is now found to be quite distinct, and Dr. P. P. Carpenter describes it as a new species and genus as follows:

Genus Choristes.

Testa helicoidea, tenuis; epidermide induta; anfractus disjuncti; labrum postice angulatum, antice haud emarginatum; labium planatum; columella simplex. Animal ignotum.

*Choristes elegans*, n. s.

Ch. t. satis elevatâ, tenui, nitente; epidermide fulvâ, tenui, lævi, extus et intus omnino appressâ; anfr. iii. + ...... ?, vertice nucleoso decollato, spiraliter obsoletius striatis; lineis incrementi tenuissimis; spirâ superne planatâ, suturis maxime impressis, basi tumente; umbilico intus majore, extus modico; aperturâ sublunatâ, postice ad angulum circ. 30° inclinatâ, antice late rotundatâ; labro acuto, postice planato; labio acuto, planato, haud reflexo; columellâ postice regulariter arcuatâ, neque emarginatâ, nec angulatâ, nec insculptâ.

*Long.* (apice decollato) ·82, *long. spir.* ·32, *lat.* ·76. poll. *Div.* 90°.

*Hab.* Montreal, in strato glaciali, fossilis, rarissime reperta. Mus. Dawson, McGill Coll., Nat. Hist. Soc.

Dr. Carpenter adds the following remarks:

While almost all the other drift fossils are of species still living in the neighbouring seas, this is not known, even generically, to be at present in existence. It is hard to pronounce satisfactorily on its relationships. In its thin, coated shell it resembles Velutina; the striæ and loose whirls recall Naticina; the straight pillar lip reminds us of Fossarus; while the umbilicus and rounded base, with entire mouth, best accord with the Natica group. With Trichotropis and its congeners I can see no resemblance. One remarkable feature in all the specimens is the decollation of the upper whirls, seen even in a nearly perfect young specimen, ·2 across; other young specimens, even smaller, have only one whirl and a half remaining. The broken portion is filled up not so mnch by a septum as by a solid thickening. The separation of the whirls is complete from the beginning; and although, in the parietal portion, they are closely appressed, the smooth and somewhat glossy epidermis is distinctly seen between. The fracture of the mouth in most of the specimens, enables this feature to be distinctly observed; and would also reveal the "internal groove" and columellar callosity ascribed to Torellia, did any such exist.

The straightening of the inner lip, at an angle of 30° from the axis, makes the umbilicus by no means large (for a Naticoid shell) when viewed from the base in the line of the pillar; but the same cause enlarges it within, recalling the adult appearance of Amphithalamus. The flattening of the upper portion of the whirls gives the shell somewhat of an Ianthinoid aspect.

While the analogies of the shell point in so many different directions, it is impossible to assign it even to its family group. It is to be hoped, however, that the dredge will yet reveal its existence in a living state.

The above species may be supposed to resemble *Torellia vestita*, Jeffreys, from Norway. Our specimens differ however in form, as above noted, and also in the absence of the tooth in the inner lip, and in the smooth epidermis.

The shell in question presents the very unusual character of having the whirls appressed, yet quite disconnected; the smooth epidermis lining the umbilical chambers, and conspicuously preserved, even in these fossil specimens, between the closest parts of the parietal region. In this respect it bears the same relation to Torellia as does Latiaxis to Rapana, Separatista to Rhizochilus, or Zanclea to Torinia. It presents a rude resemblance to Separatista Chemnitzii (Add. Gen. pl. xiv. f. 6), or still more to S. Blainvilleana (Chènu Man. p. 172, § 853), but without the grooved pillar, or the keels of the latter species.

As to the "blunt tubercle" or "callous protuberance" of Torellia, described by Mr. Jeffreys, but scarcely to be traced in Mr. Sowerby's figure, it certainly does not exist in our fossils. It is not always a character of importance, as may be seen by comparing Purpura columellaris with P. patula, Cuma tectum with the remaining species of the genus, or the gradual transition from Isapis to Fossarus. The Naticidæ are often very irregular in the callous region of the pillar, even in the same species.

*Velutina zonata*, Gould.

Fossil—Montreal; Beauport.

Recent—Arctic seas to Massachusetts.

According to Jeffreys, this shell is the same with *V. undata*, Smith, from the Clyde beds, and is found in the Crag and in the Post-pliocene of Uddevalla.

*Scalaria Grœnlandica*, Perry.

Fossil—Rivière-du-Loup; Quebec; Saco; also Scottish Post-pliocene and English Red Crag, under same varietal forms as in Canada.

Recent—Arctic seas, and American coast, as far south as Massachusetts.

The specimens from Rivière-du-Loup are very large, one being nearly two inches long; and, as Dr. Beck has remarked, the varices of some of the specimens are more slender and lamellar than in recent specimens, others, however, are similar to the more common recent variety.

*Acirsa Eschrichtii*, Holboll.

Fossil—Quebec; Rivière-du-Loup; Montreal; most abundant at Riviêre-du-Loup.

Recent—Murray Bay; Greenland; also Eastport (Verrill.)

This shell was named in former papers *Menestho albula*, the eroded specimens found being referred to that species. It has, however, been correctly described by Dr. Beck in Lyell's paper on Beauport, and named *Scalaria borealis.* It is not this species of Gould, however.

*Trichotropis borealis*, Brod. and Sow.

Fossil—Montreal; Rivière-du-Loup; Labrador, &c.; very abundant at Montreal.

Recent—Labrador, Murray Bay, Gaspé, Arctic seas, and as far south as Massachusetts.

*Trichotropis arctica ?* Middendorff.

Fossil—Montreal, very rare.

A single imperfect specimen represents this species, which is recent at Behring's Straits. The identification is perhaps doubtful.

The figure given by Reeve of *T. Kenseri* of Phillippi from Spitzbergen, resembles our shell, except in the small number of revolving bands.

*Admete viridula*, Fabricius.

Fossil—Montreal.

Recent—Labrador, (Packard); Murray Bay; Gaspé, (Whiteaves); also Greenland and Labrador. It is the *Tritonium viridulum* of Fabricius, and is a rare shell in the Canadian Post-pliocene, and in the Gulf of St. Lawrence.

*Aporrhais occidentalis*, Beck.

Fossil—Labrador (Bayfield); also Packard.

Recent—Labrador to Massachusetts.

It is remarkable that this species, which is found living from Labrador to Cape Cod, is so rare in the Post-pliocene.

*Fasciolaria ligata*, Mighels.

Fossil—Montreal, very rare.

Recent—Murray Bay; Mingan (Foote); Gaspé, (Whiteaves); Nova Scotia, (Willis); rare in all these localities.

A single mutilated specimen alone, as yet, represents this species in my Post-pliocene collections.

*Astyris Holbollii*, Möller.

Fossil—Rivière-du-Loup; also glacial beds Britain (Jeffreys).

Recent—Gaspé; Murray Bay; Labrador, (Whiteaves). If identical, as I suppose, with *Columbella rosacea*, Gould, it extends south to New England, and Gould's name has priority.

*Buccinum undatum*, Linn.
var. *undulatum*, Möller.
var. *Labradoricum*, Reeve.

Fossil—Saxicava sand and Leda clay, Rivière-du-Loup; Labrador; Duck Cove, St. John, N.B.; Maine (Packard).

Recent—Gulf St. Lawrence; south Greenland to Nantucket. (See Figure.)

I cannot satisfy myself that there is any good specific distinction between this shell and *B. undatum* of the European seas and glacial beds. It varies very much in size, in slenderness, in the fineness of the spiral striation, in the development of the ribs, in the extension of the mouth, and in the thickness of the shell. The coarser forms are *B. Labradoricum*, which passes into the ordinary *undatum*. Medium varieties are *B. undulatum*, and smooth varieties pass into *B. cyaneum* and *B. Tottenii*, which last is the *ciliatum* of Gould.

*Buccinum Tottenii*, Stimpson.

Fossil—Rivière-du-Loup, Saxicava sand and Leda clay.

Recent—Murray Bay and Tadoussac; also Newfoundland Banks. It has some resemblance to *B. Humphreysianum*, Bennet, but is specifically distinct. It is the *B. ciliatum* of Gould, but has no connection with the *ciliatum* of Fabricius, except a slight resemblance to the smoother forms of the latter. It is remarkable for its very regular spiral lines, absence of folds and convex whirls.

*Buccinum cyaneum*, Bruguière.

Fossil—Rivière-du-Loup, abundant.

Recent—Murray Bay and Tadoussac; deeper parts of Gulf St. Lawrence (Whiteaves); Arctic seas.

This species or varietal form is well represented in the Figure, which is taken from a large Rivière-du-Loup specimen. Being on the one hand very near to if not identical with the smooth varieties of *B. undulatum*, and on the other resembling *B. Grœnlandicum*, it has received many names. It is believed to be *B. boreale* of Leach, and *Grœnlandicum* of Morch. It is a very characteristic northern form. (See Figure.)

*Buccinum Grœnlandicum*, Chemnitz.

Fossil—Leda clay and Boulder clay, Montreal; St. Nicholas; Rivière-du-Loup.

Recent—Greenland. Specimens from Morch are identical with our fossils. This species is probably the *B. undatum* of Fabricius. It is allied to *B. cyaneum*, and may possibly pass into it. (See Figure.)

*Buccinum tenue*, Gray.

Fossil—Rivière-du-Loup, not uncommon; Greenland (Hayes); Labrador (Packard).

Recent—Murray Bay; Gaspé; Labrador (Packard); Arctic seas generally. A common Arctic species, but rare living in the Gulf, though much more plentiful in the Post-pliocene beds. (See Figure.)

*Buccinum ciliatum*, Fabricius.

Fossil—Montreal; Rivière-du-Loup.

Recent—Murray Bay; Greenland (Fabricius) to Nova Scotia (Willis).

This is the original *B. ciliatum* of Fabricius, and has been recognized as such by Dr. Stimpson. It is easily distinguished by its narrow Nassa-like mouth, armed with a tooth on the front of the pillar lip. It varies much in sculpture, especially in the longitudinal ribs. The variety found at Montreal is only slightly ribbed. That at Rivière-du-Loup is more distinctly ribbed, thus resembling the recent specimens from Murray Bay. It is quite distinct from *B. ciliatum*, Gould, which is very near the smoother varieties of *B. undulatum*. As it is a rare and little known shell, I have figured two extreme varieties, a fossil specimen from Montreal and a recent from Murray Bay.

*Buccinum glaciale*, Linn.

Fossil—Rivière-du-Loup; Montreal; Labrador; (Packard.)

Recent—Murray Bay; Greenland, and Arctic seas generally.

This shell has the aperture somewhat like that of *ciliatum* and a very peculiar sculpture of spiral striæ with intervening bands marked with finer striæ. It has also a carina angulating the body whirl, and sometimes more than one. In the latter case it passes into *B. Grœnlandicum*, Hancock (not Chemnitz) or *B. Hancocki* Morch. The ordinary variety is most common in the Modern Gulf, the latter in the Arctic seas and in the Post-pliocene. This shell, usually much decorticated, is the most common Buccinum in the Post-pliocence of Montreal. It was called *B. undatum* in previous lists.

*Buccinum plectrum*, Stimpson.

Fossil—Rivière-du-Loup; rare.

Recent—Murray Bay; Portland, Maine, (Stimpson); Behring's Straits, (Stimpson)

This may be a variety of the preceding species, but can be distinguished from it and grows to a larger size. It has the sculpture of *B. glaciale* with the aperture of *B. undulatum*. Recent and fossil specimens are quite similar.

The northern *Buccina* are involved in so much contusion that I have made them a subject of special study, and have sedulously collected all the forms recent and fossil. I have been very much aided in this by the abundance of specimens of the more Arctic forms at Rivière-du-Loup, and the the occurrence of most of them recent at Murray Bay and Tadousac, and I feel confident that the names given in this list represent forms actually occurring as distinct in nature, though some of them may not be distinct specific types. I believe, however, that *B. ciliatum B. glaciale*, *B. undatum*, *B. tenue* and *B. Grœnlandicum*, are probably entitled to this rank. The others appear to me on comparison of large numbers of specimens, to graduate into one or other of the above forms.

I have given in the engraved plate representatives of the more critical forms, which will enable them to be recognized.

In the drift the Buccinums often part with their outer coat of prismatic shell, and in this decorticated state are very difficult to determine.

*Buccinofusus* (*Sipho*) *Kroyeri*, Möller.

Fossil—Rivière-du-Loup; Labrador (Packard).

Recent—Gulf St. Lawrence and Arctic seas. First recognized as this species by Mr. Whiteaves. Specimens from Spitzbergen in Mr. McAndrew's collection are perfectly similar to ours. Packard found it not uncommon at Labrador, but it seems rare in other parts of the Gulf of St. Lawrence. In some previous lists it has appeared as *B. cretaceum*, Reeve, which seems to be an error.

*Chrysodomus Spitzbergensis*, Reeve.

Fossil—Montreal (small and rare.)

Recent—Murray Bay to Gaspé; also Spitzbergen, and probably Sea of Okotsk.

Only one specimen occurred at Montreal, and was an unknown form until I fortunately dredged a few specimens at Murray Bay. It is a beautiful species, evidently quite distinct from *C. Islandicus*. From Middendorff's description and figure, I think it not improbable that it may be the same with his *Tritonium Schantaricum*, from the Sea of Okotsk. I was not aware that it had been found on our coast, except at Murray Bay, until these sheets were going through the press. Young specimens are remarkably like in form and sculpture to *Fasciolaria ligata*, which is found with it at Murray Bay. Reeve's figure in Belcher's "Last of the Arctic Voyages," well represents our specimens, though perhaps a very little coarser in sculpture.

*Chrysodomus tornatus*, Gould.

Fossil—Montreal; Quebec; Rivière-du-Loup; Murray Bay; Labrador (Packard).

Recent—Gaspé Bay, large specimens (Whiteaves; Labrador (Packard).

This shell is not uncommon in the drift, and owing to its dense texture is generally in good preservation. It ranges from the typical *C. tornatus* of Gould to *Fusus despectus* of Linnæus, as described by Fabricius, from Greenland, and shells of similar form from the British Crag are considered by S. Wood as varieties of *F. antiquus*.* Dr. P. P. Carpenter thinks that this and the British *F. antiquus* may prove to belong to one very variable species. The *C. despectus* is an Arctic form, and is found fossil in Canada. The *C. tornatus* is also fossil, and is the form now found in the Gulf. *C. decemcostatus* is more southern.

*Chrysodomus decemcostatus*, Say.

Fossil—Portland, Maine.

Recent—Magdalen Islands and Gaspé Bay (Whiteaves); coasts of Nova Scotia and New England.

This species has not yet been found in the Post-pliocene of Canada, where it is represented by *C. tornatus*. There are still two opinions as to whether Say's species is identical with *C. lyratus*, Mart. = *Middendorffii*, Cooper, from the Pacific coast. The latter is variable, and graduates towards *tornatus*, Gould, but the living New England shells are tolerably constant in character.

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* The *C. despectus* of Reeve, however, is a very different species, from the Arctic regions of the North Pacific.

*Trophon scalariforme*, Gould.

Fossil—Montreal; Murray Bay; Rivière-du-Loup; Labrador.

Recent—Greenland (Hayes); Murray Bay; Nova Scotia (Willis); Gaspé and North Shore (Whiteaves).

It is a rare shell in the Post-pliocene, but of large size and in good condition.

*Trophon clathratus*, Linn.

Fossil—Montreal; Murray Bay; Rivière-du-Loup; also glacial beds of Europe.

Recent—Greenland and Arctic seas generally; Labrador; Gulf St. Lawrence (Whiteaves). The allied species or variety, *T. gunneri*, has been found living at Gaspé by Whiteaves, but not fossil as yet.

## SUB-KINGDOM ARTICULATA.

### Class I.—Annulata.

*Serpula vermicularis*, Linn.

Fossil—Montreal; Murray Bay; Rivière-du-Loup.

A small species of Serpula, apparently the above, though perhaps the determination may be regarded as uncertain.

*Vermilia serrula*, (Stimpson.)

Fossil—Rivière-du-Loup, on shells.

Recent—Gulf St. Lawrence. It is quite likely the Greenland species identified by Fabricius with *Serpula triquetra*.

*Spiochætopterus typus*, Sars.

Fossil—Labrador, (Packard).

Recent—Labrador (Packard); Norway (Sars.)

*Spirorbis glomerata*, Muller.

Fossil—Rivière-du-Loup; Labrador (Packard); Greenland (Fabr.); Gaspé.

*Spirorbis vitrea*, Fabricius.

Fossil—Montreal; Quebec; Rivière-du-Loup; Murray Bay Very common on stones and shells.

Recent—Greenland (Fabricius); Gulf St. Lawrence.

*Spirorbis Spirillum*, Lin.

Fossil—Rivière-du-Loup, on shells.

Recent—Gulf St. Lawrence; Greenland; Fabricius.

*Spirorbis sinistrorsa*, Montague.

Fossil—Rivière-du-Loup, on the inside of shells.

Recent—Gulf St. Lawrence; Fishing Banks, American Coast (Gould.)

*Spirorbis carinata*, Montague.

Fossil—Rivière-du-Loup, on shells.

This is a Spirorbis with one carina, found also in the Gulf of St. Lawrence, and possibly the same with the *S. contortuplicata* of Fabricius from Greenland.

The beautiful *Spirorbis cancellata* of Fabricius, so common in the Modern Gulf of St. Lawrence, and also in Greenland, has not yet been found in the Post-pliocene.

## Class II.—Crustacea.

The most abundant species are bivalve Entomostraca, which occur in great numbers in the Leda clay, associated with Foraminifera. The species in my collection have been kindly determined by Mr. J. S. Brady, who enumerates the following:

*Cythere MacChesneyi*, nov. sp.
" *Dawsoni* (Brady).
" *globulifera* (Brady).
" *Logani*, nov. sp.
*Cytheridea papillosa* (Bosquet).
" *punctillata* (Brady).
*Cytheridea Sorbyana* (Jones).
*Cytherura Robertsoni* (Brady).
*Cytheropteron complanatum*, nov. sp.
" *inflatum* (B., C., and R., MS.)
" *angulatum* (B., C., and R., MS.)
*Eucythere argus*.

As the paper was re-printed in the *Canadian Naturalist* (Vol. V., N. S.) it is unnecessary to notice these species further here, except to state that out of twenty-nine species of recent Ostracods obtained by Mr. Brady from material from the Gulf St. Lawrence, furnished by me, thirteen have been recognized in the Post-pliocene of Canada and Maine. though only three of these occur in the list above given. It is further remarkable that out of thirty-three fossil species from Maine and Canada, no less than twenty-three occur in the Scottish glacial beds and twenty-five are living in the British seas; while six are new species.

*Balanus Hameri*, Ascanius.

Fossil—Montreal; St. Nicholas; Quebec; Rivière-du-Loup; also, Uddevalla; Russia (Murchison); Greenland (Spengler).

Recent—Coast of Nova Scotia. I have obtained specimens from Mr. Downes of Halifax, but have not elsewhere seen the species recent. It is *B. Uddevallensis* of lists of Scandinavian fossils and *B. tulipa* of Muller. It is a widely diffused Arctic and North Atlantic species.

This Acorn-shell is very abundant at Rivière-du-Loup, and fine specimens are found entire, attached to stones and boulders in the Boulder-clay.

*Balanus porcatus*, DaCosta.

Fossil—Beauport; glacial beds of Europe.

Recent—Gulf St. Lawrence, and coast of New England; Labrador (Packard); and Arctic and northern seas generally. It is no doubt *Lepas balanus* of Fabricius from Greenland.

Much more rare in the Post-pliocene than the preceding species.

*Balanus crenatus*, Brug.

Fossil—Montreal; Quebec; Rivière-du-Loup; St. John, N.B. (Matthew); Labrador (Packard); Portland, Maine; glacial beds of Europe.

Recent—Arctic and northern seas, Greenland; Gulf St. Lawrence and American coast. It seems to be *Lepas balanaris* of Fabricius, Greenland.

*Eupagurus Bernhardus ?* Fabricius.

Fossil—Rivière-du-Loup. A small specimen in a *Turritella* may be the young of this common species.

*Hyas coarctata*, Leach.

Fossil—Riviére-du-Loup. A few claws only found, but evidently of this common Gulf of St. Lawrence species.

## SUB-KINGDOM VERTEBRATA.

The vertebrate animals of the Post-pliocene are few, and may be summed up as follows:

*Mallotus villosus*, Cuvier.

The common capelin is found in nodules at Green's Creek on the Ottawa.

*Cyclopterus lumpus*, Linn.

The lump sucker occurs in nodules at the same place.

*Gasterosteus.*

In nodules at the same place, found by Sheriff Dickson. It closely resembles the two-spined stickleback of the Gulf St. Lawrence, but is not sufficiently perfect for description.

Vertebrae and other fragments of fishes not determinable, have been found at Rivière-du-Loup, and a bird's feather in a nodule on the Ottawa.

The Mammalia are represented in the marine Post-pliocene of Canada by *Phoca Grœnlandica*, Muller, found in the Leda clay at Montreal, and *Beluga Vermontana* in the same situation, and also in the Saxicava sand at Cornwall (Billings). The latter I believe to be identical with the modern *Beluga* of the Gulf St. Lawrence.

In the superficial gravels of Ontario, probably more recent than the marine beds, remains of a fossil elephant, *Euelephas Jacksonii*, have been found, and have been described by Mr. Billings (Can. Nat. vol. VIII).

## FOSSIL PLANTS.

The only locality where fossil plants in any considerable number have been obtained, is at Green's Creek on the Ottawa, where they owe their preservation to the nodules of calcareous matter that have enclosed delicate specimens which otherwise could not have been secured from the soft Leda clay in which the nodules are enclosed. In addition to specimens collected by myself, I have examined the collections made by the late Rev. Mr. Bell of L'Original, those of the late Sheriff Dickson, and those of the Geological Survey. The whole were described in my paper in the Canadian Naturalist for February, 1866, and since that time no new material of importance has come into my hands. The species recognized are:

*Drosera rotundifolia*, Linn.
*Acer spicatum*, Lamx.
*Potentilla Canadensis*, Linn.
*Gaylussacia resinosa*, Jones.
*Populus balsamifera*, Linn.

*Thuja occidentalis*, Linn. (found at Montreal.)
*Potamogeton perfoliatus*, Linn.
*Equisetum scirpoides*, Michx.
*Carices* and *gramineæ*, fragments.
*Fontinalis*, sp.
*Algae.*

These plants occur in the marine Leda clay, containing its characteristic fossils, and were probably washed from the neighbouring land by streams. They indicate to some extent the flora of the Laurentian hills bordering the valley of the Ottawa, at the time of the Post-pliocene subsidence. The inferences as to climate deducible from them are stated in the following extract from the paper above referred to:

"None of the plants above mentioned are properly Arctic in their distribution, and the assemblage may be characterized as a selection from the present Canadian flora of some of the more hardy species having the most northern range. Green's Creek is in the central part of Canada, near to the parallel of 46°, and an accidental selection from its present flora, though it might contain the same species found in the nodules, would certainly include with these, or instead of some of them, more southern forms. More especially the balsam poplar, though that tree occurs plentifully on the Ottawa, would not be so predominant. But such an assemblage of drift plants might be furnished by any American stream flowing in the latitude of 50° to 55° north. If a stream flowing to the north it might deposit these plants in still more northern latitudes, as the McKenzie River does now. If flowing to the sonth it might deposit them to the south of 50°. In the case of the Ottawa, the plants could not have been derived from a more southern locality, nor probably from one very far to the north. We may therefore safely assume that the refrigeration indicated by these plants would place the region bordering the Ottawa in nearly the same position with that of the south coast of Labrador fronting on the Gulf of St. Lawrence, at present. The absence of all the more Arctic species occurring in Labrador, should perhaps induce us to infer a somewhat more mild climate than this."

The climatic indications afforded by these plants are not dissimilar from those furnished by a consideration of the marine fauna of the period of the Leda clay.

*Addenda to Echinodermata.*

Mr. T. Curry of Montreal has been so fortunate as to find in the Leda clay near that city, in addition to fragments apparently of an *Ophioglypha*, a specimen probably of *Ophiacantha spinulosa*, Muller and Tr., and one of *Solaster papposa*, Linn. Both of these are species now found in the Gulf of St. Lawrence. Mr. Matthews has also obtained a second species of Ophiurid Starfish at St. John.

*Summary of Fossils.*

The above lists include, in all, about 205 species, being more than twice the number included in previous lists, and distributed as follows:

| | | |
|---|---|---|
| Plants | | 10 |
| Animals— | Radiata | 24 |
| | Mollusca | 140 |
| | Articulata | 26 |
| | Vertebrata | 5 |
| | | 205 |

The whole of these, with the three or four exceptions, may be affirmed to be living Northern or Arctic species, belonging in the case of the marine species, to moderate depths, or varying from the littoral zone to say 200 fathoms. The assemblage is identical with that of the northern part of the Gulf of St. Lawrence and Labrador Coast at present, and differs merely in the presence or absence of a few more southern forms now present in the Gulf, especially in its southern part, where the fauna is of a New England type, whereas that of the Post-pliocene may be characterized as Labradorian. As might have been anticipated from the relations of the Modern marine fauna, the species of the Canadian Post-pliocene are in great part identical with those of the Greenland seas and of Scandinavia, where, however, there are many species not found in our Post-pliocene. The Post-pliocene fauna of Canada is still more closely allied to that of the deposits of similar age in Britain and in Norway. Change of climate, as I have shewn in previous papers, having been much more extensive on the east than on the west side of the Atlantic, owing to the distribution of warm and cold currents resulting from the present elevation of the land.

It cannot be assumed that the fauna of the older part of the Canadian Post-pliocene is different to any great extent from that of the more modern part. Such difference as exists seems to depend merely on a gradual amelioration of climate. The shells of the lower Boulder-clay, and of those more inland and elevated portions of the beds which may be regarded as older than those of the lower terraces near the coast, are undoubtedly more Arctic in character. The amelioration of the climate seems to have kept pace with the gradual elevation of the land, which threw the cold ice-bearing Arctic currents from its surface, and exposed a larger area of land to the action of solar heat, and also probably determined the flow of the waters of the Gulf Stream into the North Atlantic. By these causes the summer heat was increased, the winds both from the land and sea were raised in temperature, and the heavy northern ice was led out into the Atlantic, to be melted by the Gulf Stream, instead of being drifted to the south-west over the lower levels of the continent. Still the cold Arctic currents entering by the Straits of Belle-isle and the accumulation of ice and snow in winter, are sufficient to enable the old Arctic fauna to maintain itself on the Northern side of the Gulf of St. Lawrence, and to extend as far as the latitudes of Murray Bay and Gaspé. South of Gaspé we have the warmer New England fauna of Northumberland Strait. I may add that some of the peculiarities of the Post-pliocene fauna in comparison with that of the St. Lawrence river, indicate a considerable influx of fresh water, derived possibly from melting ice and snow.

## PART III.—GENERAL CONCLUSIONS.

This Memoir has already extended to so great length, that I shall be under the necessity of dwelling as little as possible on the general geological truths deducible from the facts which have been stated. I shall specially refer to only two points: (1) The relation of the Post-pliocene fossils to questions of derivation of species; (2) The bearing of the facts above stated on theories of land glaciation.

On the first of these subjects I may remark that whatever may have been the lapse of geological time from the period of the oldest Boulder Clay to that in which we live, and great though the climatal and geographical changes have been, we cannot affirm that any change even of varietal value has taken place in any of the 205 species of the above lists. This appears to me a fact of extreme significance with reference to theories of the modification of species in geological time. No geologist doubts that the Post-pliocene was a period of considerable duration. The great elevations and depressions of the land, the extensive erosions, the wide and thick beds of sediment, all testify to the lapse of time. The changes which occurred were fruitful in modifications of depth and temperature. Deep waters were shallowed, and the sea overflowed areas of land. The temperature of the waters changed greatly, so that the geographical distribution of marine animals was materially affected. Yet all the Post-pliocene species survive, and this without change. Even variable forms like the species of *Buccinum* and *Astarte* show the same range of variation in the Post-pliocene as in the modern, and though some varieties have changed their geographical position, they have not changed their character. This result is obviously independent of imperfection of the geological record, because there is no reason to doubt that these species have continuously occupied the North Atlantic area, and we have great abundance of them for comparison both in the Post-pliocene and the modern seas. It is also independent of any questions as to the limits of species and varieties, inasmuch as it depends on careful comparisons of the living and fossil specimens; and by whatever names we may call these, their similarity or dissimilarity remains unaffected. We have at present no means of tracing this fauna as a whole farther back. Some of its members we know existed in the Pliocene and Miocene without specific difference; but some day the middle tertiaries of Greenland may reveal to us the ancestors of these shells, if they lived so far back, and may throw further light on their origin. In the meantime we can affirm that the lapse of time since the Pliocene has not sufficed even to produce new races; and the inevitable conclusion is that any possible derivation of one species from another is pushed back infinitely, that the origin of specific types is quite distinct from varietal modification, and that the latter attains to a maximum in a comparatively short time, and then runs on unchanged, except in so far as geological vicissitudes may change the localities of certain varieties. This is precisely the same conclusion at which I have elsewhere arrived from a similar comparison of the fossil floras of the Devonian and Carboniferous periods in America.

The second leading point to which I would direct attention is the relative value of land ice and water-borne ice as causes of geological change in the Post-pliocene. On this subject I have for the last sixteen years constantly maintained that moderate view which has been that of Sir Roderick Murchison and Sir Charles Lyell, that the Post-pliocene subsidence and refrigeration produced a state of our Continent in which the lower levels and at certain periods even the tops of the higher hills were submerged, under water filled every season with heavy ice derived from glaciers, and that at certain stages of submergence the hilly ranges were occupied with glaciers, sending down their ice to the level of the sea. I need not reiterate the arguments for this view; but may content myself with a reference to the changes of opinion on the subject. The glacier theory of Agassiz and others may be said to have grown till, like the imaginary glaciers themselves, it overspread the earth. All northern Europe and America were covered with a mer-de-glace, moving to the southward and outward to the sea. This great ice-mantle not only removed stones and clay to immense distances, and glaciated and striated the whole surface, but it cut out great lake basins and fiords, ground even the tops of the highest hills, and accounted for everything otherwise difficult in the superficial contour of the land. It was even transferred to Brazil, and employed to excavate the valley of the Amazon. But this was its last feat, and it has recently been melting away under the warmth of discussion until it is now but a shadow of its former self. I may mention a few of the facts which have contributed to this result. It has been found that the glacial Boulder-clays are in many cases marine. Cirques and other Alpine valleys, once supposed to be the work of glaciers, are now known to have been produced by aqueous denudation. Great lakes, like those of America, supposed to be inexplicable except by glacier erosion, have been found to admit of being otherwise accounted for. The transport of boulders and direction of striation have been found to conflict with the theory of continental glaciation, or to require too extravagant suppositions to account for them in that way. Greenland, at one time supposed to be a modern example of an ice-clad continent, has been found to be merely a mass of rocky hills and table-lands with local glaciers. The relation of Greenland to Baffin's Bay and Davis Straits, proves to be similar to that which may have obtained between the Laurentide hills and the submerged valley of the St. Lawrence. Lastly, the power attributed to glaciers as eroding agents, has been found to be altogether fallacious. I was surprised, in visiting the Alps in 1865, to find that this boasted erosive power was little else than a myth; and I see that since that time many other observers have arrived at similar conclusions. I have recently seen a very sensible view of this question in a popular book by the well-known Alpine explorer, Whymper, of which I may quote the concluding paragraph, as precisely stating my own view as expressed in the Canadian Naturalist in 1866:

"If I were asked whether the action of glaciers upon rocks should be considered as chiefly destructive or conservative, I should answer without hesitation principally as conservative. It is destructive certainly to a limited extent; but like a mason who dresses a column that is to be afterwards polished, the glacier removes a small portion of the stone on which it works in order that the rest may be more effectually preserved."*

Some of the ablest of the advocates of the action of continental glaciers have recently in my opinion contributed largely to the overthrow or modification of the theory. I may refer to two examples.

Prof. Dana has given the *coup de grace* to the American continental glacier by his paper in the No. of Silliman's American Journal for November, 1871. In this paper he affirms that "the idea of a central glacier source for the continent is without foundation," so that it comes to be a question of local glaciers. He demands, however, one very large glacier of this kind. South-east striae occur on the mountains of New England to a height of 5000 to 5200 feet above the sea. A glacier to make these must, as he admits, have moved from a higher level. But N.W. of these striated mountains lie the valley of Lake Champlain and the great plain of the St. Lawrence, the latter with S. W. striæ at right angles to those on the mountains. Still farther in the same direction is the valley of the Ottawa, and between this and the great low region of Hudson's Bay is only the Laurentian watershed of about 1500 feet high. From this must have flowed the glacier which passed over the tops of the White Mountains. In order to effect this result, it is necessary to suppose an elevation of the Hudson's Bay watershed in the Post-pliocene period to at least

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* Whymper, "Scrambles amongst the Alps."

4,500 feet above its present height, and considering the uneven nature of the intervening country this is far too little. From this imaginary plateau 6000 to 7000 feet high, flowed a glacier over an intervening valley at least 5000 feet deep and thence over the Green and White Mountains. The glacier must consequently have been itself at least 7000 to 8000 feet thick. Farther "on nearing the St. Lawrence the lower part of its mass yielded to the impulse of gravity according to the slopes of this transverse valley, so that along this valley only *southwest* scratches were made." But the southwest scratches of the St. Lawrence valley run from Labrador to the lake region and beyond, and have been produced by a force acting from the northeast, so that the actual fact must have been the flowing of a transverse glacier under the other up the slope of the country, then on the hypothesis probably greater than at present. But the whole assumption of an unequal elevation of the continent, so as to give a mountain region of the required elevation is destitute of proof; and not only so but contrary to the observed facts, which indicate very equable movements of elevation and depression as high at least as the terraces and raised beaches extend. In short, while our continental glacialists demand a glacier that shall move up the St. Lawrence valley and over the Niagara escarpment into Lake Erie, they also demand the creation of a mountain north of the St. Lawrence, high enough to enable a glacier to glide from it over the White Mountains. These extravagant assumptions are fatal to their theory, and shew that they will be driven to have recourse to floating ice to explain a large part at least of the phenomena.

Mr. J. Geikie, one of the most stubborn of land glacialists, is doing a similar service to the cause of truth, in a series of articles now appearing in the London Geological Magazine. He candidly admits that the "evidence which has been accumulating during recent years will compel us to modify materially" the views of the extreme glacialists. He further admits that the Boulder-clay or till contains stratified gravel, clay and sand, with marine shells. He still maintains that the Boulder-clay proper is moraine matter produced on land, though there is evidence that this Boulder-clay as well as the stratified beds included in it, sometimes at least holds marine shells. He further seems to maintain that Boulder-clay proper, being an unstratified deposit, cannot be of marine origin, though this assumption is controverted, first, by the fact that clays full of stones and boulders contain marine shells, and in Canada at least, the boulders imbeded in such hard clays of the nature of till, often have Bryozoa and Acorn-shells attached to them; and, secondly, by the fact that the clays holding numerous boulders sometimes are stratified. Holding, however, his peculiar views about the Boulder-clay, Mr. Geikie must account for it by land glaciers, and the facts, according to him, shew that these could not have been merely a number of small local glaciers, but a general *mer de glace.* To reconcile this with the occurrence of the marine beds, he is obliged to have recourse to a series of cold and warm periods, and of emergences and submergences, some of them of sufficient duration to enable the country to be occupied with forests and with terrestrial mammalia. Thus it becomes necessary to exaggerate the duration of the glacial period, and indeed to invoke the aid, not of one glacial period, but of many, separated from each other by long periods of ameliorated climate. All this would be avoided by at once admitting the existence of marine Boulder-clays, and endeavouring to separate these either by their fossils or by their chemical and mechanical character from the glacial moraines, which I have no doubt will be found in Scotland as in North America to belong merely to local glaciers flowing in the existing valleys. The kames or eskers, which used both in Scotland and this country to be confounded with moraine ridges, Mr. Geikie now, with all other good geologists, regards as marine, though he attributes some of them to an older date than that held by Home and others.

My general conclusion on this subject is therefore precisely what it was many years ago, and that on which I have proceeded throughout this paper; namely, that we have in Canada evidence of a glacial period in which all the hilly ranges above water, were covered with snow and had glaciers in their valleys; these glaciers terminating and giving off icebergs at the mouths of the valleys, where these opened on the plain of the St. Lawrence, then under water. In the earlier part of the period the elevated land of the Pliocene epoch gradually sunk under the waters, and the remainder of it became refrigerated and covered with snow and ice. At the period of greatest subsidence, nearly all the hills were submerged, and heavy ice from the north ground over their summits; while the upper part of the Boulder-clay and the lower beds of the Leda clay were deposited in the valleys.

As the land rose again, ice-clad hills returned, and new though perhaps less extensive glaciers were formed, and fresh crops of boulders were deposited in the shallowing seas of the Saxicava sand period. Snow still exists throughout the summer in the higher ravines of the White Mountains, and on the hills of Labrador, and a subsidence of a few hundred feet in the valley of the St. Lawrence and the country to the southward, would suffice to restore them to the condition of snow-clad hills giving off icebergs from their bases, so near are we yet to the glacial period; and so little did it really differ from that condition of the continent which still exists. I do not here enter into the question of possible astronomical causes of refrigeration suggested by Croll and others. These may have been influential both with reference to changes of level and of temperature; but I believe the changes of level are sufficient to account for the observed facts.

On my return from Europe in 1866, I endeavoured in a popular lecture, printed in Vol. III. N. S. of the Canadian Naturalist, and entitled comparisons of the "Icebergs of Belleisle and the Glaciers of Mont Blanc," to picture the condition of Post-pliocene Canada. I may refer to this paper as more fully stating my conclusions on the subject, and shall close this summary of the results of sixteen years' work in the Post-pliocene, with two extracts referring to the nature of the action of glaciers and the probable state of Post-pliocene Canada.

"Glaciers are mills for grinding and triturating rock. The pieces of rock in the moraine are, in the course of their movement, crushed against one another and the sides of the valley, and are cracked and ground as if in a crushing-mill. Farther, the stones on the surface of the glacier are ever falling into crevasses, and thus reach the bottom of the ice, where they are further ground against one another and the floor of rock. In the movement of the glacier these stones seem in some cases to come again to the surface, and their remains are finally discharged in the terminal moraine, which is the waste-heap of this great mill. The fine material which has been produced, the flour of the mill, so to speak, becomes diffused in the water which is constantly flowing from beneath the glacier, and for this reason all the streams flowing from glaciers are turbid with whitish sand and mud.

"The Arve which drains the glaciers of the north side of Mont Blanc, carries its burden of mud into the Rhone, which sweeps it, with the similar material of many other Alpine streams, into the Mediterranean, to aid in filling up the bottom of that sea, whose blue waters it discolours for miles from the shore, and to increase its own ever enlarging delta which encroaches on the sea at the rate of about half a mile per century. The upper waters of the Rhone, laden with similar material, are filling up the Lake of Geneva; and the great deposit of 'loess' in the alluvial plain of the Rhine, about which Gaul and German have contended since the dawn of European history, is of similar origin. The mass of material which has thus been carried off from the Alps, would suffice to build up a great mountain chain. Thus by the action of ice and water—

> "The mountain falling cometh to naught
> And the rock is removed out of its place."

"Many observers who have commented on these facts have taken it for granted that the mud thus sent off from glaciers, and which is so much greater in amount than the matter remaining in their moraines, must be ground from the bottom of the glacier valleys, and hence have attributed to these glaciers great power of cutting out and deepening their valleys. But this is evidently an error, just as it would be an error to suppose the flour of a grist-mill ground out of the mill-stones. Glaciers it is true groove and striate and polish the rocks over which they move, and especially those of projecting points and slight elevations in their beds, but the material which they grind up is principally derived from the exposed frost-bitten rocks above them, and the rocky floor under the glacier is merely the nether mill-stone against which these loose stones are crushed. The glaciers in short can scarcely be regarded as cutting agents at all, in so far as the sides and bottoms of their beds are concerned, and in the valleys which the old glaciers have abandoned, it is evident that the torrents which have succeeded them have far greater cutting power."

"In conclusion, I would wish it to be distinctly understood, that I do not doubt that at the time of the greatest post-pliocene submergence of Eastern America, at which time I believe the greater part of the boulder clay was formed, and the more important striation effected, the higher hills then standing as islands would be capped with perpetual snow, and through a great part of the year surrounded with heavy field and barrier ice, and that in these hills there might be glaciers of greater or less extent. Further it should be understood that I regard the boulder clays of the St. Lawrence valley as of different ages, ranging from the early post-pliocene to that at present forming in the gulf of St. Lawrence. Further, that this boulder clay shows in every place where I have been able to examine it, evidence of sub-aquatic accumulation, in the presence of marine shells or in the unweathered state of the rocks and minerals enclosed in it, conditions which, in my view, preclude any reference of it to glacier action, except possibly in some cases to that of glaciers stretching from the land over the margin of the sea, and forming under water a deposit equivalent in character to the 'boue glaciare' of the bottom of the Swiss glaciers. But such a deposit must have been local, and would not be easily distinguishable from the marine boulder clay. I have not had opportunities to study the boulder clay of Scotland, which in character and relations so closely resembles that of Canada, but I confess several of the facts stated by Scottish Geologists lead me to infer that much of what they regard as of sub-aerial origin must really be marine, though whether deposited by ice-bergs or by the fronts of glaciers terminating in the sea, I do not pretend to determine. It must however be observed that the antecedent probability of a glaciated condition is much greater in the case of Scotland than in that of Canada, from the high northern latitude of the former, its more hilly character, and the circumstance that its present exemption from glaciers is due to what may be termed exceptional and accidental geographical conditions; more especially to the distribution of the waters of the Gulf stream, which might be changed by a comparatively small subsidence in Central America. To assume the former existence of glaciers in a country in north latitude 56°, and with its highest hills, under the present exceptionally favourable conditions, snow-capped during most of the year, is a very different thing from assuming a covering of continental ice over wide plains more than ten degrees farther south, and in which, even under very unfavourable geographical accidents, no snow can endure the summer sun, even in mountains several thousand feet high. Were the plains of North America submerged and invaded by the cold Arctic currents, the Gulf stream being at the same time turned into the Pacific, the temperature of the remaining North American land would be greatly diminished; but under these circumstances the climate of Scotland would necessarily be reduced to the same condition with that of South Greenland or Northern Labrador. As we know such a submergence of the land to have occurred in the Post-pliocene period, it does not seem necessary to have recourse to any other cause for either side of the Atlantic. It would, however, be a very interesting point to determine, whether in the Post-pliocene period the greatest submergence of America coincided with the greatest submergence of Europe, or otherwise. It is quite possible that more accurate information on this point might remove some present difficulties. I think it much to be desired that the many able observers now engaged on the Post-pliocene of Europe, would at least keep before their minds the probable effects of the geographical conditions above referred to, and enquire whether a due consideration of these would not allow them to dispense altogether with the somewhat extravagant theories of glaciation now agitated."

It is hardly necessary to add that I hold and have endeavoured to prove by modern facts, in the Memoirs above referred to, that heavy icebergs borne by powerful currents, are potent agents in the production of striated surfaces and glaciated stones, as well as in transporting boulders, and that cold ocean currents are powerful eroding agents, especially when aided by heavy ice. Witness the Straits of Belle-Isle in modern times. Mr Vaughan, for many years Superintendent of the Lighthouse at that place, states that for ten icebergs which enter the straits fifty drift to the southward, yet he records that on the 30th of May, 1858, he counted in the Strait of Belle-Isle 496 bergs, the least of them sixty feet in height, some of them half a mile long and two hundred feet high. Only one-eighth of the volume of floating ice appears above water, and many of these great bergs may thus touch the ground in a depth of thirty fathoms or more, so that if we imagine four hundred of them moving up and down under the influence of the current, oscillating slowly with the motion of the sea, and grinding on the rocks and stone-covered bottom at all depths from the centre of the channel, we may form some conception of the effects of these huge polishers of the sea-floor.

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If this memoir had not already extended to too great length, I could have wished to notice the evidence as to the existence of ice-action in more ancient periods than the Post-pliocene. I would now merely state my belief that some of the considerations which render it necessary to invoke the action of frost and ice in the Post-pliocene period, apply also to the origin of some rocks of much higher antiquity. Ramsay has already noticed this in the case of the Permian conglomerates of England. In Canada an instance occurs in the conglomerate with boulders two feet in diameter, found in the Lower Silurian of Maimanse, Lake Superior.* A still more remarkable case is that of the New Glasgow conglomerate in the coal formation of Nova Scotia, which seems to be a gigantic esker, on the outside of which large travelled boulders were deposited, probably by drift ice, while in the swamps within, the coal flora flourished and fine mud and coaly matter were accumulated.†

A second indication of the existence of intense frost in ancient geological periods, is afforded by the occurrence of angular fragments of hard rocks cemented together. Such beds of angular fragments and chips, occur locally at various horizons, for example in the Upper Silurian and Lower Carboniferous in Nova Scotia, and the material of which they are composed seems precisely similar to that which is at present produced by the disintegrating action of frost on hard and especially schistose and jointed rocks. Such deposits may, I think, fairly be regarded as evidence of somewhat intense winter cold.

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Supplementary Note.—A visit to Nova Scotia while these sheets were going through the press enables me to add the following facts: (1.) The discovery by Mr. G. F. Matthews of shells of Tellina Grœnlandica in the Post-pliocene gravel at Horton Bluff, Nova Scotia. (2.) The occurrence of Laurentian boulders, probably from Labrador, in the Carboniferous region of Nova Scotia. I may specially mention a very fine boulder of Labradorite near the mouth of Carribou River, Pictou County. In Nova Scotia, however, as well as in Prince Edward Island, native stones predominate in the lower Boulder-clay, and the foreign blocks appear more toward the surface; where also, in many cases the greater part of the blocks derived from neighbouring heights are collected. I had occasion often to notice the fact, referred to above, of drift from the south as well as from the north, and also the great frequency in the boulder deposits of glaciated stones.

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* Can. Nat. II, p. 6. † Acadian Geology, p. 324.

# HISTORY OF THE NAMES CAMBRIAN AND SILURIAN IN GEOLOGY.

By T. Sterry Hunt, LL.D., F.R.S.

(*Concluded from page* 312).

## III. Cambrian and Silurian Rocks in North America.

In accordance with our plan we now proceed to sketch the history of the lower paleozoic rocks in North America. While European geologists were carrying out the researches which have been described in the first and second parts of this paper, American investigators were not idle. The geological studies of Eaton led the way to a systematic survey of the state of New York, the results of which have been the basis of most of the subsequent geological work in eastern North America, and which was begun by legislative enactment in 1836. The state was divided into four districts, the work of examining and finally reporting upon which was committed to as many geologists. The first or south-eastern district was undertaken by Mather, the second or north-eastern by Emmons, the third or central by Vanuxem, and the fourth or western by James Hall; the paleontology of the whole being left to Conrad, and the mineralogy to Beck. After various annual reports the final results of the survey appeared in 1842. The whole series of fossiliferous rocks known, from the basal or Potsdam sandstone to the coal-formation, was then described as the New York system.

At that time the published researches of British geologists furnished the means of comparison between the organic remains found in the rocks of New York, and those then known to exist in the paleozoic strata of Great Britain. Prof. Hall was thus enabled in his Geology of the Fourth District of New York, to declare, from the study of its fossils, that the New York system included the Devonian of Phillips, the Silurian of Murchison, and the Cambrian of Sedgwick; meaning by the latter the Upper Cambrian, or Bala group, which alone was then known to be fossiliferous. From the evidence then before him, he concluded that the Upper Cambrian was represented in the New York system by the whole of the rocks from the base of the Utica slate, downward, with the probable exception of the Potsdam sandstone; while he conceived, partly on lithological grounds, that the Utica and Hudson-River groups represented the Llandeilo and Caradoc, or the Lower Silurian of Murchison [loc. cit. pages 20, 29, 31]. The origin of the Cambrian and Silurian controversy, and the errors by which the Llandeilo and a part of the Caradoc had by Murchison been classed as a series distinct from the Bala group, were not then known; but in a note to this report [page 20,] Hall informs us of the declaration of Murchison, already quoted from his address of 1842, that the Cambrian, so far as then known, could not, on paleontological grounds, be distinguished from his Lower Silurian.

Emmons meanwhile had examined in eastern New York and western New England a series of fossiliferous rocks, which on lithological and stratigraphical grounds, he regarded as older than any in the New York system; a view which had been previously maintained by Eaton. Holding, with Hall, that the lower members of the New York system were the equivalents of the Upper Cambrian of Sedgwick, he looked upon the fossiliferous rocks which he placed beneath them, as the representatives of the Lower Cambrian. By this name, as we have seen, Sedgwick, in 1838, designated all those uncrystalline rocks of North Wales which he subsequently divided into Lower and Middle Cambrian, and which lie beneath the base of the Bala group. When Murchison, in 1842, in his so often quoted declaration, asserted that "the term Cambrian must cease to be used in zoological classification, it being in that sense synonymous with Lower Silurian," he was speaking only on paleontological grounds, and, disregarding the great Lower and Middle Cambrian divisions of Sedgwick, had reference only to the Upper Cambrian. This however was overlooked by Emmons, who feeling satisfied that the sedimentary rocks which he had examined in eastern New York were distinct from those which he, with Hall, regarded as corresponding to the Bala group or Upper Cambrian, (the Lower Silurian of Murchison), and probably equivalent to the inferior portions of Sedgwick's Cambrian; and supposing that the latter term was henceforth to be effaced from geology (as indeed was attempted shortly after, in the copy of Sedgwick's map published in 1844 by the Geological Society) devised for these rocks the name of the Taconic system, as synonymous with the Lower (and Middle) Cambrian of Sedgwick. These conclusions were set forth by him in 1842, in his report on the Geology of the Northern District of New York [page 162]. See also his Agriculture of New York [I, 49] the fifth chapter of which, "On the Taconic system," was also published separately in 1844; when the presence of distinctive organic remains in the rocks of this series was first announced.

Meanwhile to Prof. Hall, after the completion of the survey, had been committed the task of studying and describing the organic remains of the state, and in 1847 appeared the first volume of his great work on the "Paleontology of New York." Since 1842 he had been enabled to examine more fully the organic remains of the lower rocks of the New York system, and to compare them with those of the old world; and in the Introduction to the volume just mentioned [page xix] he announced the important conclusion that the New York system itself contained an older fauna than the Upper Cambrian of Sedgwick. According to Hall, the organic forms of the Calciferous and Chazy formations had not yet been found in Europe, and our comparison with European fossiliferous rocks must commence with the Trenton group. He however excepted the Potsdam sandstone, which already, in 1842, he had conceived to be below the Upper Cambrian of Sedgwick, and now regarded as the probable equivalent of the Obolus or Ungulite grit of St. Petersburg. Thus Emmons, in 1842, asserted, on lithological and stratigraphical grounds, the existence, beneath the base of the New York system, of a lower and unconformable series of rocks, in which, in 1844, he announced the discovery of a distinctive fauna. Hall, on his part, asserted in 1842, and more fully in 1847, that the New York system itself held an older fauna than that hitherto known in the British rocks.

It is not necessary to recall in this place the details of the long and unfortunate Taconic controversy, which I have recently discussed in my address before the American Association for the Advancement of Science in August, 1871. It is however to be remarked that Hall, in common with all other American geologists, followed Henry D. Rogers in opposing the views of Emmons, whose Taconic system was supposed to represent either the whole or a part of the Champlain division of the New York system; which included, as is well known, all of the fossiliferous rocks up to the base of the Oneida conglomerate (and also this latter, according to Emmons); thus comprehending both the first and the second paleozoic fauna; as shown in the table on page 312.

Emmons, misled by stratigraphical and lithological considerations, complicated the question in a singular manner, which scarcely finds a parallel except in the history of Murchison's Silurian sections. Completely inverting, as I have elsewhere shown, the order of succession in his Taconic system, estimated by him at 30,000 feet, he placed near the base of the lower division of the system the Stockbridge or Eolian limestone, including the white marbles of Vermont; which, by their organic remains, have since been by Billings found to belong to the Levis formation. A large portion of the related rocks in western Vermont and elsewhere, which afford a fauna now known to be far more ancient than that of the Lower Taconic just referred to, and as low if not lower than anything in the New York system, were, by Emmons, then placed partly near the summit of the Upper Taconic, and partly not only above the whole Taconic system, but above the Champlain division of the New York system. Thus we find in 1842, in his Report on the Geology of the Northern District of New York (where Emmons defined his views on the Taconic system), that he placed above this latter horizon, both the green sandstone of Sillery near Quebec, and the red sandrock of western Vermont, (which he then regarded as the representatives of the Oneida and the Medina sandstones,) and described the latter as made up from the ruins of Taconic rocks [pages 124, 282]. In 1844–1846, in his Report on the Agriculture of New York [I. 119], he however adopted a different view of the red sandrock, assigning it to the Calciferous; and in 1855, in his "American Geology" [ii. 128], it was regarded as in part Calciferous and in part Potsdam. In 1848 Prof. C. B. Adams, then director of the Geological Survey of Vermont, argued strongly against these latter views, and maintained that the red sandrock directly overlaid the shales of the Hudson-River group and corresponded to the Medina and Clinton formations of the New York system. [Amer. Jour. Sci. II, v. 108.] He had before this time discovered in this sandrock, besides what he considered an *Atrypa*, abundant remains of a trilobite, which Hall, in 1847, referred to the genus *Conocephalus* (*Conocoryphe*), remarking at the same time that inasmuch as this genus was (at that time) only described as occurring in "graywacke in Germany" and elsewhere, no conclusions could be drawn from these fossils as to the geological horizon of the rocks in question. [Ibid. II, xxxiii, 371.] In September, 1861, however, Mr. Billings, after an examination of the rocks in question, pronounced in favor of the later opinion of Emmons, declaring the red sandrock near Highgate Springs, Vermont, containing *Conocephalus* and *Theca*, to belong to the base of the second fauna "if not indeed a little lower," and to be "somewhere near the horizon of the Potsdam." [Ibid. II, xxxii, 232.]

The dark colored fossiliferous shales which were asserted, both by Adams and by Emmons, to underlie this red sandrock, were, by the former, as we have seen, regarded as belonging to the Hudson-River group, while by the latter they were described as an upper member of the Taconic system; which was here declared to be unconformably overlaid by the red sandrock, a member of the New York system. These slates, a few years before, had afforded some trilobites, which after remaining in the hands of Prof. Hall for two years or more, were in 1859, described by him in the 12th "Report of the Regents of the University of New York," as *Olenus Thompsoni* and *O. Vermontana*. He soon however found them to constitute a distinct genus, for which he proposed the name of *Barrandia*, but finding this name preoccupied, suggested in 1861, in the 14th "Regents' Report," that of *Olenellus*, which was subsequently adopted by Billings, in 1865. [Paleozoic Fossils, pages 365, 419.] In 1860, Emmons, in his "Manual of Geology," described the same species, but placed them in the genus *Paradoxides*, as *P. Thompsoni and P. Vermontana*. Hall had already, in 1847, in the first volume of his Paleontology of New York, referred to *Olenus* the *Elliptocephalus asaphoides* of Emmons, and also a fragment of another trilobite from Saratoga Lake; both of which were described as belonging to the Hudson-River group of the New York system, or to a still higher horizon. The reasons for this will appear in the sequel. The *Elliptocephalus*, with another trilobite named by Emmons *Atops*, (referred by Hall to *Calymene*, and subsequently, by Billings to *Conocoryphe*,) occurs at Greenwich, New York. These were by Emmons, in his essay on the Taconic system (in 1844), described as characteristic of that system of rocks.

A copy of the Regent's Report for 1859 having been sent by Billings to Barrande, this eminent paleontologist, in a letter addressed to Prof. Bronn of Heidelberg, July 16, 1860 [Amer. Jour. Sci. II, xxxi, 212], called attention to the trilobites therein figured, and declared that no paleontologist familiar with the trilobites of Scandinavia would "have hesitated to class them among the species of the primordial fauna, and to place the schists enclosing them in one of the formations containing this fauna. Such is my profound conviction, etc." The letter containing this statement had already appeared in the American Journal of Science for March, 1861, but Mr. Billings in his note just referred to, on the fossils of Highgate, in the same Journal for September of that year, makes no allusion to it. In March, 1862, however, he returns to the subject of the sandrock, in a more lengthy communication [Ibid II, xxxiii, 100), and after correcting some omissions in his former note, alludes in the following language to Mr. Barrande, and to the expressed opinion of the latter, just quoted, with regard to the fossils in question and the rocks containing them: "I must also state that Barrande first determined the age of the slates in Georgia, Vermont, holding *P. Thompsoni* and *P. Vermontana*." He adds "at the time I wrote the note on the Highgate fossils it was not known that these slates were conformably interstratified with the red sandrock. This discovery was made afterwards by the Rev. J. B. Perry and Dr. G. M. Hall of Swanton."

Mr. Billings now blames me [Canadian Naturalist, new series, vi, 318] for having written in my address of last year, with regard to the Georgia trilobites, first described as *Olenus* by Prof. Hall, that Barrande "called attention to their primordial character, and thus led to a knowledge of their true stratigraphical horizon." I had always believed that the letter of Barrande and the explicit declaration of Mr. Billings, just quoted, contained the whole truth of the matter. My attention has since been called to a subsequent note by Mr. Billings in May, 1862, [Ibid II, xxxiii, 421] in which, while asserting that Emmons had already assigned to these rocks a greater age than the New York system, he mentions that in sending to Barrande, in the spring of 1860, the Report of Prof. Hall on the Georgia fossils, he alluded to their primordial character, and suggested that they might belong to what Mr. Barrande has called 'a colony' in the rocks of the second fauna. This is also stated in a note by Sir William Logan in the preface to the Geology of Canada [page viii.] As the genus Olenus, to which Prof. Hall had referred the fossils in question, was at that time (1860) well-known to belong, both in Great Britain and in Scandinava, to the primordial fauna, Mr. Barrande does not seem to have thought it necessary in his correspondence to refer to the very obvious remark of Mr. Billings.

Mr. Billings further showed in his paper in March, 1862, that fossils identical with those of the Georgia slates had been found by him in specimens collected by Mr. Richardson of the Geological Survey of Canada in the summer of 1861, on the Labrador coast, along the strait of Belisle: where *Olenellus* (*Paradoxides*) *Thompsoni* and *O. Vermontana* were found with *Conocoryphe* (*Conocephalus*) in strata which were by Billings referred to the Potsdam group. [See for the further history of these fossils the Geology of Canada, pages 866, 955, and Pal. Fossils of Canada, pages 11, 419.]

The interstratification of the dark-colored fossiliferous shales holding *Olenellus* with the red sandrock of Vermont, announced by Mr. Billings, was further confirmed by Sir William Logan in his account of the section at Swanton, Vermont [Geology of Canada, 281]. They were there declared to occur about 500 feet from the base of a series of 2200 feet of strata, consisting chiefly of red sandy dolomites (the so-called sandrock) containing *Conocephalus* throughout, while the shaly beds held in addition, the two species of *Paradoxides* (*Olenellus*) and some brachiopods. These beds, like those of Labrador, were referred by Logan and by Billings to the Potsdam group. The conclusions here announced were of great importance for the history of the Taconic controversy. The trilobites of primordial type, from Georgia, Vermont, which by Emmons were placed in the Taconic system, lying unconformably beneath a series of rocks belonging to the lower part of the New York system, were now declared to belong to the red sandrock group, a member of this overlying system. Much has been said of these fossils, as if they furnished in some way a vindication of the views of Emmons, and of the Taconic system; a conclusion which can only be deduced from a misconception of the facts in the case. Emmons had, previous to 1860, on lithological and stratigraphical evidence alone, called the Georgia slates Taconic, and placed them unconformably beneath the red sandrock. If now both he and Billings were right in referring the red sandrock to the Calciferous and Potsdam formations, and if the stratigraphical determination of Messrs. Perry and G. M. Hall, confirmed by those of Logan, were correct, viz: that the trilobites in question occur not in a system of strata lying unconformably beneath the red sandrock, but in beds intercalated with the red sandrock itself, it is clear that these trilobites must belong not to the Taconic, but to the New York system. We shall return to the question of the age of these rocks.

We have seen that Prof. James Hall, in 1847, and again in 1859, referred trilobites regarded by him as species of *Olenus* to the Hudson-River group, or in other words to the summit of the second paleozoic fauna, while it is now well known that they are characteristic of the first fauna. In this reference, in 1847, Prof. Hall was justified by the singular errors which we have already pointed out in the works of Hisinger on the geology of Scandinavia. In his *Anteekningar*, in 1828, while the colored map and accompanying sections show the alum-slates with *Paradoxides* to lie beneath, and the clay-slates with graptolites, above the orthoceratite-limestone, the accompanying colored legend, designed to explain the map and sections, gives these two slates with the numbers 3 and 4, as if they were contiguous and beneath the limestone, which is numbered 5. The student who, in his perplexity, turned from this to the later work of Hisinger, his *Lethaea Suecica*, found the two groups of slates, as before, placed in juxtaposition, but assigned, together, to a position above the orthoceratite-limestone. Thus, in either case, he would be led to the conclusion that in Scandinavia the alum-slates with *Olenus*, *Paradoxides* and *Conocephalus* (*Conocoryphe*) were closely associated with the graptolitic shales; and, upon the authority of the latter work, that the position of both of these was there above the orthoceratite-limestones, and at the summit of the second fauna. The graptolitic shales of Scandinavia were already identified with those of the Utica and Hudson-River formations of the New York system. The red sandrock of Vermont, containing *Conocephalus*, had been, both by Emmons and Adams, alike on lithological and stratigraphical grounds, referred to the still higher Medina sandstone; a view which, as we have seen, was still maintained and strongly defended by Adams. This was in 1847, and Angelin's classification of the transition rocks of Scandinavia, fixing the position of the various trilobitic zones, did not appear until 1854. Prof. Hall had therefore at this time the strongest reasons for assigning the rocks containing *Olenus* to the summit of the second fauna. Before we can understand his reasons for maintaining a similar view in 1859, we must notice the history of geological investigation in eastern Canada. So early as 1827, Dr. Bigsby, to whom North American geology owes so much, had given us [Proc. Geol. Soc. I, 37] a careful description of the geology of Quebec and its vicinity. He there found resting directly upon the ancient gneiss, a nearly horizontal dark colored conchiferous limestone, having sometimes at its base a calcareous conglomerate, and well displayed on the north shore of the St. Lawrence at Montmorenci and Beauport. He distinguished moreover a third group of rocks, described by him as a "slaty series composed of shale and graywacke, occasionally passing into a brown limestone, and alternating with a calcareous conglomerate in beds, some of them charged with fossils * * * * derived from the conchiferous limestone." (This fossiliferous conglomerate contained also fragments of clay-slate.) From all these circumstances Bigsby concluded that the flat conchiferous limestones were older than the highly inclined graywacke series; which latter was described as forming the ridge on which Quebec stands, the north shore to Cape Rouge, the island of Orleans, and the southern or Point-Levis shore of the St. Lawrence; where besides trilobites, and the fossils in the conglomerates, he noticed what he called vegetable impressions, supposed to be fucoids. These were the graptolites which, nearly thirty years later, were studied, described and figured for the Geological Survey of Canada by Prof. James Hall; who has shown that two of the species from this locality were described and figured under the name of fucoids by Ad. Brongniart, in 1828. [Geol. Sur. Canada, Decade II, page 60.] Bigsby, in 1827, conceived that the limestones of the north shore might belong to the carboniferous period, and noted the existence of what were called small seams of coal in the graywacke series of the south shore, which substance I have since described in the Geology of Canada [page 525.]

In 1842, the Geological Survey of Canada was begun by Sir William Logan, who in a Preliminary Report to the Government, in that year [page 19], says "of the relative age of the contorted rocks of Point Levis, opposite Quebec, I have not any good evidence, though I am inclined to the opinion that they come out from below the flat limestones of the St. Lawrence." He however subsequently adds, in a foot-note, "the accumulation of evidence points to the conclusion that the Point Levis rocks are superior to the St. Lawrence limestones." In 1845, Captain, now Admiral Bayfield, maintained the same view, fortifying himself by the early observations of Bigsby, and expressing the opinion that the flat limestones of Montmorenci and Beauport passed beneath the graywacke series. These limestones, from their fossils, were declared to be low down in the Silurian, and identical with those which had been observed at intervals along the north shore of the St. Lawrence to Montreal, [Geol. Journal, i. 455] the fossiliferous limestones of which were then well known to belong to the Trenton group of the New York system. The graywacke series of Quebec, which was still supposed by Bayfield to hold in its conglomerates fossils from these limestones, was therefore naturally regarded as belonging to the still higher members of that system; and, as we have seen, the green sandstone near Quebec, a member of that series, had already in 1842, been regarded by Emmons as the representative of the Oneida or Shawangunk conglomerate, at the summit of the Hudson-River group of New York.

It is to be noticed that immediately to the north-east of Quebec, rocks undoubtedly of the age of the Utica and Hudson-River divisions overlie conformably the Trenton limestone, on the left bank of the St. Lawrence; while a few miles to the south-west, strata of the same age, and occupying a similar stratigraphical position, appear on both sides of the St. Lawrence, and are traced continuously from this vicinity to the valley of Lake Champlain. These moreover offer such lithological resemblances to the so-called graywacke series of Quebec and Point Lévis, (which extends thence some hundreds of miles north-eastward along the right bank of the St. Lawrence,) that the two series were readily confounded, and the whole of the belt of rocks along the south-east side of the St. Lawrence, from the valley of Lake Champlain to Gaspé, was naturally regarded as younger than the limestones of the Trenton group. It was in 1847 that Sir William Logan commenced his examination of the rocks of this region, and in his report the next year [1848, page 58] we find him speaking of the continuous outcrop "of recognized rocks of the Hudson-River group from Lake Champlain along the south bank of the St. Lawrence to Cape Rosier." In his Report for 1850, these rocks were farther noticed as extending from Point Lévis south-west to the Richelieu, and north-east to Gaspé, [pages 19, 32]. They were described as consisting, in ascending sequence from the Trenton limestone and the Utica slate, of clay-slates and limestones, with graptolites and other fossils, followed by conglomerate-beds supposed to contain Trenton fossils, red and green shales and green sandstones; the details of the section being derived from the neighborhood of Quebec and Point Lévis, and from the rocks first described by Bigsby. As farther evidence with regard to the supposed horizon of these rocks, to which he subsequently (in 1860,) gave the name of the Quebec group, we may cite a letter of Sir William Logan, dated November, 1861, [Amer. Jour. Sci. II, xxxiii, 106,] in which he says "In 1848 and 1849, founding myself upon the apparent superposition in Eastern Canada of what we now call the Quebec group, I enunciated the opinion that the whole series belonged to the Hudson-River group and its immediately succeeding formation; a *Leptœna* very like *L. sericea*, and an *Orthis*, very like *O. testudinaria*, and taken by me to be these species, being then the only fossils found in the Canadian rocks in question. This view supported Prof. Hall in placing, as he had already done, the Olenus rocks of New York in the Hudson-River group, in accordance with Hisinger's list of Swedish rocks as given in the *Lethœa Suecica* in 1837, and not as he had previously given it."

The concurrent evidence deduced from stratigraphy, from geographical distribution, from lithological and from paleontological characters, thus led Logan, from the first, to adopt the views already expressed by Bigsby, Emmons and Bayfield, and to assign the whole of the paleozoic rocks of the south-east shore of the St. Lawrence, below Montreal, to a position in the New York system above the Trenton limestone. While thus, as he says, founding his opinion on the stratigraphical evidence obtained in Eastern Canada, Logan was also influenced by the consideration that the rocks in question were continuous with those in western Vermont. Part of the rocks of this region had, as we have seen, originally been placed by Emmons at this horizon, while the others, referred by him to his Taconic system, were maintained by Henry D. Rogers to belong to the Hudson-River group; a view which was adopted by Mather and by Hall, and strongly defended by Adams, at that time engaged in a Geological Survey of Vermont, with which in 1846 and 1847, the present writer was connected.

As regards the subsequent paleontological discoveries in these rocks in Canada, it is to be said that the graptolites first noticed by Bigsby in 1827, were re-discovered by the Geological Survey, at Point Lévis in 1854, and having been placed in the hands of Prof. James Hall, (who in that year first saw the rocks in question) were partially described by him in a communication to Sir W. E. Logan, dated April, 1855, and subsequently at length in 1858 [Report Geol. Survey for 1857, page 109, and Decade II.] They were new forms, it is true, but the horizon of the graptolites, both in New York and in Sweden, was the same as that already assigned by Logan to the Point-Lévis rocks. Thus these fossils appeared to sustain his view, and they were accordingly described as belonging to the Hudson-River group.

Up to 1856, no other organic remains than the graptolites and the two species of brachiopods noticed by Sir William Logan, were known to the Geological Survey as belonging to the Point Lévis rocks; the trilobites long before observed by Bigsby not having been re-discovered. In 1856, the present writer, while engaged in a lithological study of the various rocks of Point Lévis, found in the vicinity of the graptolitic shales, beds of what were described by him in 1857, [Report Geol. Surv. 1853-56, page 465,] as "fine granular opaque limestones, weathering bluish-gray, and holding in abundance remains of orthoceratites, trilobites, and other fossils; which are replaced by a yellow-weathering dolomite." In these, which are probably what Bigsby had long before described as fossiliferous conglomerates, the dolomitic matter is so arranged as to suggest a resemblance to certain beds which are really conglomerate in character, and were, at the same time, described by me as interstratified with the fossiliferous limestones, and as holding pebbles of pure limestone, of dolomite, and occasionally of quartz and of argillite; the whole cemented by a yellow-weathering dolomite, and occasionally by a nearly pure carbonate of lime. [Ibid 466.] The included fragments of argillite, (previously noticed by Bigsby) which are greenish or purplish in color, with lustrous surfaces, are precisely similar to those which form great beds in the crystalline schists of the Green Mountain series of the Appalachian hills, which extend in a north-east and south-west course along the south-eastern border of the rocks of the Quebec group. I conceive that these argillite fragments, (like those in the Potsdam conglomerate near Lake Champlain, referred to in my address of last year,) are derived from the ancient schists of the Appalachians.

This re-discovery of fossiliferous limestones at Point Lévis led to farther exploration of the locality, and in 1857, and the following years, a large collection of trilobites, brachiopods, and other organic remains was obtained from these limestones by the Geological Survey of Canada.

Mr. Billings, who in 1856, had been appointed paleontologist to the Geological Survey, at once commenced the study of these fossils from Point Lévis, and at length arrived at the important conclusion that the organic remains there found, belonged not to the summit of the second fauna, but were to be assigned a position in the first or primordial fauna. This conclusion he communicated to Mr. Barrande in a letter, dated July 12, 1860, [Amer. Jour. Sci. II, xxxi, 220] and gave descriptions of many of the organic forms in the Canadian Naturalist for the same year. I have already alluded, in describing the rocks of Point Lévis, to the peculiarities of aspect which probably led Dr. Bigsby, in 1827, to confound these fossiliferous limestones, penetrated by dolomite, with the true dolomitic conglomerates associated with them, and helped him to suppose the fossils to be derived from the limestones of the north shore, now known to be younger rocks. This mistake was a very natural one at a time when comparative paleontology was unknown.

Sir William Logan meanwhile made a careful stratigraphical examination of the rocks of Point Lévis, and notwithstanding the peculiarities of the limestones which there contain the primordial fauna, declared himself, in December, 1860, satisfied that "the fossils are of the age of the strata." In consequence of the discovery of Mr. Billings, Logan now proposed to separate from the Hudson-River group the graywacke series of Bigsby and Bayfield, and ascribed to it a much greater antiquity; regarding it as "a great development of strata about the horizon of the Chazy and Calciferous, brought to the surface by an overturn anticlinal fold, with a crack and a great dislocation running along the summit," by which the rocks in question were "brought to overlap the Hudson-River formation." This series, to which was assigned a thickness of from 5000 to 7000 feet, he named the Quebec group, which included the green sandstones of Sillery, regarded as the summit, the fossiliferous limestones and graptolitic shales at the base, which afterwards received the name of the Levis formation, and a great intermediate mass of barren shales and sandstones, called the Lauzon formation. The first account of this change in the stratigraphical views of Logan occurs in his letter to Barrande, dated December 31st, 1860. [Amer. Jour. Sci. II, xxxi, 216.]

This important distinction once established, it was found necessary to draw a line from the St. Lawrence, near Quebec, to the vicinity of Lake Champlain, separating the true Hudson-River group, with its overlying Oneida or Medina rocks, on the northwest side, from the so-called Quebec group, on the south and east. This division was by Logan ascribed to a continuous dislocation, which had disturbed a great conformable paleozoic series, including the whole of the members of the New York system from the base of the Potsdam to the summit of the Hudson-River group, and, throughout the whole distance of 160 miles, had raised up the lower formations in a contorted and inclined attitude, and caused them to overlie in many cases the higher formations of the system. This dividing line was by Logan traced north-eastward through the island of Orleans, the waters of the lower St. Lawrence, and along the north shore of Gaspé; and south-westward through Vermont, across the Hudson, as far at least as Virginia; separating, throughout, the rocks of the Quebec and Potsdam groups, with their primordial fauna, from those of the Trenton and Hudson River groups, with the second fauna. This is shown in the geological map of eastern America from Virginia to the St. Lawrence, which appears in the Atlas to the Geology of Canada, published in 1865. In an earlier geological map published by Sir William Logan at Paris in 1855, before this distinction had been drawn, the region in question in Eastern Canada is colored partly as the Oneida formation, and partly as the Hudson-River group; while in the accompanying text the Sillery sandstone is spoken of as the equivalent of the Shawangunk grit or Oneida conglomerate of the New York system. [Esquisse Géologique du Canada; Logan and Sterry Hunt, Paris, 1855, page 51.] These rocks were by Logan traced southwards across the frontier of Canada, into Vermont, where they included the red sandrock and its associated slates; which were thus by Logan, as well as by Adams, looked upon as occupying a position at the summit of the second fauna. When therefore in 1859, Prof. Hall described the trilobites found in these slates in Georgia in Vermont, he referred them to the genus *Olenus*, whose primordial horizon in Europe was then well determined, but in deference to the conclusions of Adams and of Logan, assigned them to a position at the summit of the Hudson-River group; Hall himself never having examined the region stratigraphically. [Amer. Jour. Sci. II, xxxi, 221.] In justification of this position he appended to his description the following note, [Ibid. pages 213, 221:] "In addition to the evidence heretofore possessed regarding the position of the slates containing the trilobites, I have the testimony of Sir W. E. Logan that the shales of this locality are in the upper part of the Hudson-River group, or forming part of a series of strata which he is inclined to rank as a distinct group, above the Hudson-River proper. It would be quite superfluous for me to add one word in support of the opinion of the most able stratigraphical geologist of the American continent." Paleontology and stratigraphy here came into conflict, and it was not till in 1860, when Mr. Billings, in the face of the evidence adduced from the latter, asserted the primordial age of the Point Lévis fauna, that Sir William Logan attempted a new explanation of the stratigraphy of the region; declaring at the same time, that "from the physical structure alone no person would suspect the break which must exist in the neighborhood of Quebec; and without the evidence of the fossils every one would be authorized to deny it." [Ibid. page 218.]

The typical Potsdam sandstone of the New York system, as seen in the Ottawa basin in northern New York and the adjacent parts of Canada, affords but a very meagre fauna, including two species of brachiopods, one or two gasteropods, and a single crustacean, *Conocephalites* (*Conocoryphe*) *minutus*, found at Keeseville, New York. In 1852, however, David Dale Owen found and described an extensive fauna in Wisconsin, from rocks which were regarded as the equivalent of the Potsdam sandstone; while the observations of Shumard in Texas, in 1861, and the latter ones of Hayden and Meek in the Black Hills, have since still further extended our knowledge of the distribution and the organic remains of the rocks which are supposed to represent, in the west, the Potsdam and Calciferous formations of the New York system.

As early as 1842, Prof. Hall, in a comparison of the lower paleozoic rocks of New York with those of Great Britain, declared the Potsdam to be lower than the base of the Upper Cambrian or Bala group of Sedgwick. In 1847, as we have seen, he extended this observation to the Calciferous and Chazy, both of which he placed below this horizon; which until a year or two previous had been looked upon as the base of the paleozoic series in Great Britain, and was subsequently made the lower limit of the second fauna of Barrande. Although from these facts it was probable that these lower members of the New York system might correspond to the primordial fauna of Barrande, we still remained, in the language of Prof. Hall, without "the means of parallelizing our formations with those of Bohemia, by the fauna there known. The nearest approach to the type of the primordial trilobites was found in the Potsdam of the northwest, described by Dr. D. D. Owen; but none of these had been generically identified with Bohemian forms, and the prevailing opinion, sanctioned as I have understood, by Mr. Barrande, was that the primordial fauna had not been discovered in this country until the re-discovery (in 1856) of *Paradoxides Harlani* at Braintree, Mass. The fragmentary fossils published in vol. I of the Paleontology of New York, and similar forms of the so-called Taconic system, were justly regarded as insufficient to warrant any conclusions." [Amer. Jour. Sci. II. xxxi, 225]. Such, according to Prof Hall, was the state of the question up to 1860. The *Conocephalus*, detected by him from the red sandrock of Vermont, in 1847, and subsequently recognized in Europe as an exclusively primordial type, seems to have been forgotten by Hall, and overlooked by others, until it was re-discovered in the sandrock by Billings in 1861. He had previously, in 1860, detected the same genus at Point Levis, together with Arionellus, and other purely primordial types. Associated with these, and with many other trilobites belonging to the second fauna, were found several species of Dikellocephalus and Menocephalus, genera first made known by Owen from the Potsdam of Wisconsin. It is by an error that Messrs. Harkness and Hicks, in a recent paper [Quar. Geol. Jour., xxvii, 395] have asserted that Owen, in 1852, found there, together with these genera, Conocephalus and Arionellus; the history of the first discovery of these genera in America, being as above given. The limestones of Point Levis thus furnished what was hitherto wanting, a direct connecting link between the fauna of the American Potsdam and the primordial zone of Bohemia.

The history of the *Paradoxides Harlani*, alluded to by Prof. Hall, is as follows: In 1834, Dr. Jacob Green received from Dr.

Richard Harlan, the cast of a large trilobite occurring in a silicious slate, which was in the collection of Francis Alger, of Boston, and, it was supposed, might have come from Trenton Falls, New York. Dr. Green, who at once pointed out the fact that the rock was wholly unlike any found at this locality, declared the fossil to resemble greatly the *Paradoxides Tessini*, Brongn.,—the former *Entomolithus paradoxus* of Linnaeus, from Westrogothia, —and named the species *P. Harlani.* [Amer. Jour., Sci. I, xxv, 336]. In 1856, the attention of Prof. William B. Rogers was called to a locality of organic remains in Braintree, on the border of Quincy, Massachusetts, where, on examination, he at once recognized the *Paradoxides Harlani* in a silicious slate similar to that of the original specimen. This was announced by him in a communication to the American Academy of Sciences [Proc., vol. iii], as a proof of the protozoic age of some of the rocks of eastern Massachusetts. Prof. Rogers then called attention to the fact that this genus of trilobites is characteristic of the primordial fauna, and noticed that Barrande had already remarked that, from the casts of *P. Harlani*, in the London School of Mines, and the British Museum (which had been made from the original specimen, and distributed by Dr. Green), this species appeared to be identical with *P. spinosus* from Skrey in Bohemia.

In 1858, Salter found in specimens sent to the Bristol Institution, in England, by Mr. Bennett, of Newfoundland, from the promontory between St. Mary's and Placentia Bays, in the southwestern part of the island, a large trilobite, described by him as *Paradoxides Bennettii* [Geol. Jour., xv, 554], which appears, according to Mr. Billings, to be identical with *P. Harlani.* On the same occasion Salter described under the name of *Conocephalites antiquatus*, a trilobite from a collection of American fossils sent by Dr. Feuchtwanger of New York to the London Exhibition of 1851. This was said to occur in a boulder of brown sandstone from Georgia, and, as I have been informed by Dr. F., was found near the town of Columbus in that state.

The slates of St. John, New- Brunswick, and its vicinity have recently yielded an abundant fauna, examined by Prof. Hartt, who at once recognized its primordial character. This conclusion was first announced, on the authority of Prof. Hartt, in a paper by Mr. G. F. Matthew, in May 1865 [Geol. Jour., xxi, 426]. The rocks of this region have afforded two species of *Paradoxides*, and fourteen of *Conocoryphe*, together with *Agnostus* and *Micro-*

*discus*, all of which have been described by Prof. Hartt. It may here be noticed that in 1862, Prof. Bell found in the black shales of the Dartmouth valley, in Gaspé, a single specimen of a large trilobite, which, according to Mr. Billings, closely resembles *Paradoxides Harlani*, but from its imperfectly preserved condition cannot certainly be identified with it. [Geol. Canada, 882].

The geological examinations of Mr. Alexander Murray in Newfoundland since 1865, have shown that the south-eastern part of that island contains a great volume of Cambrian rocks, estimated by him at about 6,000 feet in all. No traces of the Upper Cambrian or second fauna have been detected among these, but some portions contain the Paradoxides already mentioned, while others yield the fauna which Mr. Billings has called Lower Potsdam. This name was first given in an appendix (prepared by Sir W. E. Logan,) to Mr. Murray's report on Newfoundland for 1865, published in 1866 [page 46; see also Report of the Geol. Survey of Canada for 1866, page 236.] The Lower Potsdam was there assigned a place above the Paradoxides beds of the region, which were called the St. John group,—the fossiliferous strata of St. John, New Brunswick, being referred to the same horizon; which corresponds to the Menevian of Wales, now recognized as the summit of the Lower Cambrian. The succession of the rocks containing these two faunas in south-eastern Newfoundland is not yet clear; the Lower Potsdam fauna is regarded by Mr. Billings as identical with that found on the strait of Bellisle, at Bic, (on the south shore of the river St. Lawrence, below Quebec,) at Georgia, Vermont, and at Troy, New York; but in none of these other localities is it as yet known to be accompanied by a Menevian fauna. The trilobites hitherto described from these rocks belong to the genera *Olenellus*, *Conocoryphe* and *Agnostus;* neither *Paradoxides*, which characterizes the Menevian and the underlying Harlech beds in Wales, nor *Olenus*, which there abounds in the rocks immediately above this horizon, having as yet been described as occurring in the Lower Potsdam of Mr. Billings. Future discoveries may perhaps assign it a place below instead of above the Menevian horizon.

The characteristic Menevian fauna in and near St. John, New Brunswick, is found in a band of about 150 feet, towards the base of a series of nearly vertical sandstones and argillites, underlaid by conglomerates, and resting upon crystalline schists, in a narrow basin. The series, the total thickness of which is estimated by Messrs. Matthew and Bailey at over 2000 feet, contains Lingula throughout, but has yielded no remains of a higher fauna. The same Menevian forms have been found in small outlying areas of similar rocks, at two or three places north of the St. John basin, but to the south of the New Brunswick coal-field. To the north of this is a broad belt of similar argillites and sandstones, which extends south-westward into the state of Maine. This belt has hitherto yielded no organic remains, but is compared by Mr. Matthew to the Cambrian rocks of the St. John basin, and to the gold-bearing series of Nova Scotia, [Geol. Jour. xxi, 427,] which at the same time resembles closely the Cambrian rocks of southeastern Newfoundland. This was remarked by Dr. Dawson in 1860, when he expressed the opinion that the auriferous rocks of Nova Scotia were "the continuation of the older slate series of Mr. Jukes in Newfoundland, which has afforded Paradoxides," and probably the equivalent of the Lingula flags of Wales. [Supplement to Acadian Geology (1860,) page 53; also Acad. Geol. 2nd ed., page 613.] Associated with these gold-bearing strata, along the Atlantic coast of Nova Scotia, occur fine grained gneisses, and mica-schists with andalusite and staurolite; besides other crystalline schists which are chloritic and dioritic, and contain crystallized epidote, magnetite and menaccanite. These two types of crystalline schists, (which, from their stratigraphical relations, as well as from their mineral condition, appear to be more ancient than the uncrystalline gold-bearing strata,) were in 1860, as now, regarded by me as the equivalents respectively of the White Mountain and Green Mountain series of the Appalachians; as will be seen by reference to Dr. Dawson's work just quoted. At that time, however, and for many years after, I held, in common with most American geologists, the opinion that these two groups of crystalline schists were altered rocks of a more recent date than that assigned to the auriferous series of Nova Scotia by Dr. Dawson; who was much perplexed by the difficulty of reconciling this view with his own. The difficulty is however at once removed when we admit, as I have maintained for the last two years, that both of these groups are pre-Cambrian in age [Amer. Jour. Sci. II, l. 83; address to the Amer. Assoc. Adv. Sci. August, 1871.]

A notice by Mr. Selwyn of some of these crystalline schists in

Nova Scotia will be found in the Report of the Geological Survey of Canada for 1870, [page 271]. He there remarks moreover the close lithological resemblances of the gold-bearing strata to the Harlech grits and Lingula-flags of North Wales, and announces the discovery among these strata at the Ovens gold-mine in Lunenberg, Nova Scotia, of peculiar organic markings regarded by Mr. Billings as identical with the *Eophyton Linnæanum*, which is found in the Regio Fucoidarum, at the base of the Cambrian in Sweden. In the volume just quoted [page 269] will be found some notes by Mr. Billings on this fossil, which occurs also near St. John, New Brunswick, in strata supposed to underlie the Paradoxides beds. The same form is found in Conception Bay, in south-eastern Newfoundland, in strata regarded by Mr. Murray as higher than those with *Paradoxides*, and containing also two new species of *Lingula*, a *Cruziana* and several fucoids. Still more recently, *Eophyton*, accompanied by these same fucoids, has been found by Mr. Billings at St. Laurent, on the island of Orleans near Quebec, in strata hitherto referred by the Geological Survey, on stratigraphical grounds, to the Quebec group. The evidence adduced by Mr. Billings shows that this organic form, whatever its nature, belongs to a very low horizon in the Cambrian.

As regards the probable downward extension of these forms of ancient life, I cannot refrain from citing the recent language of Mr. Hicks. [Quar. Jour. Geol. Soc., May 1872, page 174.] After a comparative study of the Lower Cambrian fauna, including that of the Harlech and Menevian rocks in Wales, and the representatives of the latter in other regions, he adds:

"Though animal life was restricted to these few types, yet at this early period the representatives of the several orders do not show a very diminutive form, or a markedly imperfect state; nor is there an unusual number of blind species. The earliest known brachiopods are apparently as perfect as those which succeed them; and the trilobites are of the largest and best developed types. The fact also that trilobites had attained their maximum size at this period, and that forms were present representative of almost every stage in development, from the little *Agnostus*, with two rings to the thorax, and *Microdiscus* with four, to *Erinnys* with twenty-four; and blind genera along with those having the largest eyes; leads to the conclusion that for these several stages to have taken place numerous previous faunas must have had an existence, and moreover, that even at this time in the history of our globe, an enormous period had elapsed since life first dawned upon it."

The facts insisted upon by Hicks do not appear to be inconsistent with the view that at this horizon the trilobites had already culminated. Such does not, however, appear to be the idea of Barrande, who in a recent learned essay upon the trilobitic fauna [1871] has drawn from its state of development at this early period, conclusions strongly opposed to the theory of derivation.

The strata holding the first fauna in south-eastern Newfoundland, rest unconformably, according to Mr. Murray, upon what he has called the Intermediate series; which is of great thickness, consists chiefly of crystalline rocks, and is supposed by him to represent the Huronian. He has however included in this intermediate series several thousand feet of sandstones and argillites which, near St. Johns in Newfoundland, are seen to be unconformably overlaid by the fossiliferous strata already noticed, and have yielded two species of organic forms, lately described by Mr. Billings. One of these is an *Arenicolites*, like the *A. spiralis* found in the Lower Cambrian beds of Sweden, and the other a patella-like shell, to which he has given the name of *Aspidella Terranovica*. [Amer. Jour. Science, III, iii, 223.] These, from their stratigraphical position, have been regarded as Huronian; but from the lithological description of Mr. Murray, the strata containing them appear to be unlike the great mass of the Huronian rocks of the region. Their occurrence in these strata, in either case, marks a downward extension of these forms of paleozoic life.

Mr. Billings has described from the rocks of the first fauna certain forms under the name of *Archeocyathus*, one of the species of which, according to Dr. Dawson, belonged to a calcareous chambered foraminiferal organism similar in its nature to much of the *Stromatopora* of the second, and closely related *Coenostroma* of the third fauna. All of these Dawson shows to have strong affinities to *Eozoon*, which is represented by *E. Canadense* of the Laurentian, and by similar forms in the newer crystalline schists of Hastings, Ontario, as well as by the *E. Bavaricum* of the upper crystalline schists of Bavaria. The succession of related foraminiferal organisms, is farther seen in the Devonian limestones of Michigan, where occur great masses like Stromatopora, which present, according to Dawson a structure intermediate between the Eozoon of the Laurentian and the genera Parkeria and Loftusia of the Cretaceous and the Eocene. The details are taken from Dr. Dawson's recent presidential address to the Natural History Society of Montreal, in May, 1872, where he has announced some of the results of his studies, yet in progress, on the earlier foraminifera.

In 1856 the late Prof. Emmons described [Amer. Jour. Sci. II, xxii, 389] under the name of *Palaeotrochis*, certain forms regarded by him as organic, found in North Carolina in a bed of auriferous quartzite, among rocks referred to his Taconic system. Their organic nature has also been maintained by Prof. Wurtz, but from my own examinations, I agree with the opinion expressed by Prof. Hall, and subsequently supported by the observations of Prof. Marsh, [Ibid. II, xxiii, 278; xvl. 217] that the forms to which the name of Palaeotrochis has been given are nothing more than silicious concretions.

As regards the geological horizon of the series of strata to which Sir William Logan has given the name of the Quebec group, the Sillery and Lauzon divisions have as yet yielded to the paleontologist only two species of *Obolella* and one of *Lingula*. Our comparisons must therefore be based upon the fauna of the Levis limestones and graptolitic shales, which have already been compared with the Middle Cambrian or Festiniog group of Sedgwick, by the combined labors of Billings and Salter. The former has moreover carefully compared this fauna with that of the lower members of the New York system; in which the succession of organic life appears to have been very much interrupted. Thus, according to Mr. Billings, of the ninety species known to exist in the Chazy limestone of the Ottawa basin, only twenty-two species have been observed to pass up into the directly-overlying Birdseye and Black-River limestones. The break between the Chazy and the underlying Calciferous sandrock, in this region, is still more complete; since, according to the same authority, of forty-four species in the latter only two pass up into the Chazy limestone. This latter break in the succession appears to be filled, in the region to the eastward of the Ottawa basin, by the Levis limestone; which has been studied near Quebec, and also near Phillipsburg, not far from the outlet of Lake Champlain. This formation (including the accompanying graptolitic shales,) has yielded, up to the present time, 219 species of organic remains, (comprising seventy-four of crustacea, and fifty-one of graptolitidiæ) none of which, according to Mr. Billings, have been found either in the Potsdam or in the Birdseye and Black River limestone. Twelve of the species of the Levis formation are however met with in the Calciferous, and five in the Chazy of the Ottawa basin, and the Levis is therefore regarded by Mr. Billings as the connecting link between these two formations.

With regard to the British equivalents of these rocks, the Levis limestone, according to Salter, corresponds to the Tremadoc beds; although the species of *Dikellocephalus* found in the Levis rocks are by him compared with those found in the Upper Lingula flags or Dolgelly beds. The graptolitic strata of Levis however clearly represent the Lower Llandeilo or Arenig rocks of North Wales, the Skiddaw group of Sedgwick in Cumberland, the graptolitic beds which in Esthonia, according to Schmidt, are found below the orthoceratite-limestones, [Can. Naturalist, I. vi. 345] and those of Victoria in Australia, [Mem. Geol. Sur. III, part 2, 255, 304.] In the Lower Llandeilo and Upper Tremadoc beds there appears to be in North Wales, a mingling of forms of the first and second faunas, as in the Levis and Chazy formations. The latter was already, by Hall, in 1847, declared to be beneath the Silurian horizon then recognized in Great Britain. By its fauna it is comparatively isolated from the strata both below and above it, and stratigraphically as well as paleontologically it would appear to belong rather than to the lower than to the higher rocks. According to a private communication from Prof. James Hall, the Chazy limestone at Middleville, Herkimer county, New York, to the south of the Adirondacks, is wanting, and the basal beds of the Trenton group (the Birdseye limestone) there rest unconformably upon the Calciferous sandrock.

The relations of the various members of the Quebec group to each other, and of the group, as a whole, to the succeeding Trenton and Hudson-River groups, require further elucidation. If, as I am disposed to believe, the southeastward-dipping series of the older strata near Quebec, exhibits the northwest side of an overturned and eroded anticlinal, in which the normal order of the strata is inverted, then the Lauzon and Sillery divisions, which there appear to overlie the Levis limestones and shales, are older rocks, occupying the position of the Potsdam or still lower members of the Cambrian. Sir William Logan supposes the appearance of these rocks in their present attitude by the side of the strata of the Trenton and Hudson River-groups, in the vicinity of Quebec, to be due to a great dislocation and uplift, subsequent to the deposition of these higher rocks; but, as suggested in my address of last year, I conceive the Quebec group to have been in its present upturned and disturbed condition before the deposition of the Trenton limestones. The supposed dislocation and uplift, extending from the gulf of St. Lawrence to Virginia, is according to this view, but the outcrop of the rocks of the first fauna from beneath the unconformably overlying strata of the second fauna. The later movements along the borders of the Appalachian region have however, to some extent, affected these, in their turn, and thus complicated the relations of the two series. This unconformity, which corresponds to the marked break between the Levis and Trenton faunas, is farther shown by the stratigraphical break and discordance in Herkimer county, New York; and by the fact that beyond the limits of the Ottawa basin, on either side, the limestone of the Trenton group rests directly on the crystalline rocks; the older members of the New York system being altogether absent at the northern outcrop, as well as in the outliers of Trenton limestone seen to the north of Lake Ontario, and as far to the north-east as Lake St. John on the Saguenay. This distribution shows that a considerable movement, just previous to the Trenton period, took place both to the west and the east of the Adirondack region, which formed the southern boundary of the Ottawa basin.

The Levis and Chazy formations, as we have seen, offer a commingling of forms of the first and second faunas, which shows them to belong to a period of transition between the two; but it is remarkable that so far as yet observed, no representatives of the later of these faunas are known to the east and south of the Appalachians, along the Atlantic coast; the first fauna, whether in Massachusetts, New Brunswick or southeastern Newfoundland, being unaccompanied by any forms of the second. The third fauna, on the contrary, is represented in various localities both within and to the east of the Appalachian region, from Massachusetts to Newfoundland. In parts of Gaspé, and also in Nova Scotia, strata holding forms referred to the Clinton and Niagara divisions are met with, as well as other beds of Lower Helderberg age, associated with species of shells and of plants which connect this fauna with that of the succeeding Lower Devonian or Erian period. To this Lower Helderberg horizon (corresponding to the Ludlow of England) appear to belong certain fossiliferous beds found along the Atlantic coast of Maine and of New Brunswick, in Nova Scotia and (?) in Newfoundland; as well as others included in the Appalachian belt in Massachusetts, New Hampshire, Vermont and Quebec, along the Connecticut valley and its north-eastern prolongation. The fossiliferous strata just noticed, both in the Connecticut valley, and along the Atlantic coast, occur in small areas among the older crystalline schists, often made up of the ruins of these, and in highly inclined attitudes. The same is true in some places of the similarly situated strata of Cambrian, Devonian and Lower Carboniferous periods. These derived strata, of different ages, have, from their lithological resemblances to the parent rocks, been looked upon as examples of a subsequent alteration of paleozoic sediments; and by a farther extension of this notion, the pre-Cambrian crystalline schists themselves throughout this region have been looked upon as the result of an epigenic change of these various paleozoic strata; portions of which, here and there, were supposed to have escaped conversion, and to have retained more or less perfectly their sedimentary character, and their organic remains, elsewhere obliterated.

From the absence of the second fauna we may conclude that the great Appalachian area was, at least in New England and Canada, above the ocean during its period, and suffered a partial and gradual submergence in the time of the third fauna. This movement corresponds to the well-marked paleontological and stratigraphical break between the second and third faunas in the great continental basin to the westward, made evident by the appearance of the Oneida or Shawangunk conglomerate (apparently derived from the ruins of Lower Cambrian rocks) which, in some parts, overlies the strata of the Hudson-River group, The break is elsewhere shown by the absence of this conglomerate, and of the succeeding formations up to the Lower Helderberg division. This latter, in various localities in the valleys of the Hudson and the St. Lawrence, rests unconformably upon the strata of the second fauna, as it does upon the older crystalline rocks to the eastward.

In Ohio, according to Newberry, the base of the rocks of the third fauna (Clinton and Medina) is represented by a conglomerate which holds in its pebbles the organic remains of the underlying strata of the second fauna.

To the north-eastward, the island of Anticosti in the gulf of St. Lawrence, presents a succession of about 1400 feet of calcareous strata rich in organic remains, which, according to Mr. Billings, include the species of the Medina, Clinton and Niagara formations, and were named by him, in 1857, the Anticosti group. They rest upon nearly 1000 feet of almost horizontal strata, consisting of limestones and shales rich in organic remains, with many included beds of limestone-conglomerate. This series has by the Geological Survey of Canada been referred to the Hudson-River group, but notwithstanding the large number of forms of the second fauna which it contains, Prof. Shaler is disposed to look upon it as younger, and belonging rather to the succeeding division. There seems not to have been any marked paleontological break between the second and third faunas in this region; and it is worthy of note, in this connection, that in the outlying basin of paleozoic rocks, found at Lake St. John, to the north of Anticosti, *Halysites catenulatus* is met with in limestones associated with many species of organic remains characteristic of the Trenton and referred to that group. [Geology of Canada, page 165.]

The strata to which, in 1857, Mr. Billings gave the name of the Anticosti group were at the same time designated by him Middle Silurian, in which he subsequently included the local sub-division known as the Guelph formation, which in western Ontario succeeds the Niagara; the name of Upper Silurian being thus reserved for the Lower Helderberg division and the underlying Onondaga formation [Report Geol. Sur. Can. 1857, page 248, and Geol. Can. page 20.] Both the Guelph and the Onondaga have been omitted from the table on page 312; the Guelph because it was not recognized in the New York system, and is by some regarded as but a sub-division of the Niagara; and the Onondaga, for the reason that it is a local deposit of magnesian limestones, wiih gypsums and rock-salt, destitute of organic remains.

As to the name of Middle Silurian, it had some years previously been used by the officers of the government Geological Survey in Great Britain to designate the Lower and Upper Llandovery rocks; but is referred to in 1854 by Sedgwick as one that had, at that time, already been abandoned, (L. E. & D.

Philos. Mag. III, viii, 303, 367, 501,) and is also rejected by Lyell, (Student's Manual of Geology, page 452.) It is not used by Murchison, either in his *Silurian System* or in the various editions of *Siluria*, or by Ramsay, who however speaks of the Llandovery rocks as an intermediate series, (Mem. Geol. Survey III. part 2, page 2.) Inasmuch as the name of Silurian was erroneously applied to the rocks of the second fauna, and properly belongs to those of the third fauna only, that of Middle Silurian should be rejected from our nomenclature in North America, as has already been done in England. The strata to which it has been applied, on both sides of the Atlantic, are however important as illustrations of the passage from one fauna to another.

The history of the introduction of the names of Silurian and Devonian into North American geology demands our notice. Prof. Hall, as we have seen, while recognizing in the rocks of the New York system the representatives alike of the British Cambrian, Silurian and Devonian, wisely refrained from adopting this nomenclature drawn from a region where wide diversities of opinion and controversies existed as to the value and significance of these divisions. Lyell however in the account of his first journey to the United States, published in 1845, applied the terms Lower and Upper Silurian and Devonian to our paleozoic rocks. Later, in 1846, de Verneuil, the friend and the colleague of Murchison in his Russian researches, visited the United States, and on his return to France published, in 1847, (Bul. Soc. Geol. de Fr. II. iv. 12. 646) an elaborate comparison between the European paleozoic deposits and those of North America, as made known by Hall and others. He proposed to group the whole of the rocks of the New York system, up to the summit of the Hudson-River group, in the Lower Silurian, and the succeeding members, including the Lower Helderberg, and the overlying Oriskany, in the Upper Silurian; the remaining formations to the base of the Carboniferous system being called Devonian. This essay by de Verneuil was translated and abridged by Prof. Hall, and published by him in the American Journal of Science (II. v. 176, 359; vii. 45, 218,) with critical remarks, wherein he objected to the application of this disputed nomenclature to North American geology.

Meanwhile the Geological Survey of Canada was in progress under Logan, who in his preliminary report in 1842, and in his subsequent ones for 1844 and 1846, adopted the nomenclature of the New York system, without reference to European divisions. Subsequently however, the usage of Lyell and de Verneuil was adopted by Logan, who in his report for 1848 (page 57) spoke of the Clinton group as the base of the "Upper Silurian series," while in that for 1850 (page 34) he declared the whole of a great series of fossiliferous rocks in Eastern Canada, including the Trenton, Utica and Hudson-River divisions, and the shales and sandstones of Quebec, (then supposed to be superior to these,) to "belong to the Lower Silurian." In the report for 1852 (page 64) the Lower Silurian was made by Mr. Murray to include not only the Utica and Trenton, but the Chazy limestone, the Calciferous sandrock and the Potsdam sandstone of the New York system. From this time the Silurian nomenclature, as applied by Lyell and de Verneuil to our North American rocks, was employed by the officers of the Canadian Geological Survey (myself among the others,) and was subsequently adopted by Prof. Dana in his Manual of Geology, published in 1863.

The Geological Survey of Pennsylvania, under the direction of Prof. Henry Darwin Rogers, was begun, like that of New York, in 1836, and the paleozoic rocks of the state were at first divided, on stratigraphical and lithological grounds, into groups, which were designated, in ascending order, by Roman numerals. Subsequently, as he informs us in the preface to his final Report on the Geology of Pennsylvania, Prof. H. D. Rogers, in concert with his brother, Prof. William B. Rogers, then directing the Geological Survey of Virginia, considered the question of geological nomenclature. Rejecting, after mature deliberation, the classification and nomenclature both of the British and New York Geological Surveys they proposed a new one for the whole paleozoic column to the top of the coal-measures, founded on the conception of a great paleozoic day, the divisions of which were designated by names taken from the sun's apparent course through the heavens. (Geology of Penn. I. vi, 105.) So far as regards the three great groups which we have recognized in the lower paleozoic rocks, the later names of Rogers, and his earlier numerical designations, with their equivalents in the New York system, were as follows:

*Primal*, (I.) This includes the mass of 2500 feet or more of shales and sandstones, which in Pennsylvania and Virginia, and farther southward, form the base of the paleozoic series, and rest upon crystalline schists. The Primal division was regarded by the Messrs. Rogers as the equivalent both of the Potsdam and the still lower members of the Cambrian.

*Auroral*, (II.) This division, which, with the last, includes the first fauna, consists in great part of magnesian limestones, and corresponds to the Calciferous and Chazy formations. Its thickness in Pennsylvania varies from 2500 to 5000 feet, and with the preceeding division, it includes the first fauna. The representatives of the Primal and Auroral divisions attain a great development in eastern Tennessee, where they have been studied by Safford.

*Matinal*, (III.) In this, which represents the second fauna, were comprised the limestones of the Trenton group, together with the Utica and Hudson-River shales.

*Levant*, (IV.) This division corresponds to the Oneida and Medina conglomerates and sandstones.

*Surgent*, *Scalent* and *Pre-Meridional* (V. VI.) In these divisions were included the representatives of the Clinton, Niagara and Lower Helderberg groups of New York, making, with division IV., the third fauna.

The parallelism of these divisions with the British rocks was most clearly and correctly pointed out by H. D. Rogers himself, in an explanation prepared, as I am informed, with the collaboration of Prof. William B. Rogers, and published in 1856, with a geological map of North America by the former, in the second edition of Keith Johnson's Physical Atlas. The paleozoic rocks of North America are there divided into several groups, of which the first, including the Primal, Auroral and Matinal, is declared to be the near representative of " the European paleozoic deposits from the first-formed fossiliferous beds to the close of the Bala group; that is to say the proximate representatives of the Cambrian of Sedgwick." A second group embraces the Levant, Surgent, Scalent and Pre-Meridional. These are said to be " the very near representatives of the true European Silurian, regarding this series as commencing with the May-Hill sandstone." The Levant division is farther declared to be the equivalent of the sandstone just named; while the Matinal is made to correspond to the Llandeilo, Bala or Upper Cambrian; the Auroral with the Festiniog or Middle Cambrian ; and the Primal with the Lingula flags, the Obolus sandstone of Russia and the Primordial of Bohemia.

The reader of the last few pages of this history will have seen how the Silurian nomenclature of Murchison and the British Geological Survey has been, through Lyell, de Verneuil and the Canadian Survey, introduced into American geology in opposition to the judgment, and against the protests of James Hall and the Messrs. Rogers, the founders of American paleozoic geology.

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Three points have I think, been made clear in the first and second parts of this sketch: First, that the series to which the name of Cambrian was applied by Sedgwick in 1835, (limited by him as to its downward extension, in 1838) was co-extensive with the rocks characterized by the first and second faunas. Second, that the series to which the name of Silurian was given by Murchison in 1835, included the second and third faunas; but that the rocks of the second fauna, the Upper Cambrian of Sedgwick, were only included in the Silurian system of Murchison by a series of errors and misconceptions in stratigraphy, on the part of the latter, which gave him no right to claim the rocks of the second fauna as a lower member of his Silurian. Third, that there was no ground whatever for subsequently annexing to the Silurian of Murchison, the Lower and Middle Cambrian divisions of Sedgwick, which the latter had separated from the Upper Cambrian on stratigraphical grounds, and which were subsequently found to contain a distinct and more ancient fauna.

The name of Silurian should therefore be restricted, as maintained by Sedgwick and by the Messrs. Rogers, to the rocks of the third fauna, the so-called Upper Silurian of Murchison; and the names of Middle Silurian, Lower Silurian and Primordial Silurian banished from our nomenclature. The Cambrian of Sedgwick however includes the rocks both of the first and second faunas. To the former of these, the lower and middle divisions of the Cambrian, (the Bangor and Festiniog groups of Sedgwick.) Phillips, Lyell, Davidson, Harkness, Hicks and other British geologists, agree in applying the name of Cambrian. The great Bala group of Sedgwick, which constitutes his Upper Cambrian, is however as distinct from the last as it is from the overlying Silurian, and deserves a not less distinctive name than these two. Its original designation of Upper Cambrian, given when the zoological importance of Lower and Middle Cambrian was as yet unknown, is not sufficiently characteristic, and the same is to be said of the name of Lower Silurian, wrongly imposed upon it. The importance of this great Bala group in Britain, and of its North American equivalent, the Matinal of Rogers,—including the whole of the limestones of the Trenton group, with the succeeding Utica and Hudson-River shales,—might justify the invention of a new and special name. That of Cambro-Silurian, at one time proposed by Sedgwick himself, and adopted by Phillips and by Jukes, was subsequently withdrawn by him, when investigations made it clear that this group had been wrongly united with the Silurian by Murchison. Deference to Sedgwick should therefore prevent us from restoring this name, which moreover, from its composition, connects the group rather with the Silurian than the Cambrian. Neither of these objections can be urged against the similarly constructed term of Siluro-Cambrian, which moreover has the advantage that no other new name could possess, of connecting the group both with the true Silurian, to which it has very generally been united, and with the Cambrian, of which, from the first, it has formed a part. I therefore venture to suggest the name of Siluro-Cambrian, as a convenient synonym for the Upper Cambrian of Sedgwick, (the Lower Silurian of Murchison,) corresponding to the second fauna; reserving at the same time the name of Cambrian for the rocks of the first fauna,—the Lower and Middle Cambrian of Sedgwick,—and restricting with him the name of Silurian to the rocks of the third fauna,—the Upper Silurian of Murchison.*

The late Prof. Jukes, it may here be mentioned, in his Manual of Geology, published in 1857, still retained for the Bala group the name of Cambro-Silurian (which had been withdrawn by Sedgwick in 1854) and reserved the name of the "true Silurian period" for the Upper Silurian of Murchison. In his recent

* Dr. Dawson, in his address as president of the Natural History Society of Montreal, in May 1872, has taken the occasion of the publication in the *Canadian Naturalist*, of the first and second parts of this sketch, to review the subject here discussed. Recognizing the necessity of a reform in the nomenclature of the paleozoic rocks, in conformity with the views of Sedgwick, he would restrict to the rocks of the third fauna the name of Silurian, making it a division equivalent to Devonian; and while reserving with Lyell, Phillips and others, the name of Cambrian for the first fauna only, agrees with me in the propriety of adopting the name of Siluro-Cambrian for the second fauna.

and much improved edition of this excellent Manual (1872), Prof. Giekie, the director of the Geological Survey of Scotland, has substituted the nomenclature of Murchison; with the important exception, however, that he follows Hicks and Salter in separating the Menevian from the Lingula-flags, and uniting it with the underlying Harlech rocks (as has been done in the table on page 312), giving to the two the name of Cambrian [loc. cit., pages 526–529], and thus, on good paleontological grounds, extending this name above the horizon admitted by Murchison. Barrande, on the contrary, in his recent essay on trilobites (1871, page 250), makes the Silurian to include not only the Lingula-flags proper (Maentwrog and Dolgelly), but the Menevian, and even a great part of the Harlech rocks themselves (the Cambrian of Murchison and the Geological Survey), for the reason that the primordial fauna has now been shown by Hicks to extend towards their base. This, although consistent with Barrande's previous views as to the extension of the name Silurian, is a still greater violation of historic truth. By thus making the Silurian system of Murchison to include successively the Upper Cambrian and the Middle Cambrian of Sedgwick, and finally his Lower Cambrian, (the Cambrian system of Murchison himself,) we seem to have arrived at a *reductio ad absurdum* of the Silurian nomenclature; and we may apply to Siluria, as Sedgwick has already done, the apt quotation once used by Conybeare, with reference to the Graywacke of the older geologists, which it replaces; "*est Jupiter quodcunque vides.*"

It would be unjust to conclude this historical sketch of the names Cambrian and Silurian in Geology, without a passing tribute to the venerable Sedgwick, who to-day, at the age of eighty-seven years, still retains unimpaired his great powers of mind, and his interest in the progress of geological science. The labors of his successors in the study of British geology, up to the present time, have only served to confirm the exactitude of his early stratigraphical determinations; and the last results of investigations on both continents unite in showing that in the Cambrian series, as defined by him more than a generation since, he laid, on a sure foundation, the bases of paleozoic geology.

# SEXUAL SELECTION IN MAN.

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"Sexual selection" is the term employed by Darwin to denote a twofold winnowing, to which he believes that the individuals of many species of animals are subjected. On the one hand, certain males being stronger and more powerful than the others, succeed in leaving descendants behind them, whilst other weaker males do not get the opportunity of perpetuating their peculiarities, the female in this case remaining passive. On the other hand, it is believed that in some cases the females have the power of choosing their mates, and that they select such males as please them best, whether this be in consequence of some peculiarity of form, colour, or voice, or as a result of some undefinable attraction. In this process the selection lies with the female, and the male remains passive, in any other sense than that he does what he can to secure that the choice of the female shall fall upon him instead of upon any other of his rivals. In either case Mr. Darwin believes that great modifications have been produced in this way, and that many animals owe to this cause some of their most striking peculiarities. Mr. Darwin, in fact, has so far abandoned his former belief in the efficacy of "natural selection" as an agent in producing the differences which separate different species of animals, as to admit that some supplementary cause must, in some cases at any rate, be looked for; and this he thinks is to be found in the action, through long periods, of "sexual selection."

Without entering into the question of the extent to which Mr. Darwin's views may be depended on as regards animals, we purpose here very briefly to survey his application of the theory of sexual selection to the case of man. In so doing we shall glance at the leading propositions laid down in Chapters XIX and XX of the "Descent of Man," examining in greater detail those which appear to be of the highest importance. It may as well be premised, however, that there are two distinct aspects to the question of sexual selection, in the case of all animals alike, but especially in the case of man. It is one thing to admit the existence of what Mr. Darwin calls "sexual selection," as an actual fact; and in the case of man it is undeniable that such a kind of selection must have existed, whilst it is almost certain that it must have played some important part in the development of the species. It is one thing to admit this; but it is quite another thing to admit that any of the peculiarities which separate man from the brutes are due to this cause. Few will be disposed to deny the existence of selection, both natural and sexual, amongst mankind, but many will be disposed to doubt if any adequate ground has as yet been advanced for the belief that man's distinctive characters have been acquired in consequence of the action of either of these causes. In the case of sexual selection, with which alone we are dealing at present, Mr. Darwin himself admits the weakness of his case, as regards man; and does not hesitate to candidly confess that his views on this subject "want scientific precision." We shall endeavour to show, not only that this is the case, but that some important elements in settling this question have been altogether overlooked; whilst we must fully recognize the ability with which Mr. Darwin supports his views, and the vast research which characterises all his observations on this and kindred topics.

Mr. Darwin begins by pointing out the chief physical differences which distinguish the man from the woman; and he indicates that "as with animals of all classes, so with man, the distinctive characters of the male sex are not fully developed until he is nearly mature; and if emasculated they never appear." It follows from this—as, indeed every one will admit—that some of the characters of the male, as his possession of a beard and his bass voice, are characters clearly connected with his relations with the other sex; so that if these relations be disturbed or abolished, they do not appear. A still more striking fact, pointing in the same direction, and showing how certain apparently trivial characters are in both sexes connected with the function of reproduction, is the not uncommon growth of hair to a greater or less extent upon the face of women in whom the reproductive functions have naturally ceased to be active.

A curious consideration, however, arises here. If we take the case of a male who has been emasculated in early life, we find that, more or less perfectly, he retains throughout life some of the characters of his boyhood, which are also common to the female, such as smoothness of skin, a beardless face, and a treble voice. Are we, however, on this account to conclude that we are dealing with anything but a male? There are the strongest grounds for the belief that the characters which distinguish the two sexes lie far deeper than the mere physical structure. The difference between the male and female, in man at any rate, seems to be a fundamental one, in which the entire nature is involved; and the male, when artificially mutilated, no more ceases to be a male, than a man ceases to be a man when his leg has been amputated. It is true that the mutilation has rendered him imperfect in one very important aspect of his nature; but the difference is bodily, not mental, and he cannot do otherwise than remain a male as regards his essential nature. It is quite true, also, that as in the case of emasculated animals, the bodily incapacity is accompanied by a deficiency in certain mental attributes which minister to the corporeal function. Thus, the mutilated might very possibly be less courageous or pugnacious than the normal man. Still, we cannot believe that the deeper differences which fundamentally separate the man from the woman, are in any way affected by such a mutilation. We should, at any rate, require much more evidence than we hold at present before concluding that such mutilated males are not distinguished by just those mental characters (with the exception of the above) which are afterwards enumerated by Darwin as distinguishing the male from the female in the human species.

Having discussed the physical differences between the male and female, Mr. Darwin, under the head of "Law of Battle," next endeavours to show that man, in his earlier stages at any rate, must have had to fight for his wife, and that success in marriage must have been to the strongest, in most, if not in all cases. No doubt if this could be shown, there would be a reasonable probability that the race might have been much improved in this way, the strongest and most powerful males leaving the largest number of children, and these inheriting the physical characters to which the success of their fathers was due. We cannot think, however, that Mr. Darwin sufficiently recognizes to what an extent even the lowest savage is something more than a mere animal, and how largely the spiritual element enters into his composition. Taking the savage races known to us—and we have no right to speak dogmatically as to the supposed habits of a hypothetical and still more degraded race—Professor Huxley has recently admitted that the intellectual labour of a good hunter or warrior "considerably exceeds that of an ordinary Englishman." A much smaller admission would answer our purpose, as all that is here contended for is that the struggle for any coveted object, amongst even the lowest savage races known to us, is in the main a spiritual contest and not a physical one. Even if we suppose the struggle to be decided by purely physical arguments, still success would by no means invariably attend the strongest, but would be more likely, in the long run, to fall to the cleverest. In the case of a contest between two male animals, such as two stags, we may believe that the strongest is sure to win; but this would by no means hold good amongst even the lowest savages. No races of men are known to us so degraded as to fight solely with the weapons nature has given. But the moment artificial weapons are employed, the contest becomes essentially one of skill and not of mere strength. In other words, the result of the contest would depend mainly upon the mental characters of the combatants, instead of on their relative physical strength. Take the only case Mr. Darwin adduces in support of his view, namely the case of the North American Indians, of whom Hearne says that the men wrestle for any woman to whom they are attached, and that "of course, the strongest party always carries off the prize." Any one, however, who has ever seen wrestling knows that this last statement does not express a fact. Success in wrestling depends only to a very limited extent upon actual strength or even weight, but almost entirely upon skill. Not only is this the case, but success in wrestling is largely influenced by the possession of certain mental peculiarities, wholly irrespective of mere mechanical adroitness.

Upon the whole, then, it is perhaps safe to conclude that even the actual physical contests between individual men or tribes of men, however savage, are ultimately decided by the mental characters of the competitors, as much as by anything else. We may, however, go further than this. Admitting that women are always likely amongst savage races to constitute a bone of contention for the men to fight over, still we need not admit that success in such a fight would always, or even generally, fall to the strongest. On the contrary, the man most skilful in the use of his weapon, most fertile in resource, with the most inventive genius, and with the most ready use of his tongue, would be at least as likely to win a wife as the biggest and strongest of his competitors. Mere brute strength is not always the *ultima ratio* even amongst the lowest savages. In some respects savages are often singularly like children, and one can imagine many cases in which a savage might carry of his wife from several competitors by his mental ascendency alone, without having recourse to the carnal weapon. Lastly, Mr. Darwin himself afterwards points out at length that there are many cases even amongst savages in which the woman has a free choice, and in which she does not play the merely passive part of espousing the strongest of her suitors. Whenever this is the case, and we have no right to assume that it was not the case in a hypothetical semi-human race, the strongest would, of course, by no means always be the most successful in his matrimonial affairs.

We cannot, then, agree with Mr. Darwin in thinking that man owes his greater size and strength as compared with woman, "together with his broader shoulders, more developed muscles, rugged outline of body, and greater courage and pugnacity," to the continued success of the strongest man of some primaeval race in a long series of combats for the possession of their wives. On the contrary, if any "selection" of this kind has ever taken place to an extent sufficient to produce any palpable and recognisable effect, we believe that it has been in favour of the most cunning, clever, inventive, and skilful men. We also cannot believe that man's superior strength, as compared with woman, has been kept up amongst the civilized races by the fact that "the men, as a general rule, have to work harder than the women for their mutual subsistence." Civilized man has as a rule to work harder than his wife, but his work in a very large proportion of cases is itself of a nature to diminish his physical strength, or it is attended with concomitant circumstances which do not favour his physical development. It is also worthy of notice here that the physical superiority of man as compared with women is even higher amongst civilized races than amongst savages, and this not only relatively but absolutely. Amongst savages, the women have generally to work at least as hard as the man, and thus the disproportion between the sexes is reduced. In a state of civilisation, on the other hand, whilst the women may have to work less and may thus be physically stunted of their full development, the man, contrary to what might have been expected—are on the whole physically superior to the savage races, in spite of the fact that their avocations are not such as always promote physical strength. That civilized man is a finer *animal* than savage man may be disputed, but little doubt can be entertained as to the general truth of the above assertion. There is, therefore, a greater disproportion in strength between the sexes among civilized than among savage races; though, on Mr. Darwin's views, the cause which has led to this disproportion must have ceased to operate for many successive generations of the former.

Passing on now to the differences in the mental powers of the two sexes, Mr. Darwin adopts the view which most impartial and unbiassed reasoners affect, namely, that man is decidedly the superior of the women in intellectual calibre. In spite of all that has been said of late about the equality between the sexes, Mr. Darwin concludes that "the chief distinction in the intellectual powers of the two sexes is shown by man attaining to a higher eminence, in whatever he takes up, than woman can attain—whether requiring deep thought, reason, or imagination, or merely the use of the senses and hands." Accepting this intellectual difference, there are also other differences sufficiently weighty to support the view that the two sexes differ fundamentally in their mental constitution. If this be admitted, we might go farther than Mr. Darwin, and we might defend the proposition that the difference between the sexes, in the case of man, is one essentially and primarily mental, and that the physical difference is a secondary and non-essential one, truly flowing from and depending on the former. Facts are by no means wanting which would support this view, but they are mostly unsuitable for introduction here.

We next have a remarkable section on the voice and musical powers of man and some of the lower animals, the leading feature in which is the proposition that "although the sounds emitted by animals of all kinds serve many purposes, a strong case can be made out that the vocal organs were primarily used and perfected in relation to the propagation of the species." This is no new theory, and we have not time to analyse here the grounds upon which it rests. We may observe, however, that this theory leads to what we cannot but regard as a very debasing view of what music is and what it can effect. We are called upon, in fact, to believe that the feelings called up by music, of which Herbert Spencer remarks that it "arouses dormant sentiments of which we had not conceived the possibility and do not know the meaning," are merely reminiscences of the passions felt by some "half-human progenitor of man" during the season of courtship, when his excitement led him to express himself in harmonious tones and cadences. On this view, "musical tones would be likely to excite in us, in a vague and indefinite manner, the strong emotions of a long past age." So that, the emotions which we feel on listening to one of the productions of a great composer stand on no higher level than the impulse felt by dogs which leads them to turn round and round on the carpet as if to trample down grass to form their bed; both alike being vague associations inherited from some aboriginal ancestor! Water, however, rises no higher than its source; and it would be difficult to show how the complicated and wholly inexpressible emotions evoked by music, from their vague and indefinite nature, could ever have been developed out of the emotions felt by one of our savage ancestors in the performance of what, on Darwinian principles, must have been a purely animal function. Natural selection, certainly, never could have led to such a development, for it would need very strong evidence to establish the view that the appreciation of music is in any way beneficial either to the individual or the species; and there are no grounds for believing that sexual selection could have brought about such a fundamental change.

An elaborate account is next given of the habits of savages, in order to prove that men in all states of civilization, but especially in the lowest, are more or less influenced in their marriages by the beauty of the women. No one, we take it, will hesitate to admit this to the fullest extent; so that it is hardly necessary to devote any time to the demonstration of the fact that beauty, in all times and amongst all peoples, is a mere matter of taste; features which are admired by one man being regarded as hideous by another. Admitting that men are in many cases influenced in their choice of a wife by mere external appearances, we have to enquire whether "the consequent selection during many generations of those women which appear to the man of each race the most attractive, has altered the character either of the females alone or of both sexes." Mr. Darwin answers this enquiry in the affirmative, and though he adduces no very strong evidence in support of this view, we see no reason for doubting its general correctness. If, in fact, we admit that man is an animal at all, and no reasonable person would dispute this proposition, we must admit that he is amenable to the general laws which govern the improvement of the various breeds of domesticated animals. We cannot, therefore, doubt but that the tendency of each man to choose a good-looking wife, according to his standard of beauty, must in successive generations have had the effect of improving the personal appearance of the women, and, through them, of the race in general. This admission, however, in no way carries with it the acceptance of any belief that the fundamental characters which distinguish the sexes, or which separate man from the monkeys, have been produced by any conceivable action of "sexual selection" of this kind, acting through any conceivable period.

Mr. Darwin next passes on to notice the causes which he conceives to have interfered with or prevented the action of sexual selection amongst savages. The only cause adduced by him which demands our consideration, is what Sir John Lubbock has politely termed "communal marriages," *i. e.* the state of things in some savage tribes in which "all the men and women in the tribe are husbands and wives to each other." This state of things is, of course, a complete bar to the existence of "sexual selection," and we may at once dismiss it, so far as this aspect of the question is concerned. There is, however, another aspect of this subject upon which it may be well to make a few remarks. Upon strict Darwinian principles such a habit as that of "communal marriage" could never have been "the original and universal form throughout the world," unless it had been derived by modification from habits and feelings existing in some prehuman type of animal. But this is one of the numerous points in which—paradoxical as it may seem—man really proves his superiority over the brutes, by being *worse* than any beast. The disciples of Mr. Darwin's school do not recognize that man's sins and vices, indeed his very capacity for doing wrong, raise him immeasurably above the brutes that perish. *They* can do no wrong, for they cannot transgress the laws of their nature; but man can act in opposition to the dictates of his higher nature, when he becomes, not worse than himself merely, but worse than any animal. The capacity to fall, however, is truly but a easure of the capacity to rise; and man's evils distinguish him n the lower animals as much as his virtues. From this point v, it is not difficult to shew that "communal marriage" is y human institution, that it can never have existed the quadrupeds, and that it cannot, therefore, have been amongst the early races of mankind by a modification or expansion of habits existing amongst the animals. Not only is communal marriage an infinitely worse institution than anything known to obtain amongst the mammals; but it would not be difficult to show that its very existence depends upon the fact that man, alone of all the mammals, is not limited to a particular period of the year in which he courts the female. But Darwinism fails to assign any adequate cause to explain how man should in the first instance have come to depart from the ordinary rule amongst animals in this very important respect. On the other hand, communal marriage is utterly opposed to all the feelings which are known to regulate the relations between the sexes amongst the higher mammals. "With the existing Quadrumana, so far as their habits are known, the males of some species are monogamous, but live during only a part of the year with the females, as seems to be the case with the Orang. Several kinds, as some of the Indian and American monkeys, are strictly monogamous, and associate all the year round with their wives. Others are polygamous, as the Gorilla and several American species, and each family lives separate. . . . . . Again, other species are polygamous, but several males, each with their own females, live associated in a body, as with several species of baboons." Upon the whole, therefore, Mr. Darwin concludes that "communal marriage" never prevailed amongst the mammals in a state of nature, or even amongst the primeval races of men, "if we look far enough back in the stream of time." It would appear, however, that such an admission strongly militates against the whole Darwinian hypothesis of the descent of man. If man be descended from "some ape-like creature," as Mr. Darwin asks us to believe, it ought to be shown that the habits of man, at any rate in his savage condition, are modifications of habits in pre-human ancestors; and as such ancestors are unknown to us, traces of such habits, to say the least of it, ought to be shown to exist in the monkeys, since these are assumed to be man's nearest living relatives. But communal marriage, like so many of man's vices and degraded habits, is strictly human, and no traces of such an institution can be shown to exist in any of the mammals. Nay more, such an institution is wholly foreign to all the instincts of the brutes, so far as these are known to us. We may readily suppose that each male quadruped (except amongst the monogamous species) would prefer having as many wives as he could get; and hence we have no difficulty in understanding how various species of mammals come to be polygamous. But polygamy stands on a totally different footing to communal marriage. The possession by each male of many wives would certainly be secured by communism; but this recommendation of the system would be far more than counterbalanced by the fact that each male has to undergo the trial of knowing other males, his rivals, to be just as well off in this respect, as he is himself. Judging from what we know of the habits and instincts of wild animals, no male mammal would or could endure this trial with patience; especially as the males are often armed "with special weapons for battling with their rivals," and as they are limited to a short breeding-season. Communal marriage implies that each male should acquiesce in the success of his rivals, in order that a similar license may be extended to himself, and he may be permitted to pursue his loves in peace. Each male, on the other hand, amongst the mammals, resists, so far as he is able, the successes of the other males; and we can not, therefore, suppose that communal marriage, in our sense of the term, ever occurs, or has occurred, amongst the quadrupeds. We are thus unable to trace in any mammal the commencement of those feelings which render communal marriages possible amongst men.

As regards the manner of action of sexual selection with mankind, there are only three points which may be noticed. In the first place, sexual selection is said by Mr. Darwin to have acted much more powerfully in very remote periods than at the present day. We cannot see that any adequate grounds exist for such an assertion. Sexual selection, so far as it acts at all, must be at least as powerful now as it ever was. Its action amongst the most civilized nations has doubtless become infinitely complex, but men select their wives, or wives select their husbands, just as much as they ever did, and if sexual selection has any action in modifying races, it cannot be less effective now than it used to be, simply because the grounds of the selection have been changed. In the second place, it is a fallacy, so far, at any rate, as civilized peoples are concerned, to suppose that the strongest men necessarily leave the largest number of children. On the contrary, the notorious fact is that it is amongst the weaker members of the community, and those both physically and morally below the standard, that the highest ratio of multiplication is found. Not only does a certain amount or kind of physical degeneracy predispose to rapid multiplication; but the same classes of society in which the best examples of this may be found are just those in which early marriage is the rule, instead of the exception. The strongest classes of the community, therefore, certainly have no assured advantage over the weaker and poorer classes, as regards the number of descendants likely to be left by each. In the third place, Mr. Darwin believes that the characters of male animals have in the main been acquired by "the law of battle," in consequence of their having been compelled to fight for their wives. If such had been the case with man, however, the characters gained in this way must have been chiefly, if not exclusively, *mental*. For, we have already seen that the struggle between man and man, even in the savage state, turns upon skill, ingenuity, cunning, and patience, far more than upon mere brute strength; whilst man, alone of all the higher animals, has been endowed by nature with no special weapons either of offence or defence. In fact, on Mr. Darwin's hypothesis, he is supposed to have early lost the few natural weapons with which he commenced the battle of life; a supposition very inconsistent with the theory of sexual selection.

Finally, it only remains to add that the chief character of the human race which Mr. Darwin proposes to account for by the action of sexual selection, is the general hairlessness of his body. It is admitted that natural selection, formerly so confidently appealed to, cannot have metamorphosed man from a hairy into a hairless animal; but it is now supposed that this change may have been brought about by the constant selection by the males of a hairy race of men of females in whom the hairy covering became "small by degrees and beautifully less." Mr. Darwin thinks that there is "nothing surprising in a partial loss of hair having been esteemed as ornamental by the ape-like progenitors of man." We can only say that we cannot agree with him in feeling no surprise on this head; whilst we do not think that the general evidence bears out his views as to the origin of man's hairless skin.

# ADDITIONAL NOTES ON THE TACONIC CONTROVERSY.

By E. Billings, F.G.S.

In the last number of this journal I stated that the error in regard to the age of the Taconic rocks, was corrected by the investigations of the Geological Survey of Canada. I now propose to advance some further evidence in support of that averment. The question was decided chiefly by our discoveries at Point Levis, in May, 1860.

A trilobite that had been collected in the Georgia slates, was sent to me by Col. Jewett, in April, 1859. I considered that its occurrence in that group of rocks, was very much in favour of the views of Dr. Emmons. It is to this that he refers in his letter, published in my former note, where he says, "I had for years past looked upon the subject with a kind of indifference, until you had expressed to Col. Jewett opinions favourable to the existence of the lower rocks I had contended for."

I did not publish my opinion, but when afterwards Prof. Hall described and figured three trilobites from the same locality, I sent his pamphlet to Barrande, and called his attention to them as a group of primordial fossils, in a formation which was by the principal geologists of America, considered to be of the age of the Hudson River group. I saw that the facts could only be explained in one of two ways—either Dr. Emmons was right, or the trilobites constituted a sort of a colony of primordial fossils, in the Lower Silurian. The following are some extracts from Barrande's letter in reply:

"Paris, 28th May, 1860.

"My Dear Sir,

"A short time ago I received your letter of the 25th April, and at the same time the three Decades with two pamphlets, equally important for me. * * *

"You will see shortly, in the Bulletin my observations on the subject of *Paradoxides Harlani*, which I consider as identical with *Paradoxides spinosus* of Bohemia; that opinion dates back to 1851. Being then in London, at the British Museum, they presented to me for determination, a cast sent from the United States under the name of *P. Harlani*. After having examined it, I was convinced that this cast had been made from a Bohemian specimen, which had been sent to the other side of the Atlantic. I therefore thought myself right in effacing the American name, and in substituting that of *P. spinosus.* A short time afterwards I experienced the same illusion at the School of Mines in Paris. You may perceive by this how evident it is that these two forms are identical.

"After this fact, I think with you, that the opinions of our American confreres might well be modified. Besides you are aware that my doctrine, often expressed, is that the local deposits of countries, distant from each other, do not necessarily correspond exactly, one to one. * * *

"Nothing is more remarkable than the apparition of the three *Olenus* of Vermont, described by J. Hall in the pamphlet which I owe to your kindness. I demand of you, before all, if the figures are of the natural size, because there is nothing said about it in the text. The dimensions figured, greatly exceed those of the congeneric species of the ancient continent. You have good reason certainly to consider the apparition of these three species, in the Hudson River group, as a fact analogous to that of my colonies. * * *

"These three *Olenus* reproduce certainly the forms, which appear in Europe, only in the Primordial fauna. Consequently they would constitute by themselves, the phenomena, of the re-apparition of a genus heretofore considered as having become extinct with the primordial fauna. It would be a fact analogous to the Colonies, and I would be happy to be able to cite it in the work which I am preparing upon that subject, and which I hope to publish soon. But before placing that fact among those on which I found my doctrine, you will perceive that it is indispensable for me to obtain a perfect security of its reality. * * *

"You will render me a great service, if you can send me the facts which I have asked you for. If the three *Olenus* of Georgia represent really a re-apparition of an extinct type, or a sort of a colony, that fact would be very apropos for me, since it will show that on the new continent the succession of organic beings has been subjected to anomalies, similar to those which I have discovered in our old Europe. But if by chance, by some local accident, hitherto not perceived, there has been an illusion, very conceivable, as to the age of the Georgia slates holding the *Olenus*, it would simply be in America a repetition of that which has taken place in England, in Spain, and in Germany, as I have already related to you. * * *

J. Barrande."

The above is quite sufficient to prove, that I had recognized the trilobites to be primordial, before the pamphlet in which they were figured was sent to Barrande. Prof. Hall had referred them to *Olenus*, but I have been assured by several of the geologists who followed him, that he never intimated to them that the fossils indicated a horizon lower than that of the Hudson River group. I was the first to point this out. I considered that the evidence afforded by these trilobites was strongly in favour of Dr. Emmons' views, but did not amount to a perfect demonstration. They might constitute a colony, or something analogous thereto. Had no other evidence of the antiquity of the Georgia slates ever been discovered, it is possible that their age might still be disputed.

About the middle of May, 1860, before I had received Barrande's letter above quoted, and in fact before it was written, the trilobites and other fossils in the limestone of Point Lévis were collected. This discovery at once changed the whole aspect of the question. Up to this time the three trilobites of the Georgia slates stood alone, but now a crowd of similar forms came to their assistance. As these new fossils were partly primordial, and in part Lower Silurian types, I assigned to them a position about the horizon of the Calciferous and Chazy formations.* It was at first thought that those which occurred in a peculiar white limestone might constitute a group distinct from the others, and that they might represent some portion of a strictly primordial fauna. It was afterwards found that this group was connected with the others, and that the whole belonged to one series.

On the 12th of July, 1860, I wrote to Barrande, and gave him an account of our discovery. The following are some extracts from his answer:

"Paris, 19th August, 1860.

"My Dear Sir,

"Your letter of the 12th July last remained some days at Prague, where it awaited me. I have received it, and hasten to inform you, that I have read it with the most lively interest and the greatest satisfaction. The important discovery which you announce did not surprise me, upon the whole, since, as you have reminded me, I have always hoped for it. I recognize a coincidence, so to speak, providential, between that manifestation of the primordial fauna in the environs of Quebec and the moment when the question relative to the three *Olenus* of Vermont is about to arise.

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* When Sir W. E. Logan first examined these rocks he thought they were older than the Trenton. In his "Preliminary Report" dated 6th December, 1842, he states "of the relative age of the contorted rocks at Point Lévis opposite Quebec, I have not any good evidence, though I am inclined to the opinion that they come out from below the flat limestone of the St. Lawrence." We now know that his first view was the correct one.

" Without knowing in detail, the forms of the primordial fauna which you have collected, the only head of the *Conocephalites*, of which you have sent me the engraving, suffices to show me, that your appreciation of the ensemble of that fauna is exact. Besides I am convinced, by all that I know of your works up to this time, that your judgment is correct, and that you are not the man to permit yourself to be led away by preconceived ideas. Therefore the distinction which you have established between the three faunas; the black slates, the white and the grey limestones constitute for me facts which merit all my confidence.

" I think then as very rational all that you have said on the order of succession. If the locality at Quebec, does not admit of the determination, in an evident manner, of the relative age of the three faunas, by observation of their superposition, that which is the fundamental proof in palæontology as it is in stratigraphy, I think you will discover some other locality, in which may be more clearly decided that relative age.

" In the meantime we can only judge from the nature of the fossils. As to those of the white limestone, such as you have recognized them, they indicate clearly a stage of the primordial fauna. Whether that stage is above or below that of the Potsdam, or whether it represents the same horizon as the latter, is a question of secondary and local importance, which probably will be solved in time. There may be several stages distinct from each other in America as in Sweden, while I recognize only one in Bohemia. These are only such diversities as we may expect in countries distant from each other.

" The fauna of the black slates, as you have described it in your letter, consisting almost entirely of Graptolites with two *Lingulæ*, a *Discina* and a small trilobite, does not present a decisive character like that of the white limestone. We cannot then, on the first view, declare that it constitutes a stage of the primordial fauna. But if these black slates are the same as those which have furnished the three species of *Olenus* in Vermont, there can be no hesitation, and it will be necessary to recognize also that fauna, in that schistose mass. In that case, the occurrence of the graptolites, in such great numbers on that horizon, would be a very remarkable phenomenon, of which we have no example in other Silurian regions. It would be necessary to recognize, in that fact, a new proof, of the remarkable privilege of anteriority, which I have signalized for the zone of the North, of which your country forms a part. As to the small trilobite found in these slates, its dimensions calls forth the thought that you may discover the metamorphoses (of trilobites) in that formation.

" The fauna of the grey limestone is well characterized as appertaining to the second fauna, as you have observed, for it presents the ordinary genera of Trilobites, Cephalopods, Gasteropods, &c. The presence of one species of *Agnostus*, is also very natural, since that Genus is found in other Silurian countries, just up to the superior limit of the second fauna, for example, in Bohemia just in d 5.

" I think you are acting wisely in studying with time and all necessary care, all the elements of the question before asserting in a positive manner, the order of the succession of these three fauna. As there are many savants interested in the debate which will infallably arise, when you publish your discoveries, it is very desirable that your opinion may be so well founded that it may be inattackable.

" At all events, it is certain that the labours of the Geological Survey of Canada, will throw a great light on the Geology of the North of America, and in particular on the Silurian Epoch. Naturally, that light will reflect on the ancient continent, and we will be permitted to fix our ideas on bases more broad and solid, &c., &c.

J. Barrande."

This letter proves that the age of the Point Levis fossils was determined by me before I had written to Barrande about them. It now became almost certain, that the trilobites in the Georgia slates did not constitute a colony. This was confirmed by stratigraphical evidence, in 1861, by J. Richardson, who while making some examinations for our Survey at the straits of Belle Isle, found the fossils of the Georgia slates, in the undisturbed rocks lying directly on the Laurentian. He also discovered them in the same position, in Newfoundland, but in this instance with other rocks holding the fossils of the Potsdam and calciferous above them. The above appears to me to be quite sufficient to show, that the error relating to the Taconic rocks, was removed by the investigations and discoveries of the Geological Survey of Canada.

In December 1860, Mr. Marcou, who took a very active interest in the investigation, published Barrande's opinion on the age of the Georgia slates. This I have always considered to be equivalent to the publication of Barrande himself, as no doubt it was authorized by him. According to the laws of priority, therefore, Barrande was the first to determine the horizon of this formation on palæontological grounds, and I have on several occasions given him full credit for it. But by so doing, I am not precluded from showing what my own views were. I had previously recognized that the fossils were primordial forms, and that either they constituted a colony, or the rocks were older than the Hudson-River group.

American geology is indebted to Barrande for much greater services. It was he that discovered that, as a general rule, rocks holding trilobites of those types which we now call primordial, lie below the Lower Silurian. It was by the application of this rule, or law of nature as it may be called, that met only the age of the Taconic but also the age of the slates, at St. Johns New Brunswick, and of the great series of rocks investigated by Mr. Murray in Newfoundland were determined. The age of a number of other deposites in the Western States and in the Rocky Mountains has been decided by the same law.

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# ON SOME FOSSILS FROM THE PRIMORDIAL ROCKS OF NEWFOUNDLAND.

By E. Billings, F.G.S.

In Mr. Murray's "Report upon the Geological Survey of Newfoundland for the year 1870," the Primordial rocks of the south-easterly portion of the Island, are estimated to have a thickness of about 6000 feet. The upper 476 feet, constituting Bell Island, in Conception Bay, a short distance from the city of St. Johns, hold a peculiar group of fossils, the exact age of which has not yet been determined. The species thus far collected, consist entirely of *Lingulæ*, *Cruziana* and fucoids. Among the latter are fine specimens of several species of *Eophyton*, a genus first discovered on this continent by Mr. Murray. The *Lingulæ*, on a superficial examination, might be taken for those of the Upper Potsdam of Wisconsin. They are, however, specifically, and two of them are, perhaps, even generically, different. These two are distinguished by the remarkable convexity of the dorsal valve. They have their nearest representatives in some species from the "Budleigh Salterton Pebble-bed" of Devonshire, England. The pebbles of this latter formation, which hold the *Lingulæ*, are supposed to have been derived from the "Armoricain sandstone" of Brittany, France, considered to be about the base of the Lower Silurian. In Newfoundland, up to the present time, true primordial trilobites have been collected, only in beds, the highest of which are full 2000 feet below the lowest strata of Bell Island.

I shall therefore describe the fossils of this Island as a distinct division.

## FOSSILS FROM GREAT BELL ISLAND.

### Genus Eophyton, *Torell.*

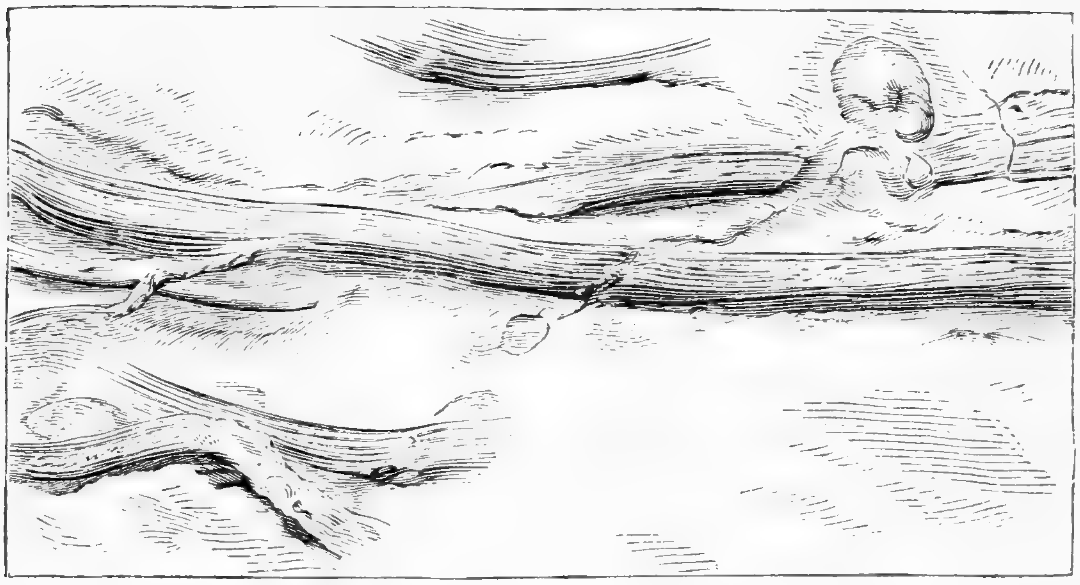

Fig. 1. *Eophyton Linnæanum?* Torell. Part of a slab of sandstone with several fragments supposed to be of this species.

The only specimen I have access to at present, is a slab of sandstone, about 15 inches in length and 12 inches wide, on the surface of which there are about thirty stems of the fossil. Most of these lie across the stone in a direction nearly parallel to each other. They appear to have been, when perfect, slender, cylindrical, straight, reed-like plants, about three lines in diameter, with the surface longitudinally striated; four striæ upon an average in the width of one line. Some of the stems, which have been partially flattened by pressure, are coarsely grooved or fluted; but when the surface of such is perfect, the fine striæ can always be seen on the large ridges and in the furrows between them. When pressed quite flat some of the stems only exhibit the fine striæ. I cannot see that any of the stems are branched. One of them, which is pressed flat, is bifurcated, but I think this due to the pressure, which has split the stem into two portions.

I refer this species as above, because it is impossible to distinguish it from some of the figures of the Swedish form. As it occurs above the *Paradoxides* beds, while the Swedish specimens, have as yet, only been found below, it is most probably a distinct species.

### Eophyton Jukesi, spec. nov.

In this species the stems are nine lines in diameter, cylindrical, straight or slightly flexuous. They are longitudinally striated, but the surface of the specimens examined, are not sufficiently well preserved to exhibit the dimensions of the striæ. It is separated from the former principally on account of its much greater size.

ARTHRARIA ANTIQUATA, gen. and spec. nov.

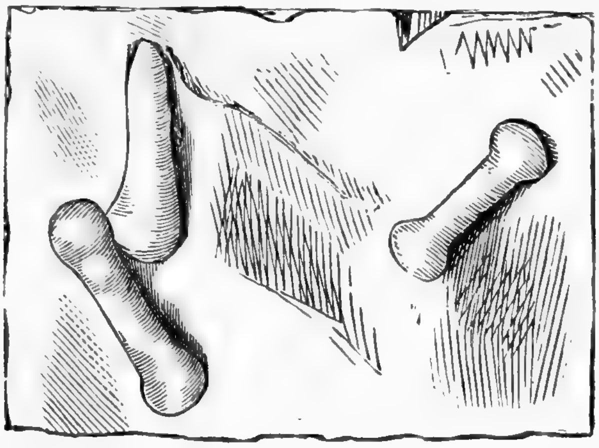

FIG. 2. Part of a slab of sandstone with *Arthraria antiquata.*

The fossils for which the above generic and specific names are proposed, are small cylindrical bodies, with usually an expansion at each end, giving the form of a dumb bell. Those that I have seen, are from six to nine lines in length, and from the manner in which they are grouped upon the surface of the stone, they appear to me to be segments of a jointed plant. Similar forms occur in the Clinton formation.

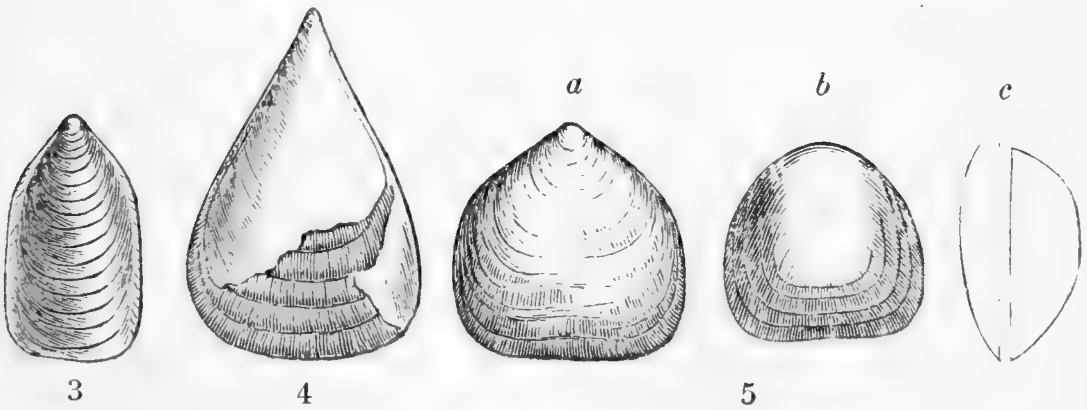


FIG. 3. *Lingula Murrayi.*
4. *Lingulella? affinis*, ventral valve.
5. " *spissa*, *a* ventral valve; *b*, dorsal valve; *c*, side view of both valves.

LINGULA MURRAYI, spec. nov.

Fig. 3.

Shell elongate, sub pentagonal; front margin straight or gently convex for a space equal to about two-thirds the width in the middle; anterior angles rounded; sides somewhat straight or very gently convex and parallel for two-thirds the length, then converging to the apex, where they meet at an angle of between seventy and eighty degrees. In one of the two specimens collected, there is a flat margin on each side one-sixth the whole width of the shell. Between these two flat margins the remainder of the shell is gently convex. In the other specimen this central space is slightly convex in the anterior part of the shell, but on approaching the beak it becomes an angular roof-shaped ridge. The shell is thin, black and shining with obscure fluctuating, concentric undulations of growth, and with very fine, obscurely indicated, longitudinal striæ.

Length nine lines; width five lines.

### Lingulella? affinis, spec. nov.

Fig. 4.

Ventral valve elongate, conical or acutely triangular. Apical angle about 45°. Front margin gently convex in the middle, rounded at the angles; sides nearly straight, uniformly converging from the anterior angles to the beak. Surface with very fine longitudinal striæ, about ten in the width of one line.

This species is founded upon the single specimen of a ventral valve above figured. The upper two-thirds is partly worn away in the middle, leaving only the outline in the stone. It appears to have been, when perfect, gently convex, the rostral portion near the beak semi-cylindrical. Length about thirteen lines, width nine lines.

The dorsal valve has not been identified.

### Lingulella? spissa, spec. nov.

Fig. 5, a, b, c.

Shell sub-pentagonal, or sub-ovate, length and width about equal, sometimes strongly ventricose. Dorsal valve with the front margin straight or very gently convex for about two-thirds the width in the middle; anterior angles rounded; sides straight or slightly convex and sub-parallel until within one-third or one-fourth the length from the beak, then converging to the apex, where they form an obtuse angle which varies from 100 to about 110 degrees. This valve is generally very convex, sometimes almost hemispherical, the outline on a side view is rather abruptly elevated in the rostral third, depressed convex for a short space in the middle, and then more gently descending to the front margin. Most of the specimens of this valve are eight or nine lines in length, and about the same in width.

The shell which is supposed to be the ventral valve of this species, is gently convex, with usually a somewhat flat space extending from the front margin upwards towards the beak. The apical angle appears to be from 90 to 100 degrees. Shell very thick, of a lamellar structure, dark brown or nearly black, and, sometimes, where exfoliated, of an ashy grey colour. Surface with a number of obscure undulations of growth and with fine longitudinal striæ, about ten in the width of one line.

### Cruziana similis, spec. nov.

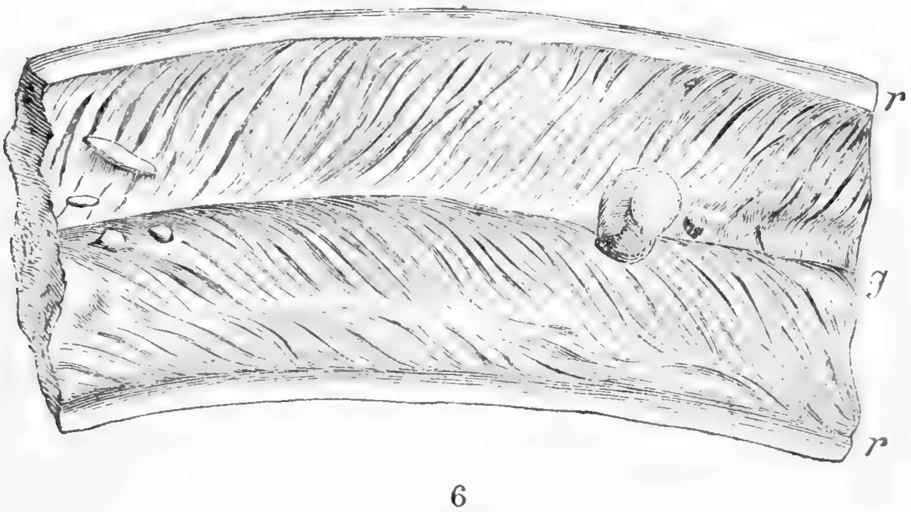


Fig. 6. *Cruziana similis*; *g*, the median groove; *r*, *r*, the ridges at the sides.

The specimens are from twelve to fifteen lines wide, divided along the middle by an angular groove, and bordered on each side by a narrow ridge, about one line wide. The space on each side between the median groove and the marginal ridges, are moderately convex and crossed obliquely by numerous irregular raised lines, with furrows between them. These lines usually have the form of a gentle sigmoid curve, sometimes extending quite across, but are often crowded together in a somewhat confused manner, still preserving the general oblique direction. Upon an average there are about ten lines in the length of half an inch. The marginal ridges are sometimes longitudinally striated.

This species has been heretofore referred by me to *C. semiplicata*, Salter, but although closely allied, none of our specimens agree exactly with the figures of the British species.

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Besides the above six species, many of the beds of sandstone of Great Bell Island, are covered with several species of *Palæo-*

*phycus* and other forms allied to *Eophyton* and *Cruziana*. To describe these would require further collections. In the upper strata there are yet two or three new species of *Lingula*, of which we have only fragments.

## FOSSILS FROM THE MENEVIAN GROUP.

Below the strata of Bell Island, there are about 2000 feet consisting of sandstones and slates, in which no fossils have been found except a few fucoids. These with the Bell Island rocks may represent the Middle and Upper Lingula Flags. They are immediately underlaid by about 2000 feet of slates, sandstones and limestones, holding fossils which prove them to be of the age of the Lower Lingula Flags, or the Menevian group of Salter and Hicks. Fossils in some of the beds are abundant but very imperfect. The following are all that are sufficiently well preserved to admit of description.

### OBOLELLA ? MISER, spec. nov.

Shell small, transversely broad ovate, nearly circular, width slightly greater than the length. Ventral valve strongly convex, depressed conical, greatest elevation at about one-third or one-fourth the length from the hinge line. The latter appears to be straight and about one-fifth the width of the shell. In the apex, or the most elevated point of this shell, there is an irregularly circular aperture or depression. The dorsal valve is less convex than the ventral but more uniformly so, the greatest elevation near the centre; beak apparently curved down to the level of the hinge line.

Surface to the naked eye apparently smooth, but when magnified showing very fine concentric striæ. The width of the largest specimen of the dorsal valve seen, is about one line; length a little less. This species occurs at Chapel Arm, in Trinity Bay.

Mr. Davidson has figured and described* under the name of *O. saggitalis*, Salter, a species from the Menevian group, North Wales, which is closely allied to this, the only difference, (so far as can be made out without comparison of specimens) being, that the English species is about double the size of ours. As I un-

* On the earliest forms of Brachiopoda hitherto discovered in the British Palæozoic rocks; by, Thomas Davidson, Esq., F.R.S., Geological Magazine, Vol. 5, No. 7, July 1868.

derstand Mr. Davidson, what appears to be an aperture, in the apex of the ventral valve, is not truly such, but an impression made in the cast of the interior by a tubercle on the inside of the shell.

STRAPAROLLINA REMOTA, spec. nov.


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FIG. 7. *Straparollina remota*, *a*, view of the spire; oblique view of anterior side.

Shell small hemispherical, spire depressed and rounded in outline, height 2 to 3 lines, width 3 to 4 lines, whorls about three, suture deep. The whorls are nearly uniformly rounded, more narrowly so on the upper side close to the suture, and also on the basal side. On a side view the minute apical whorl is scarcely at all seen; the next below it is elevated about half its own diameter above the body whorl. In a specimen 4 lines wide, the width of the aperture is about $1\frac{1}{2}$ lines, as nearly as can be determined from an individual partly buried in the matrix. Surface nearly smooth.

Occurs at Smith's Sound, Trinity Bay.

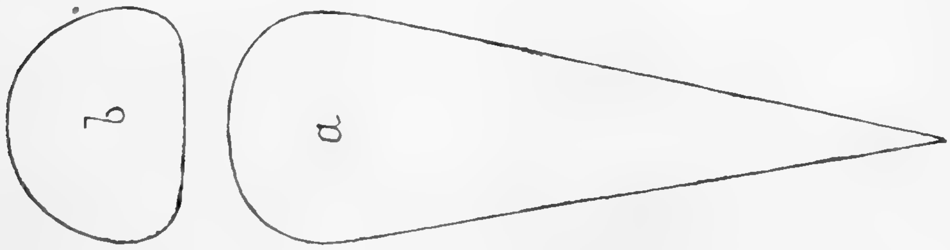


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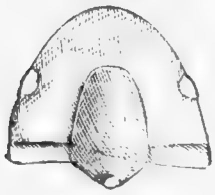
FIG. 8. *Hyolithes excellens.* In these diagrams, *n*, represents the rate of tapering on the ventral side; *b*, the transverse section. The dorsal side of *b* is too broadly rounded.

HYOLITHES EXCELLENS, spec. nov.

Shell usually about two inches in length, tapering at the rate of between four and five lines to the inch. The ventral side is nearly flat or very gently convex; the lateral edges narrowly rounded, in some specimens rounded angular; the most projecting parts of the sides are at about one-third the height; above this the sides are gently convex, the dorsum more narrowly rounded. The shell is thin, nearly smooth with very fine obscure striæ, about ten in one line. The striæ curve forwards on the ventral side, forming an arc the height of which is equal to about one-third the width of the shell. On crossing the lateral edges the striæ curve backwards, until they reach the most projecting part of the sides, then cross up and over the dorsum at a right angle. On a side view the shell is gently curved upwards on approaching the apex.

A specimen 24 lines in length on the ventral side is $8\frac{1}{2}$ lines wide and 6 lines in depth at 20 lines from the apex.

Occurs in the red limestone at Smith's Sound, Trinity Bay.



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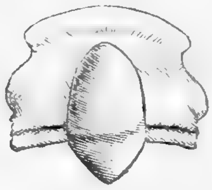

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Fig. 9. *Agraulos socialis.* The head without the moveable cheeks. The glabella is too distinctly defined in this figure.

Fig. 10. " *strenuus.*

Agraulos socialis, spec. nov. Fig. 9.

Head (without the moveable cheeks) semi-elliptical or conical, width at the base a little greater than the length, gently convex. Glabella conical and (including the triangular projection backwards from the neck-segment) about two-thirds the whole length of the head, neck-furrows all across but obscurely impressed; neck-segment with a triangular projection backwards, terminating in a short, sharp spine. Fixed cheeks gently convex; front margin sometimes with a portion in front of the glabella thickened. Eyes of moderate size and situated on a line drawn across the head at about the mid-length, distant from each other about the length of the head. Surface nearly smooth.

In small perfect specimens no trace of glabellar furrows can be seen, but in some of the large ones four or five obscure furrows are exhibited.

The largest specimen seen is six lines in length and seven in width. It occurs at Chapel Arm, Trinity Bay.

### AGRAULOS STRENUUS, spec. nov. Fig. 10.

Head (without the moveable cheeks) irregularly quadrangular, broadly rounded in front. Glabella rather strongly convex, conical, variable in its proportional length and width, either smooth or with several obscure impressions on each side representing the glabellar furrows; neck segment with a strong triangular projection backwards; neck furrows all across but usually obscurely impressed. In some specimens the front of the head has a thick, convex marginal rim separated from the front of the glabella by a narrow groove. In others this rim is scarcely at all developed. The eyes, shown by the form of the lobe, appear to have been semi-annular and about one-third the length of the head. The surface appears to be smooth. The following are the dimensions of the best preserved specimen:

Length of the head including the large posterior projection, 6 lines; width of the convex marginal rim, 1 line; width of the groove between the rim and the front of the glabella, $\frac{1}{3}$ of a line; length of the glabella including the projection, $5\frac{2}{3}$ lines; width of the glabella at the posterior margin, 3 lines; width of the fixed cheek from the centre of the edge of the eye-lobe to the side of the glabella, 2 lines. A line drawn across the head at $2\frac{1}{4}$ lines from the front margin, would pass through the anterior angles of the eyes. The length of the eye appears to be nearly 2 lines.

As above remarked, this species varies somewhat in its proportional length and width, and hence the dimensions, above given, would not be found to be exactly parallelled in all the specimens.

Occurs in the grey limestone of Topsoil Head and also in the pinkish limestone of Brigus, Conception Bay.

### AGRAULOS AFFINIS, spec. nov.

This species is closely allied to *A. socialis* and is of the same size but differs in the following respects. The glabella is broader and with the sides gently convex. The eyes are somewhat nearer the sides of the glabella. The whole of the anterior portion in front of the glabella is convex. The dorsal furrows are more distinctly impressed all around the glabella.

It occurs at Branch, St. Mary's Bay.

## Genus Conocepalites.

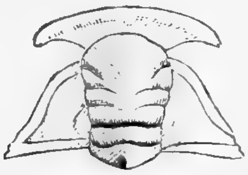
This genus has been used as a general receptacle for a number of groups which, according to several authors, constitute distinct genera. Although it has been found very convenient, there has lately sprung up a disposition to dispense with it altogether. I have no doubt but that this will be done, and I shall therefore dispose of our species as follows.

## Solenopleura communis, spec. nov.

Glabella conical, convex, about two-thirds the whole length of the head, about one-third wider at the neck-furrows than at the front; on a side view considerably elevated above the fixed cheeks; neck-furrow well defined all across; neck-segment thickened in the middle and bearing a small tubercle. The fixed cheeks are strongly convex but not so prominent as the glabella. The dorsal furrows are deeply defined all around the glabella. The front margin has a strong rounded rim, separated from the front part of the cheeks by a narrow, but distinct, groove; between the groove and the front of the glabella, there is a gentle depression, which separates the anterior angles of the fixed cheeks. The eyes are small, situated a little in advance of the mid-length of the head, distant from the side of the glabella a little less than half the length of the head, and are connected with the front of the glabella by an obscure ocular fillet. Surface with a few scattered tubercles, just visible to the naked eye, and between these numerous minute tubercles only seen when magnified.

The glabella exhibit traces of two or three obscure furrows on each side. Length of the largest head collected five lines.

Occurs at Chapel Arm, Trinity Bay.



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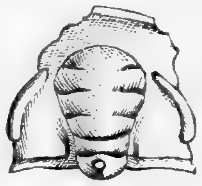

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Fig. 11. *Anopolenus venustus.* 12. *Paradoxides tenellus.*

## Anapolenus venustus, spec. nov.

Fig. 11.

*Description.*—Glabella convex, most elevated in front, obscurely angular along the median line widest at the anterior third of the length; sides gently concave in the posterior two-thirds, and slightly diverging from each other forwards; anterior third and front uniformly rounded. Neck segment with the margin convex and projecting backwards, an obscure tubercle, or rather, an angular elevation in the middle, neck furrows all across. There are four glabellar furrows; of these, the posterior is strongly marked and extends in a nearly straight line all across; the next two are linear, slightly impressed, extend inwards about one-third the width of the glabella and are gently curved backwards, but still almost at right angles to the sides. The anterior furrow is short, extends inwards about one-fifth the width of the glabella, and curves backwards at an angle of about 45° to the sides. The dorsal furrow around the glabella is very shallow. The fixed cheeks are triangular, nearly flat, with a small elevation, close to the extremity of the posterior furrow. Front of the head with a moderately convex marginal rim, almost in contact with the glabella or separated therefrom by a narrow space. The eye-lobe starts from a point close to the side of the glabella and just opposite or a little behind the short frontal furrow, and runs with a gently sigmoid curve (at first convex outwardly, and then concave) backwards and outwards to the posterior marginal furrow, which it reaches at a distance from the sides of the glabella, about equal to the length of the neck segment. The facial suture leaves the side of the glabella a little in front of the anterior furrow, and runs outwards, nearly at a right angle, but with a gentle convex curve, to the margin.

The surface is covered with fine rippled striæ. These on the marginal rim are irregularly parallel with the margin; on the glabella they curve around the front, but further back, and on the neck segment they have a rudely longitudinal direction, curving outwards in crossing over the glabellar lobes.

Length of the head of the largest specimen examined, 6 lines; length of the glabella, including neck segment, 5 lines; width of glabella at the neck segment, 3 lines, at the front pair of furrows, 3½ iines; width of the posterior margin of the fixed cheek 3 lines; length of the eye lobe, 4 lines.

When compared with the species figured by Salter and Hicks the following differences become apparent:—*A. Henrici*, Salter, has the eye lobes with a gently uniform curve outwards. In *A. Salteri*, Hicks, the eye lobes are also convex and the glabella proportionally longer, while the neck furrow "is the only one continued across." (Hicks.) *A. impar*, Hicks, has the flexuous eye lobes of our species, but the marginal rim is more decidedly in contact with the front of the glabella, while the two median pairs of furrows extend further inwards.

Occurs at Chapel Arm, Trinity Bay.

PARADOXIDES TENELLUS, spec. nov.

Fig. 12.

*Description.*—Glabella clavate, convex, most elevated at the anterior third of the length, front and sides in the anterior half, rounded, becoming sub-parallel in the posterior half. Neck segment strongly elevated in the middle, where there is situated a small tubercle, neck furrow extending all across. There are four glabellar furrows, of which the posterior extends across but is very indistinctly impressed in the middle; the next two in advance extend inwards about one-third of the width of the glabella, while the small one in front is somewhat shorter. The furrows are all nearly at a right angle to the longitudinal axis, and about equidistant from each other. The anterior margin of the head, is bordered by a narrow convex rim, which is separated from the front of the glabella by a flat space, varying in width from once to thrice its (the rim's) width. The fixed cheeks are subtriangular and nearly flat. The anterior extremity of the eye lobe is situated at a point nearly opposite, but a little behind, the anterior furrows, and is close to, but not in contact with the side of the glabella. The lobe is slightly sigmoid, its posterior extremity opposite the last glabella furrow. The dorsal furrow is distinctly impressed along the posterior half of the glabella but obscurely marked in front.

The surface is minutely granular. In all of the three specimens collected there is a small straight rounded ridge, which runs from the front of the glabella to the margin. It is situated exactly on the median line.

Of this species we have three specimens of the glabella, two of which retain portion of the fixed cheeks and show the form of the eye. The largest is three lines in length, including neck segment and front margin.

Occurs at Chapel Arm, Trinity Bay.

PARADOXIDES DECORUS, spec. nov.

*Description.*—The form of the glabella of this species is nearly the same as that of *P. tenellus* but the glabellar furrows are somewhat different. The posterior pair seem to be entirely disconnected in the middle and the next two pairs are rather more curved. The marginal rim of the front of the head, seems to be close up to, and in contact with, the front of the glabella. The surface is ornamented with minutely corrugated, raised lines which, in some places, anastomose so as to present an irregularly reticulated appearance. This at once separates the species from *P. tenellus*, the surface of which is minutely granulated. The surface of *A. venustus* is somewhat like that of this species, but the raised lines are more distant, and besides the posterior glabellar furrow extends all across. The length of the most perfect glabella examined is about thirteen lines. Only three fragments, (all of the glabella) of this species occur in the collection. Form of the eyes and of all other parts unknown.

It occurs at Chapel Arm, Trinity Bay.

Genus IPHIDEA, gen. nov.

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FIG. 13. *Iphidea bella*; ventral? aspect.

Of this genus we have no specimens showing the internal structure, but the external characters seem sufficient to separate it from any described generic group. The ventral? valve of *I. bella*, is conical, strongly elevated at the beak, hinge-line nearly straight, posterior angles narrowly rounded, sides and front nearly uniformly rounded, forming rather more than a semi-circle. Posterior side with a large false area, and a convex pseudo-deltidium, the width of which at the hinge line is nearly one-third the whole width of the shell. The dorsal valve is semi-circular, moderately convex most elevated at the beak. The hinge-line appears to be straight. The form and structure of the posterior side, (such as the area, foramen, deltidium, &c.,) cannot be made out from the specimen, owing to its imperfection. The surface is covered with fine concentric striæ, which in the ventral? valve are continued around on the area. Of these striæ there appear to be from 15 to 20 in the width of one line, their size varying somewhat in different parts of the specimen. There are also a few obscure radiating striæ. Width of ventral valve, 7 lines; length, 5 lines; height, 2 lines.

In the specimen above figured there is an aperture in the beak, but in another there is no appearance whatever of a perforation. This genus resembles *Acrotreta*, but differs therefrom in having a large convex deltidium. It seems to be also closely allied to *Kutorgina*. The shell which I have described under the name of *Obolus Labradoricus* belongs to this genus.

*I. bella* was found by T. G. Weston, in a boulder of limestone associated with numerous fragmentary trilobites, of primordial age, near Trois Pistoles below Quebec. A closely allied species of the same genus occurs in the primordial limestone at Topsail Head, Conception Bay, Newfoundland.

## FOSSILS IN THE HURONIAN ROCKS.

### ASPIDELLA TERRANOVICA, nov. gen. and spec.

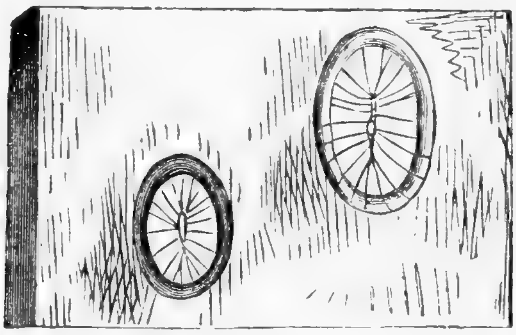

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FIG 14 *Aspidella terranovica*, two specimens on a small slab of stone, slightly restored.

These are small ovate fossils five or six lines in length and about one-fourth less in width. They have a narrow ring-like border, within which there is a concave space all round. In the middle there is a longitudinal roof-like ridge, from which radiate a number of grooves to the border. The general aspect is that of a small *Chiton* or *Patella*, flattered by pressure. It is not probable, however, that they are allied to either of these genera.

Associated with these are numerous specimens of what appear to be *Arenicolites spiralis*, a fossil that occurs in a formation lying below the primordial rocks in Sweden. These fossils were first discovered by A. Murray, Esq., F.G.S., in 1866. Other specimens were collected by Capt. Kerr, R.N., Mr. Howley and Mr. Robertson.

They occur near St. Johns, in the Huronian. A more detailed description will be given hereafter.

STENOTHECA PAUPER, spec. nov.

*Description*.—Shell small, conical, with the apex incurved, laterally compressed. Aperture ovate, elongated in the plane in which the curvature of the apex occurs. Surface with four or five small engirdling convex ridges. Length of aperture about 1½ lines; width about 1 line; height of shell about 1 line.

Occurs in the red limestone at Bridgus, Conception Bay.

In the Quar. Jour. Geol. Soc. of May last, Mr. Hicks has described and figured, under the name of *Stenotheca cornucopia*, a small shell which is evidently congeneric with this. To the same genus should perhaps be referred the shell known as *Metoptoma rugosa* of the Lower Potsdam ? of New York.

SCENELLA RETICULATA, gen. and spec. nov.

*Description*.—Shell small, almost uniformly depressed, conical; apex central or nearly so; an obscure carina extending from the apex down one side to the margin. Aperture nearly circular, apex very slightly incurved towards the side opposite the carina. Surface reticulated with fine radiating and engirdling striæ, just visible to the naked eye. Diameter of the aperture of the largest specimen collected, 3 lines; height of the apex, 2 lines.

Occurs at Topsail Head, Conception Bay.

Species resembling this have been heretofore referred to *Capulus*, *Metoptoma*, &c., to which, however, they do not belong. For the present I propose to refer those with a strongly corrugated surface to *Stenotheca*, and the others with a smoother surface to *Scenella*.

(*To be Continued.*)

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## WHAT IS TRUE TACONIC?

BY PROF. JAMES D. DANA.

The true use of the term Taconic should be learned from Prof. Emmons's first application of it when he made his formal announcement of the "Taconic system." In his final New York Geological Report, 4to., 1842, the rocks so-called are those of the Taconic mountains, on the borders of Massachusetts and New York, together with the quartzite, limestone, and slates adjoining on the east,* and not the slates far west of these mountains; †

* Professor Emmons opens the subject of the "Taconic System" in his final Report (1842) by saying that it extends north through Vermont to Quebec, and south into Connecticut; but the only rocks he describes as the rocks of the system are those of Berkshire County,

moreover the slates, the rocks of the mountain, were the typical beds, and not the quartzite. Hence, if there are any Taconic schists or slates, those of the Taconic range are the rocks entitled to bear the name, being Taconic geographically, and Taconic by the earliest authoritative use, Prof. Emmons the authority.

Prof. Emmons, in his Agricultural Report, subsequently published (in 1843), announced the Primordial beds of Bald Mt. (near Canaan Four Corners, in Columbia Co. N. Y.), as *Taconic* also; but this did not make them so. He referred to the Taconic the Black slates of northern Vermont, since shown to contain primordial fossils; he searched the country north and south for other Taconic rocks, and found them as he thought; and he set others on the search, not only in this country, but over the world. But all this has not changed the fact that the true Taconic beds, if any are such, are those he first so announced; and that the rest, so far as they are of different age from these, younger or older, have been dragged into the association without reason. The Taconic rocks of Berkshire and of the counties of New York just west, always bore the most prominent part in his later descriptions of the Taconic system.

The error on the part of Prof. Emmons, in referring beds of other ages to the Taconic system, is not surprising, considering the difficulties in the case. But it was no less an error; and his name as a backer cannot make the wrong right.

Geologists now regard the slates of Taconic Mt. and the limestone, also, as of Lower Silurian age, but later than the Potsdam sandstone. Logan refers them to the Quebec group. Whatever the period of the slates, or slates and associated limestones, to that period properly pertains the term *Taconic*.—*Amer. Naturalist.*

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Massachusetts, and their continuation westward into New York. These are the typical rocks on which the system was founded. On plate xi. four figures representing sections across this particular region are given. The only Vermont observations are contained in the only other section on the same plate representing a section from Lake Champlain to Richmond, Vt., through Charlotte. No description of the rocks of this section is to be found in the text of the volume.

† In figure 4 of plate xi. (referred to in the preceding note) representing a section through Graylock, the "Taconic slate" stops just west of Berlin, Rensselaer County, New York, the slates on the west being put down as "Hudson River shales," and in figs. 2 and 3, the boundary is near Petersburg, north of Berlin. The extension of the Taconic to the Hudson River appears first in Prof. Emmons' Agricultural Report, published in 1843.