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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.

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CONTENTS.

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THE

CANADIAN NATURALIST

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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 Diato maceæ," 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.

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

* "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." †

* "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.

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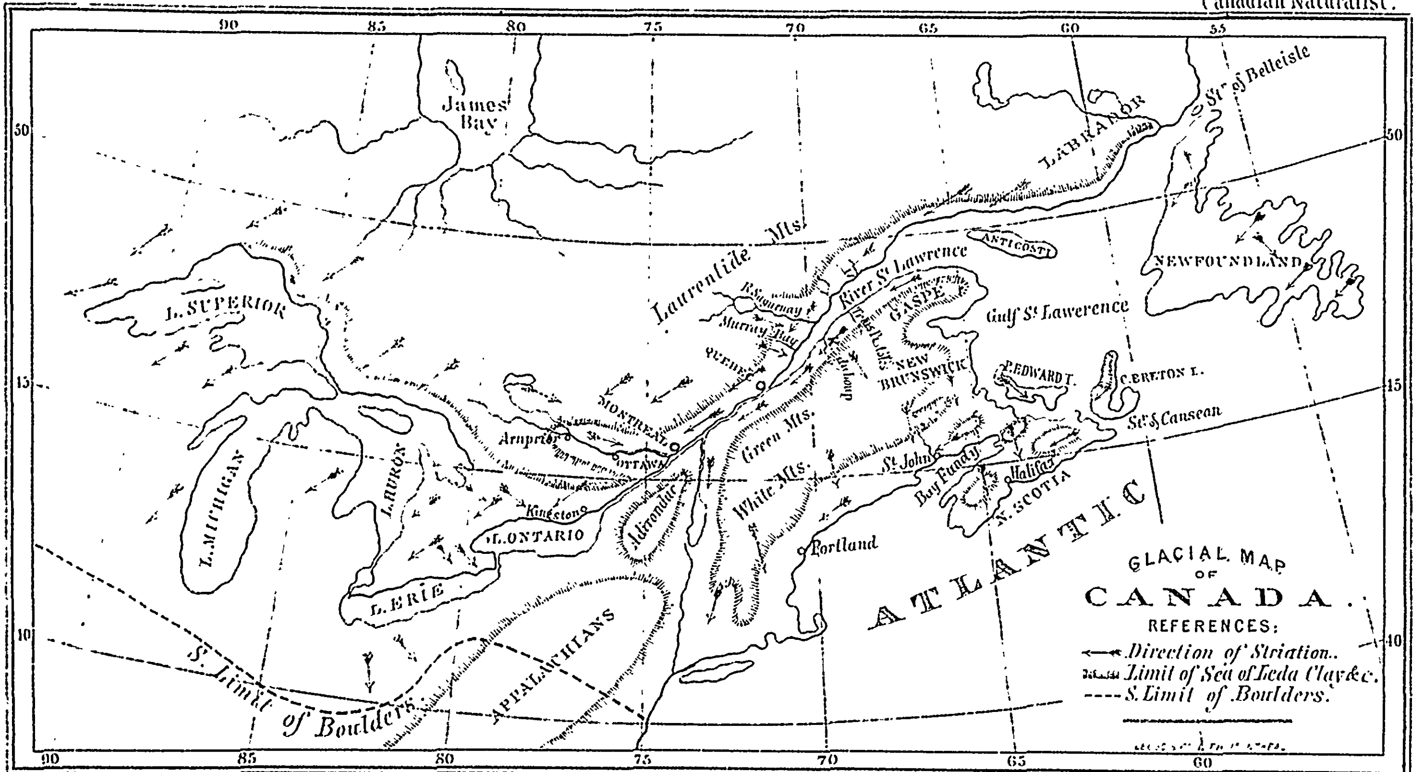
* *American Journal of Science*, July, 1860.

† *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.

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

* 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 occurring 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 brought 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 ome 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.

<table>
<tr><th colspan="2">Facts observed.</th><th colspan="2">Theoretical Views.</th></tr>
<tr><th>INLAND PLAINS.</th><th>MARGINAL AREAS.</th><th>GLACIER THEORIES</th><th>FLOATING-ICE THEORIES.</th></tr>
<tr><td>Terraces.</td><td>Terraces and raised beaches.</td><td colspan="2">Emergence of modern Land.</td></tr>
<tr><td>Travelled boulders and glaciated stones and rocks.
Stratified sand and gravel.
(Algoma sand, &c.)</td><td>Sand and gravel, with sea shells and boulders.
(Saxicava sand).</td><td colspan="2">Shallow Seas and Floating Ice.</td></tr>
<tr><td rowspan="2">Stratified clay with drift-wood, and a few stones and boulders.
(Erie clay.)

Striated rocks.</td><td rowspan="2">Stratified clay with sea shells.
(Leda clay).
Clay and boulders with or without sea shells.
(Boulder-clay).
Striated rocks.</td><td colspan="2">Deep water with Floating Ice.</td></tr>
<tr><td>Submergence of the land.

Great continental mantle of Ice.</td><td>Much floating ice and local glaciers.

Submergence of Pliocene land.</td></tr>
<tr><td>Old channels, indicating a higher level of the land.</td><td>Old channels indicating previous dry land.</td><td>Erosion by continental glaciers.</td><td>Erosion by atmospheric agencies, & accumulation of decomposed rock.</td></tr>
</table>

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.*)

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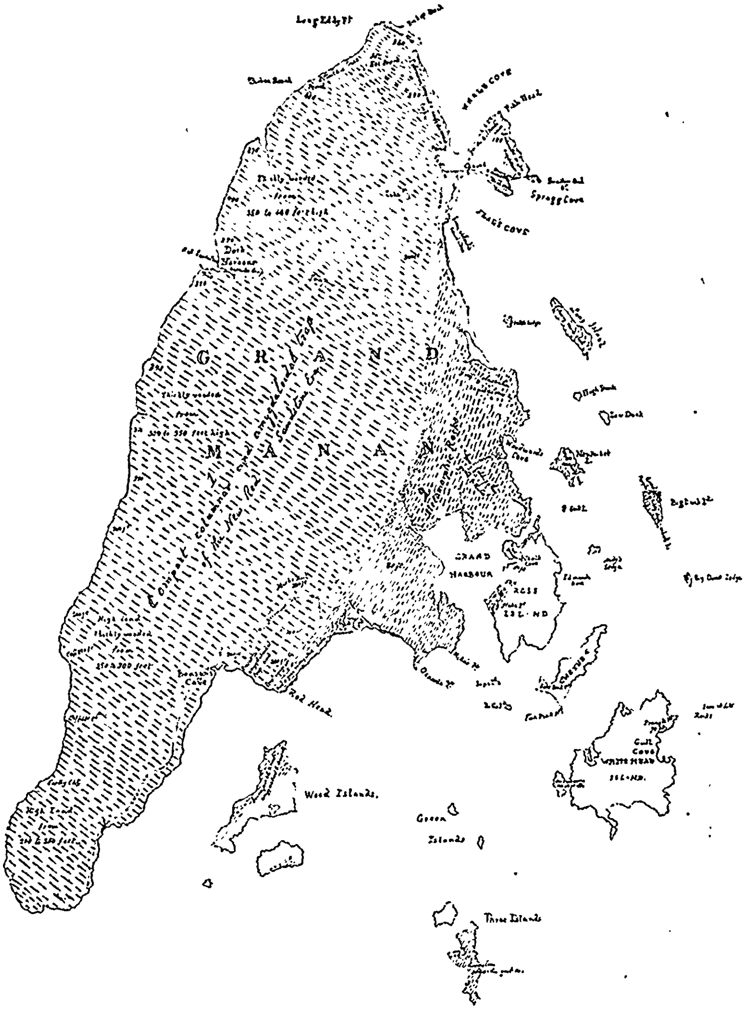
* On the Geology of South-western Ontario. Am. Jour. Sci. 1868.



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.,)

* 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-

* 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-

† 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 fiims 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.

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 unaltered, 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

* 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 petr leum 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.

* 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 Goderich. 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 we 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 310 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 lighter 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 Moisic; 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.*
Moisic, A...............	2·82	46·3 per cent.
Moisic, B........	2·88	49·3
Moisic, 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 Moisic is not very great, as may be seen by comparing the proportion of magnetic grains in A and C, the Moisic 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 Moisic, 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 sulphur 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.

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 thickn ss. 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 ice, 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 Palæozöic 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. 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 fifteen 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.

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 (*Morone 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 (*Palæmon 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 Moss-bunker is often infested by a large parasitic Lernean (*Lernocera radiata* Les.) which buries its star-shaped head deeply in the flesh.

The Summer Flounder (*Chænopsetta 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*, *Palæmon 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; *Idotæa 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.*

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 features 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 Dalll, 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 acqui ements. 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.

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 Athenæum*, 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.	
To Cash paid J. F. Whiteaves, salary	$400.00
" " W. Hunter, "	100.00
" " H. Passmore, "	100.00
" " J. E. Pell, Commissions on Collections	29.20
" " Interest	120.00
" " Coal	56.06
" " Gas Bills	56.03
" " Water Tax	32.75
" " City Tax	46.40
" " Insurance	39.00
" " 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

1870, May 1.	
By Balance in Treasurer's hands	$886.15
1870–'71.	
By Government Grant	750.00
" Members Yearly Subscriptions	595.00
" Donation towards liquidation of Debt, J. F., Jr.	50.00
" Museum Fees	35.83
" Rent of Lecture Room	172.06
" Subscription to "Naturalist"	2.00
" Interest from Treasurer one year on $886.15	62.03
	$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.