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Presidential Address. By B. E. Walker, Esq., F.G.S.

(Read 12th November, 1898.)

The scientific student, or even the mere student of science, a quite different thing, by the way, should be one who seeks truth for its own sake, indifferent to the effect it may have on his preconceptions. If we turn to the last century, we find those who were interested in the physical history of the earth readily adopting the speculations of such men as Buffon and Werner, and so captivated by their plausible theories, based on little observation, that men like Guettard and Demarest, industrious observers who gathered facts before they ventured to theorize, were utterly disregarded, although their methods and conclusions were purely scientific in spirit and have helped to build the body of real truth which was so lamentably retarded by their brilliant contemporaries. Practically the spirit of original research and of open-mindedness in accepting the results of the researches of others, is of modern origin, and such liberty of observation and thought is even yet looked upon by some as a dangerous use of our faculties. There are still those who regard the modern spirit of enquiry as an attack upon whatever old foundations may seem to constitute orthodoxy in either religion or science. But this modern spirit of scientific study covers much beside the observation of truths connected merely with the physical and natural world around us. It covers practically all knowledge which may be systematized. It is that state of mind toward all phenomena which, if we were perfectly free from bias, would not permit us to vary any conclusion warranted by the facts, in favour of our preconceived ideas or beliefs. Of course very few, if any, can entirely escape the baneful effect of preconceptions, and it is to be feared that men of science are sometimes as dogmatic and prejudiced as others. Too many follow a quest in science which may not be truth, perhaps a quest of material gain, or of mere intellectual enlargement, by adding to the facts which sustain a theory already held. The scientific student should rise above all other considerations to the moral altitude of mere truth for its own sake. If it is a truth which he is unable to square with other truths, he should be willing that it should remain a disturbing anomaly until time shall have solved it. Let us, however, descend from these high levels into the so-called practical affairs of life.

There are those who question the importance of any new fact in the natural or physical world unless the material good to flow from it to man is apparent. What is the use of studying plants, or insects, or other inedible animals, or fossils? What is the use of Crookes's tube, they would have said a few years ago? And there are those of higher intelligence who although willing to admit the value of studies bearing on the origin of life, on evolution or some recognized philosophy, still question the wisdom of spending long years in the discovery of facts which have no clear connection with other established items of knowledge. Many among the so-called practical men of the world realize the value of the entomologist who can do something to check the ravages of insects injurious to vegetation, the botanist who understands problems of forestry, or who with the added knowledge of the chemist knows the food or the medicinal value of plants, the geologist who happens to discover a coal or a gold mine, the biologist who actually saves human life by his knowledge of bacteria, or who by his knowledge of their habits shows how the fish supply of the world may be increased. But they do not always understand that the scientific discoverers who are thus able to do some direct good to man would not in all probability have attained such knowledge had they attacked the unknown fields of science in any other spirit than that which recognizes that all newly discovered items of fact are infinitely valuable, whether we can at the moment put them to any direct use or not.

No one is wise enough to recognize the full value of a newly-discovered fact. One new fact may seem to have nothing to recommend it, except its anomalous character. Another may seem of enormous importance. But some later discovery may change all this, disclosing the value of the apparently anomalous fact and diminishing the value of that which seemed the most important. Our duty is to treasure every new truth or fact discovered, no matter how unimportant it may appear. We can readily understand that what seems now of trifling value may be intimately connected with the working out of some problem in which man is deeply interested.

This may seem an unnecessarily elaborate manner in which to draw your attention to the claims of palæontology, the subject in which I hope to interest you to-night. In its early history it was peculiarly a study in which patience was necessary in recording facts which seemed to have little more than mere stratigraphical value to the discoverers. And even now that it may claim to be a body of systematized knowledge, its value is certainly underestimated in this centre of colleges and universities.

The simplest manner in which to judge of the value of any particular branch of science, such as palæontology, is doubtless to consider its interdependence with other branches of science. In the ultimate analysis, of course, all science is interdependent, but I refer to that interdependence which at once occurs to the student who desires to be a specialist. The entomologist soon finds that he must know something of botany, the botanist that he must know something of entomology. Both soon learn, also, that without some knowledge of geology, if only of soils and altitudes, they cannot proceed very far.

Let us, then, first consider the value of palæontology to the student who is trying to work out the physical history of the globe. In the record of fossils he finds almost his only sure guide. If he tries to work backward through the crust of the earth, beginning with the most recent conditions on the surface, he finds that there is but one satisfactory guide proving the regular succession of the different strata of rocks, and this is palæontology. If he concludes that the stratigraphical arrangement of the sedimentary rocks is for practical purposes the most satisfactory measure of time, he must also conclude that without the palæontological record there could be no system of stratigraphy, and that where the stratigraphic sequence is broken there is little beside the correlation of the fauna in the two unconformable strata from which to measure the time represented by the break in the sequence. It may be well to recount very briefly how our present knowledge of stratigraphy has been gained and the extent to which this knowledge is due to palæontology. The first attempt to systematize the rocks comprising the crust of the earth was made by the Freiburg professor of mineralogy, Werner.(1)

(1) Many of the references to individual geologists have been taken from Sir Archibald Geikie's "Founders of Geology."

He advanced the theory that the globe was once completely enveloped in water—that is, that the water was high enough to cover the highest mountain. From and in this water the rocks forming the basis of everything were chemically precipitated. These, according to Werner, included granite, gneiss, mica-slate, clay-slate, serpentine, basalt, porphyry and syenite. He even asserted at first that the chemical deposition was made in the order in which the rocks are here arranged. These were his Primitive rocks, and they were followed by what he termed Transition rocks, some of which were of chemical deposition and some sedimentary. Then came the so-called Floetz rocks, partly chemical, but in the main sedimentary. It became necessary, however, to recognize the existence of volcanoes, and he taught an eager, listening world that volcanoes were the result of the burning up of seams of coal and other inflammable sediments; and that volcanic action was one of the most recent of physical forces at work in the earth. If ever there was an instance of the value of collecting facts, no matter how apparently dissociated from each other, until a system could be built which would defy attack, we have it in the Neptunist geology of Werner. He could not wait for facts, but theorized most brilliantly on the basis alone of what could be gathered in the mining district in which he lived. He contended that basalt was not volcanic, and satisfied most people, after a violent controversy, that it was not, and that obsidian and pumice were chemically deposited in water, while at the same time in France the patient, tireless investigator, Demarest, who refused to theorize, had laid before a world quite deaf to facts, the truth, as now recognized, regarding basalt and the real basis of what we know regarding volcanoes.

It is true that the great founder of accurate geology, Hutton, did not upset the theories of Werner and others by the aid of fossils, but he established forever the value of ascertained facts, of real evidence as opposed to theory. He laid down the great principle in geology, that we must judge of the action of the earth in the past by the action we see around us in the present. The doctrine of Uniformity in its extreme form is, of course, disputed by many,(1) but the main principle as here stat d is generally accepted. Hutton thus settled, in many cases for all time, the manner in which the sedimentary rocks were created, setting aside the absurd notion of Werner's ocean depositing, chemically and by sediments, layers on the sloping sides of mountains covered to their tops by the sea. Hutton not only understood correctly the forces creating rocks but the destructive forces of erosion and the creation of watersheds and river systems.

But although both Werner and Hutton knew that the various rocks were created in succession and that in this succession there was an order which it was desirable to understand, other men laid the real foundations of palæontology in its relation to stratigraphy. As early as 1779 the Abbé Giraud-Soulavie, in France, set forth in a paper a stratigraphical description of a district in France in which the different strata were arranged by him in relation to their fossil contents, and in which he demonstrated that in the older rocks the fossils had no similar living species, while in some of the later rocks a percentage of the fossils were identical, or nearly related to living species. Little attention, however, was paid to these important truths, and his systematic arrangement of the rocks in question is not now recognized. The Abbé was followed by two great Frenchmen whom the world was obliged to regard. Cuvier and Brongniart were biologists who realized that they could not disregard the biological relations of fossils to living forms. Indeed, we owe it to Cuvier that palæontology is accorded its place in the study of biology, while Brongniart, in his zoology of the Trilobites, thus early demonstrated to what extent even an extinct tribe of crustaceans may be systematized and accorded their place in the order of natural history. But at the moment we

(1) Lord Kelvin "Popular Lectures and Addresses," vol. ii., page 6. Prestwich's Geology, 1886, vol. i., page 2.

are concerned only regarding their contributions to stratigraphy. Working together, these two great men thoroughly studied the geology and palæontology of the Paris basin, and established the systematic arrangement of the Tertiary or Kainozoic formations so firmly that although many new minor divisions have been added, few alterations have been made, and the main features of the present classification are as they arranged them. They distinctly state that they based their classification and division of the rocks upon the fact that at the same horizon in a series of rocks, even when examined in widely separated places, they found that the groups of fossils were generally alike. Their conclusions, which in the complete form reached the public in 1808, were followed in 1813 by the results of the labours of another Frenchman, D'Omalius d'Halloy, who worked out with true stratigraphical principles the Secondary or Mesozoic rocks of France.

Turning now to the development of stratigraphy in England, as early as 1760 the Rev. John Michell had stated most intelligently the principles of the stratification of rocks, but he contributed nothing towards the nomenclature of a system. English stratigraphy practically began with the well-known William Smith. He was born in the same year with Cuvier, and outlived him seven years, but, instead of the splendidly endowed biologist, we have only a land surveyer, imperfectly educated. He drew up as early as 1799, although he did not publish it beyond distributing copies by hand among a few scientific friends, a card of the English strata, with a tabular list of formations from the Coal up to the Chalk, giving the thickness of the several members, lists of the fossils peculiar to each, and the lithological changes. In 1815 he published a geological map covering all England, of which all subsequent maps are practically but an elaboration, and he established the Jurassic system as permanently in England, besides much of our knowledge of the Secondary rocks, as Cuvier and Brongniart did the Tertiary in France. The geology of the Secondary or Mesozoic rocks in England as known to-day is filled with the names of formations given by Smith, and we owe to him the first sufficient arrangement of the Primary or Palæozoic and the Secondary or Mesozoic rocks from the Old Red Sandstone to the Chalk. So that he and the Frenchmen referred to cleared up on palæontological grounds the entire stratigraphy from the Old Red Sandstone to the present time.

Practically nothing was known in 1831 of the stratigraphy of the rocks below the Old Red Sandstone, and I have only now to refer to the splendid work of Murchison and Sedgwick in establishing as the result of investigation in England, Wales, Scotland, the Alps and elsewhere, the Cambrian, Silurian and Devonian systems; and of the subsequent investigations, still being pursued, to work out the pre-Cambrian rocks, the foundation efforts in which are now by common consent accredited to our own great geologist, Sir William Logan, whose portrait hangs upon our walls as the first President of this Institute. Sir Archibald Geikie, on whom I have drawn most liberally for personal facts regarding the early geologists, says:—(1) "The determination of the value of fossils as chronological documents, has done more than any other discovery to change the character and accelerate the progress of geological inquiry."

The geographical discoverer is unsatisfied as long as there is a shore line not marked upon the map of the world, and naturally the geologist is unsatisfied as long as there is a section in his geological column the nature of which he has not determined. We have shown how the geological column from the top or present time back to the base of the Cambrian has been determined satisfactorily by the aid of palæontology, and we have suggested the value of such a complete record to the student trying to work out the physical history of the globe. But the geological column extends below the Cambrian to the Archæan, representing a period of time regarding the measure of which the geologist, the biologist, and

(1) Sir Archibald Geikie, "The Founders of Geology," page 242.

the physicist are in most thorough disagreement. Are there no more fossils below the base of the Cambrian to illumine this dark period? In the Lower Cambrian of North America, according to Mr. Wolcott, one of the leading authorities on the Cambrian time, there are as many as 160 species, and these cover all classes of marine invertebrates. Clearly, then, in the Lower Cambrian we are not near the beginning of life on this planet, and surely we are not near the earliest preserved remnants of life.

The rocks in North America which are older than the Cambrian are divided by Dr. Dawson[1] in descending order, as follows:—

1. Keweenawan.
2. Animikie.

Here throughout a great part of North America, there occurs a profound unconformity.

3. Huronian.
4. Upper Laurentian or Grenville Series.
5. Lower Laurentian or Fundamental Gneiss.

It is evident that if fossils are found in any of these groups the Palæozoic division must be extended downward to include such groups and the Archæan division be that much diminished. A problem, then, of enormous importance awaits solution by the geologist. How much further down than the recognized Lower Cambrian will he be able to carry the record of fossil forms? In the present state of our knowledge we find vast areas of these older rocks which seem to be sedimentary, but which appear to contain no fossils, vast areas regarding which we are not sure whether they were sedimentary or not, and again vast areas which we believe we have proved never to have been sedimentary. About this confused period floods of argument have been written and many hypotheses advanced, but what we want are fossils. Fortunately we have a few, although they do not help us very materially. Mr. G. F. Matthew, who constitutes our main authority in Canada on the subject, considered palæontologically, has established as pre-Cambrian, but Palæozoic, beds in New Brunswick and Newfoundland which he calls Etcheminian,[2] and which Sir William Dawson thinks to be equivalent to the Keweenawan.[3] They contain "but a meagre fauna, mostly animals of a low type of structure, as Protozoans, Brachiopods, Echinoderms, and Molluscs," with worm-burrows and trails. Mr. Walcott, in a memoir on the Lower Cambrian,[4] writes as follows:—

"The section laid bare in the Grand Cañon of the Colorado, beneath the great unconformity at the base of the known Cambrian, shows 12,000 feet of unaltered sandstones, shales, and limestones, that, I think, were deposited in pre-Cambrian time and should be referred to the Algonkian (Keweenawan). The entire section of pre-Cambrian strata is unbroken, and the sandstones, shales, and limestones are much like those of the Ordovician section of New York. In a bed of dark argillaceous shale, 3,500 feet from the summit of the section, I found a small Patelloid or Discinoid shell, a fragment of what appears to be the pleural lobe of a segment of a trilobite, and an obscure, small Hyolithes, in a layer of bituminous limestone. In layers of limestone, still lower in the section, an obscure Stromatoporoid form occurs in abundance. These fossils indicate a fauna, but do not tell us what it is." In the same memoir, in a note at the foot of page 552, Mr. Walcott mentions the discovery of Salterella and fragments of a trilobite, 500 feet below a series of beds in Vermont which are 700 feet thick, of conformably bedded lime

(1) G. M. Dawson. Presidential Address, Geological Section, B.A.A.S., 1897.

(2) G. F. Matthew. The Protolenus Fauna, Trans. N.Y. Acad. Science, vol. xiv., page 105, 1895.

(3) Sir W. Dawson. Note on Cryptozoon and other Ancient Fossils, Can. Record Science, vol. vii., page 203, Oct. 1896.

(4) C. D. Walcott. The Fauna of the Lower Cambrian, etc., U.S. Gov't Surv. Annual Report, page 550, 1888-9.

stone, and lie beneath the Olenellus Zone (the so-called base of the Cambrian). In the pre-Cambrian rocks of Wales and elsewhere fossils have been found, but not of a more satisfactory character than those already mentioned. I do not here discuss the so-called fossils of the Huronian and Laurentian, because until the vast beds of the Keweenawan and Animikie are cleared up it is hardly worth while to enter upon a mere controversy as to whether certain forms are fossils or not.

The subject is complicated by the many breaks or unconformities in Cambrian and pre-Cambrian times. In the extended areas of ancient rocks in North America there are sections where the Lower or some younger portion of the Cambrian rests directly upon Archæan or other pre-Cambrian rocks, and there are places where the section is conformable from the Cambrian series downward for many thousands of feet into the Keweenawan. Therefore, considering the many widely separated sections in North America, if at any point downward we were able to say we had reached the stage where in North America the Palæozoic rocks ended, it would seem at first sight as if we might conclude that the fossil remains found at this base, represented the beginning at least or organisms having hard parts. But presuming that the labours of Matthew, Walcott, and others eventually carry the Palæozoic record through the Keweenawan, down to the lowest of the beds of the Animikie, which "except when of volcanic origin," resemble "in their aspect the older Palæozoic sediments," we are then met, at least in the areas which Dr. Dawson has so happily called the "continental Protaxis of the North," with a gap in the record which he describes in the address from which I have already quoted, as "the vast lapse of time, constituting probably one of the most important breaks in geological history, by which the Cambrian and its allied rocks are separated from those of the Huronian and Laurentian systems." Regarding this break, Dr. Dawson says: "It would be difficult to deny that the time thus occupied may not have been equal in duration to that represented by the whole of the Palæozoic."

In the scattered and unsatisfactory fragments referred to above it cannot be said that we have found a fauna essentially different from the Cambrian, but somewhere—it may be in North America, in the Salt Range of India, in the Torridon sandstones of Scotland which are pre-Cambrian and said to be 10,000 feet in thickness, in Bohemia or Wales—we will doubtless be able to carry the history of the highly-developed trilobites and other organisms of the Cambrian at least further back towards their origin. This is the undiscovered shoreline in geology. In quest of it the Nansens of geology will travel as long as the limits of discovery are unsolved. We must not, however, forget that animals without hard parts leave no, or nearly no, record, and that the progenitors of many animals with hard parts had themselves no hard parts. In this connection Professor Marr,(1) after discussing the peculiarities of a well-known Cambrian trilobite, says: "If this be so, the entire outer covering of the trilobites, at a period not very remote from the end of pre-Cambrian times, may have been membranous, and the same thing may have occurred with the structures analogous to the hard parts of organisms of other groups. Indeed, with our present views as to development, we can scarcely suppose that organisms acquired hard parts at a very early period of their existence, and fauna after fauna may have occupied the globe, and disappeared, leaving no trace of its existence."

I have thus far been considering the value of fossils in demonstrating the position and relative age of the different strata of the earth's crust. It is not necessary for such purposes that the fauna of one stratum should bear any likeness to that of an immediately older or younger stratum. Indeed, to some extent,

(1) J. E. Marr. Presidential Address, Geological Section, B.A.A.S., 1896.

the less alike the better for mere purposes of distinguishing strata. It was, therefore, not unnatural that the early geologists, believing, as they did, that each particular animal or plant was a special effort of creation, should fail to recognize the value of biology in connection with the study of fossil remains. Indeed, when Cuvier and Brongniart, and, later, Deshayes and Lyell, undertook to correlate the organisms in the later rocks with living organisms—to point out where they were identical, where they were related but not identical, and where there seemed little relation—there were not wanting those who doubted the value of biology in the study of geology, and who persisted in estimating the value of fossils merely as guides in the stratigraphical arrangement of the rocks. Comparatively few fossils had been gathered, specific differences were often not recognized, the doctrine of evolution had not been advanced, and as I have already said, any particular fossil might be regarded as an organism whose history had no relation to anything but itself. The change which has come about in fifty or sixty years would be incredible were the record not clearly before us. I am not able to state even approximately the number of species now known, but a few detached facts will sufficiently illustrate the scope of modern palæontology. Prestwich estimated the species found in Great Britain in the Palæozoic rocks at 5,697, in the Mesozoic rocks at 7,546, and in the Kainozoic, including the Quaternary, at 4,013. That is, altogether, at 17,256 species, in the British Isles. This, as we know, is but a trifling part of the earth's area, although it is that which has been most thoroughly examined. Barrande estimated the Silurian species alone of Europe and America at 10,674, to which, of course, many have been added since the calculation was made. Every year great numbers of new forms are described and new territory is put under examination. No one would be so foolish as to attempt to guess the number of species which will eventually be recorded in science. If one will turn from the meagre text-books of the first half of this century to Zittel's(1) five large volumes, in which the first effort is made at a complete classification of all branches of palæontology, he will realize that the natural history of fossil animals is scarcely less perfect in its system of classification, or in its range of information, than the natural history of living animals. But it will be urged that after all we have only the hard parts of animals preserved. The soft parts are gone, and, worse still, the animals which had no hard parts have left almost no trace at all. This is quite true, and at first sight it seems an inestimable loss to the student of evolution. How will he ever fill the gaps in his record if only the bones have been preserved for him?

In the case of fossil animals having apparently no living analogues, had there been no theory of evolution there would doubtless have been no great desire to ascertain the nature of the soft parts, and thus to establish them in their proper places in the systems of natural history. And certainly in many cases, where the analogy is now clear, without this interest on the part of the biologist it would not have been suspected. But if in some class of fossil animals there are still a few living analogues, it is wonderful to what a degree the generic relations can be worked out and a system, satisfactory even to the biologist, be created, which shall include all the known extinct and living forms, even when the fossil species outnumber the living by a hundred to one. Allow me to illustrate this point by reference to the work done in connection with one of the most, if not the most, ancient order of shells, the brachiopoda. About 1884 Dr. Thomas Davidson, after thirty years of labour on the subject, finished the first great work on brachiopods(2) It fills five quarto volumes and is illustrated by 250 plates. What is perhaps more striking is the fact that the bibliography which completes the work, consists of 160 quarto pages, containing the titles of over 2,500 publications dealing with brachio-

(1) Karl von Zittel. Handbuch der Palæontologie, 5 vols., 1876-1893.
(2) T. Davidson. British Fossil Brachiopoda, vol. i.-vi., Publications of Palæontographical Society, 1850-1[illegible]

pods. The brachiopod is a bivalve, but with valves of unequal size. In the overwhelming majority of cases in the fossil form the valves are found united, and, as the valves are filled either with sediment or with crystallized matter, the interior is rarely visible. This involved a greater difficulty than that of merely ascertaining the marks of the attachments of the organs on the inner sides of the shells. The brachiopods have supports for the soft parts, the so-called arms, in the shape of loops or spirals, or other processes, and while in modern brachiopods these are not calcareous, in fossil forms they were. These spiral and other processes were occasionally but rarely exposed and separated valves showing the muscular markings were also found, but naturally the first attempts at systematizing the brachiopods were largely based on mere external characters. During the progress of Dr. Davidson's labours, however, the Rev. Norman Glass, assisted him materially. By the exercise of great ingenuity and delicate workmanship he removed the shells and exposed the delicate brachial supports referred to, in the case of many species, so that a greatly improved system was the result. It is but right to say that others were working upon the brachiopods in the same direction, notably Mr. Whitfield, of the American Museum of Natural History, New York. The number of known fossil species has, however, kept on increasing at a surprising rate, and we have also added largely to the known living forms. Dr. Davidson's work was, therefore, soon followed by important contributions from D. P. Oehlert, in 1887,[1] and by Professor Zittel in his Hand-book, already referred to. It was still maintained that we possessed no treatise in which "facts in regard to structure, function, habits, and distribution of these animals, the distinguishing characters and systematic relations of their genera," are included in one work. This Professor Hall and his co-workers have sought to do in the "Introduction to the Study of the Brachiopoda" and in the eighth volume of the Palæontology of New York. Here we can readily follow their history from the very minute and rudimentary brachiopods in the Lower Cambrian through their enormous development in the Palæozoic both in numbers of individuals and in variety of form and size, continuing in lessened though still great numbers through the Mesozoic, and gradually lessening until the present age, of which Professor Hall records only 147 species, many of which are mere varietal forms. Whether we consider the shapes of the valves as they have been influenced by the soft parts which are now gone, the microscopic structure of the shells, the systems of defence by spines, imitative surface markings or otherwise, the infinitely varied and very beautiful processes for supporting the arms, the muscular scars, the complicated nature of the hinge, the foramen, the evidence as to fixity of habit or the reverse, or any other feature which may leave its morphological evidence on the fossil; or the softer parts which may be seen in living forms and by the aid of which both the structure and habits of the fossil organisms may at least to some extent be understood, we must admit that the history of the Brachiopoda, as gathered from the study of both fossil and living forms has produced a result infinitely more satisfactory to the biologist and the geologist than could have been possible by the study of the fossil forms alone by the old-fashioned geologist and of the living forms alone by the old-fashioned biologist. And he would be a foolish man who undertook to say whether the fossil or the living forms had most aided in the final result. Both are absolutely necessary.

In almost any other branch of fossil remains quite as valuable evidence of the growth of palæontology on its biological side might be adduced. In the Protozoans, George Jennings Hinde by his microscopic work is carrying the evidence of the existence of Radiolarian remains farther and farther back in the Palæozoic rocks, and Messrs. W. D. and G. F. Matthew have found Globigerinidae in phos

(1) Paul Fischer. Manuel de Conchyliologie, Paris, 1887, with an appendix on the Brachipods by D. P. Oehlert.

phatic nodules in the Cambrian rocks of New Brunswick.(1) In the Sponges Mr. Hinde has done splendid work,(2) while Dr. Hermann Rauff has been some years labouring upon a systematic arrangement of all the known fossil forms.(3) Professor H. A. Nicholson has made the first attempt at systematizing our knowledge of those difficult Hydrozoans, the Stromatoporoids,(4) and Professor Lapworth and several other investigators are doing similar work upon the almost equally difficult Hydrozoans known as Graptolites. In the Actinozoans a vast quantity of work has been done on fossil corals since the epoch-making volumes of Milne-Edwards and Jules Haime, but the great work of revision has not been undertaken as yet. In the Echinoderms, the camerate crinoids have been revised in a most elaborate manner by Messrs. Wachsmuth and Springer,(5) and work of perhaps a higher character is now being done by Mr. F. A. Bather,(6) of the British Museum. In the Crustaceans there have been monumental works such as Barrande's, but such important discoveries as those of Beecher and others in demonstrating the morphology of the underside of the trilobites, so long practically unknown, and the wealth of forms and knowledge of embryology and zonal conditions made known by the researches of Walcott and G. F. Matthew in the Cambrian will make a general revision necessary sooner or later. In the Molluscoids, in addition to the Brachiopods, a great deal has been done by Professor H. A. Nicholson,(7) E. O. Ulrich,(8) G. B. Simpson,(9) and others, in the Palæozoic Polyzoans or Bryozoans, both towards increasing our knowledge of forms and in systematizing our knowledge, although there is not enough agreement as yet for the comfort of the ordinary student. In the Molluscs good work is being done in every direction, notably in this country, in Mesozoic forms, by Mr. Whiteaves, of our Survey, but the time has perhaps not come for a general revision of any of the classes unless it may be the Cephalopoda. These have, throughout the history of palæontology, attracted great attention, but perhaps the work of Hyatt and of Zittel, based on palæo-biological lines, has been the most important from our own point of view. However, so many men of ability have devoted themselves to the Jurassic ammonites alone, that one is afraid to venture upon an opinion as to the probability of general agreement in a scheme of classification. In connection with vertebrate palæontology, it is not necessary to speak, as the names of Cuvier, Agassiz, Owen, and Cope, among those who have passed away, are well known to you all, and many distinguished workers remain who will continue to fill the gaps, making the vertebrate record more and more complete as the years roll by.

If I had time I should like to discuss the value of that kind of palæontological study, as it is now being carried on by certain investigators, in which regard is had to the stratigraphical relations of certain fossils on the one hand, and their biological relations on the other, in order to demonstrate their evolution. In the Quarterly Journal of the Geological Society of London,(10) for August last, Mr. S. S. Buckman has divided the entire Jurassic system into minute zones, each zone

(1) G. F. Mathew. The Protolenus Fauna, Trans. N.Y. Acad. Science, vol. xiv., page 109, 1895.

(2) G. J. Hinde. British Fossil Sponges. Publication of Palæontographical Society, 1886-1893.

(3) H. Rauff. Palæospongiologie, Memoir in Palæontographica, edited by Prof. K. A. von Zittel, Stuggart, 1893.

(4) H. A. Nicholson. British Stromatoporoids. Publications of Palæontographical Society, 1885-1892.

(5) Watchsmuth and Springer. North American Criniodea Camerata, Memoir, Mus. Comp. Zool., Harvard, 1897.

(6) F. A. Bather. As an example of Mr. Bather's Palæontological work, see Petalocrinus, Q.J.G.S., vol. lv., pages 401-441.

(7) H. A. Nicholson. The Genus Monticulipora, Blackwood, Edinburg, 1881.

(8) E. O. Ulrich. Geological Surv. Illinois, vol. 8, 1890. Geological Surv. Minnesota, vol. 3, 1895.

(9) G. B. Simpson. Different Genera of Fenestellidæ, 13th Annual Report N.Y. State Geologists, 1894. Hand-book, N. A. Palæozoic Bryozoa, 48th Annual Report, N.Y.S. Mus. and 14th Annual Report N.Y.S. Geologist, 1895.

(10) On the grouping of some divisions of so-called "Jurassic" Time, S. S. Buckman, Q.J.G.S., vol. liv., pages 442-462, August 1898.

based upon a species of ammonite; and by the use of these zones in determining the precise age of one species relatively to another, he has been able to produce the genealogical tree of the Jurassic ammonites in a manner which should be satisfactory to the evolutionist. Doubtless this attempt to divide up the geological formations into zones named from apparently dominant species and to work out with this aid the phylogeny of families or orders may be carried too far. Clearly, however, by being able to divide the formations on biological grounds, so as to establish with reasonable precision the relative moment when a particular species arrived and flourished, and by being able to study young and mature individuals of the species so as to work out its embryology, great progress is being made in the history of the development of species through the medium of fossils.

I feel that I owe the members of the Institute an apology for the character of my address. My business duties preclude the possibility of engaging in original investigation even if I possessed ability of that kind. I have, therefore, merely sought by an address of a popular character to engage your attention regarding a branch of study which has been a source of deep interest to myself for many years.

The Prehistoric Monuments of Brittany. By Professor A. B. Macallum.

(Read 3rd December, 1898.)

(Abstract.)

The menhirs, dolmens, and tumuli of Brittany, though much discussed, still offer problems for solution which are of importance in determining features of the Neolithic and Bronze periods. The age of these monuments also is undecided, for Fergusson[1] believes that they are all post-Roman, while others claim for them an anterior origin. The difficulty in this matter is due to the fact that the remains were not, until the close of the last century, thought worthy of reference by writers who must have seen them. Cæsar, who was in the neighbourhood of Carnac when the sea fight between his galleys and those of the Veneti took place in the Gulf of Morbihan, makes, in his description of that battle, no reference to the thousand menhirs, which, if they were there then, he must have seen also at the time. On this ground Fergusson regards them as of later date, but one cannot depend very much on such a line of argument, for Madame de Sevigné visited Auray and the Carnac region in 1689, and although she wrote copiously about everything that apparently came under her observation then, she makes no reference to the existence of these monuments. Are we, therefore, to conclude that they were erected in the eighteenth century? On the other hand, the site of a Roman camp has been discovered in the area covered by the menhirs of Kermario, in the neighbourhood of Carnac, and some of the menhirs were used in the construction of the wall, while others inside the enclosure are blackeneed with soot, probably due to the legionaries using them as hearthstones. This clearly indicates an Ante-Roman date for the foundation of these monuments. In regard to the age of the dolmens of Brittany, the character of the skulls found in them is decisive—while the skull of the tribesman of Brittany in Cæsar's time was brachycephalic, that of the dolmen-builders was sub-dolicocephalic, or mesaticephalic. From this it is concluded that the dolmen builders were a race which preceded the Celts in Western France. How far back in time dolmens were first erected it is impossible to say, but it must be recognized that in North Germany, in Norway and Sweden, and in Ireland, dolmens were erected in the Christian era.

In regard to the significance of the menhirs, nothing as yet has been definitely determined. Remains of human skeletons, accompanied in some cases by flint implements, have been found at the foot of some of them, and hence it is inferred that they are the equivalents of our burial headstones. This explanation must appear doubtful to anyone who has examined the "alignements" of Carnac. Here very few human remains have been found in connection with them, although there are thousands in the district. The view that the "alignements" were connected with sun-worship or with herpetolatry, postulates first of all an explanation of the function of the isolated menhirs in other parts of France and in Great Britain. Sun-worship undoubtedly obtained amongst ancient British and Gallic tribes, but the founders of the menhirs have yet to be shown to be of Celtic or Belgic affinities. There is very little evidence to show that serpent-worship obtained amongst these

(1) Rude Stone Monuments, 1872, chapter 8.

or amongst the earlier inhabitants of France. In the tumulus on the island called Gavr'innis, in the Gulf of Morbihan, the local guide points out to visitors a sinuous line which is believed to represent the serpent, but anyone who examines closely the rich sculpturing about it will see at once that the artist had no preconceived plan, and that the sinuous line, being made last, is the unforeseen, haphazard result.

It is difficult to believe that the "alignements" were not connected with some religious observances or creed. The extraordinary size of some of the menhirs forming them, and particularly of the fallen and broken one near the Dol des Marchands, is such as to force one to question whether any influence, save religious, could have compelled the founders to undertake the gigantic toil of their erection. Undoubtedly they must have been regarded as sacred objects, and this leads one to understand why they were used in some cases for human burial. Their use, therefere, as burial monuments may have been secondary. We have an instance of such secondary use in the case of cathedrals and churches of to-day. The existence of stone circles or cromlechs, like the one which terminates the alignements at Menec, would further seem to strengthen the view that all these monuments were in some way connected with religious observances.

The dolmens present less difficulty as to their significance. They are more or less caverns formed in many cases of gigantic stones which are usually only partially sunken in the earth, and covered by very much larger flat stones, often weighing many tons. In these chambers have been found human bones, flint and sometimes bronze implements, with some specimens of rude pottery. Wedge-shaped specimens (*celtæ*) of jade, or green stone, have also been found in some dolmens. This bears on the "axe" cult which undoubtedly obtained amongst the dolmen-builders. In the dolmen near Locmariaquer, called the Dol des Marchands, a large figure of an axe is engraved on the under surface of the covering stone. On the large flagstone on the floor of another dolmen of that neighbourhood, the *Mané-Lud*, there is a very large figure of an axe in relief. This is pointed out by the local guide as the figure of a sword. On one of the flat stones taken from the tumulus to the south of Locmariaquer, called *Mané-er-H'roec*, there are many axes sculptured. In order to understand the significance of these figures, one must compare them with what has been observed in several of the Marne caves. In these are three instances of a female figure rudely sculptured, associated with the outlines of hafted axes. In the dolmen of Collorgues, in the Department of Gard, the slab forming the central part of the roof has a female figure rudely outlined, and under it is cut the figure of an axe. All these sculptures have been found associated with burial. The axe, therefore, was the symbol of some cult, believed to be that of a deity who is now termed the "Axe Goddess." This cult was accepted by the Celtic and other contemporaries and successors of the dolmen-builders in Gaul, and was continued even during the Roman occupation, for amongst the Romanized Gauls the practice obtained of putting a figure of an axe on a headstone, or in place of the figure the words, "*sub ascia*," or "*sub ascia dedicavit*." What the cult of the Axe Goddess signified it is impossible to do more than conjecture. Its association with death and burial possibly points to the belief in a goddess of death. The cult has for students of the origin of religions this important interest: it is the only one we know as belonging to the Neolithic age, and, further, it was handed down from Palæolithic times, or at least from the transition period between the Palæolithic and Neolithic ages, when the caves were not inhabited, but used as burial places. Borlase(1) attempts to show that the cult obtained over the whole of Western Europe, and he claims that indications of it are shown in the pottery of Hissarlik found there by Schliemann. That it had a wide range may be granted, for in Palæolithic times there was probably one race

(1) The Dolmens of Ireland, vol. ii., page 578.

occupying the whole of Europe, and this fact would account for a wide diffusion of ethnic and religious ideas, but it may be doubted if some of the figures, e.g., those of the pottery at Hissarlik, supposed to be those of the Axe Goddess, are more than accidental resemblances to the symbols of her cult.

The tumuli were undoubtedly used for the sepulture of important persons, such as kings, chiefs or leaders, and their relatives. It is not improbable that they may have been used in the case of certain religious rites, for in the tumulus called Mané-er-H'roec, at Locmariaquer, and in Mont St. Michel, at Carnac, a large number of celtæ (stone axes) were found, and these have been regarded as votive offerings either to the Axe Goddess, the manes of the dead, or to the Divinities of death. In many of the tumuli the bones found were more or less incinerated, proving that cremation was practised. On the exposed surface of the greater number of the slabs forming the walls of the tumulus of Gavr'inis the line-tracing or sculpture is very rich, and gives a marked distinction to this tumulus. It would seem to have been the tomb of a king.

It is in the dolmens, however, that one finds the largest number of inscriptions. These have not been deciphered. They would appear to consist of two kinds—one ornamental, good examples of which are to be observed in the upright supporting stone of the Dol des Marchands, the second totemic of which examples are to be found in the dolmen at Kerioned, in the Alée Couverte des Pierres Plates, near Locmariaquer, and in the Alée Couverte of Luffang. A curious fact is that in the two last named there are the outlines of the same figure, which seems to the writer to be that of an opened lentil pod. On one of the slabs in the Mané Lud dolmen there is an inscription which is difficult to classify. It is clearly not ornamental, and it is not totemic, for an almost similar one has been described as found in the New Grange tumulus, near Drogheda, Ireland. Something similar is to be observed on one of the vertical slabs at the end of the cavern in the Gavr'inis tumulus, but here the outlines are less readily traced, owing to the surrounding lines of sculpture following the curves of the inscription. It may be hierogrammatic in function.

Of what race were the dolmen builders? The definite answer to this question would determine also who were the founders of the menhirs and of the tumuli, for it is generally conceded that the three classes of monuments may have, in Brittany at least, been built by the same tribe or race. Though first looked upon as of Celtic origin, it is now recognized that they are the remains of a race which inhabited the western and north-western part of Europe before the advent of the Celts. This race, known as Iberian, also occupied Ireland, Wales, and the western portions of England and Scotland, and thus the distribution of dolmens and other megalithic remains would be accounted for. There are, however, difficulties in accepting this view. The dolmen-builders were mesaticephalic, the Iberians dolichocephalic. The Iberians who inhabited the Dordogne district and the portion of the Landes district, including Dax and its neighbourhood, from Palæolithic times, did not build dolmens, and in all the country lying between the Garonne and the Pyrenees, inhabited in Cæsar's day by the Aquitani, a tribe of the Iberians, there are very few megalithic remains.

The explanation of these difficulties can only be conjectural. According to Collignon(1) the Iberians were not a race, but an assemblage or collection of tribes, derived from three races which inhabited from the earliest times the Spanish peninsula. These were the Neanderthaloids of Gibraltar, a people like the Cro-Magnon race, and the type called by de Quatrefages the race of Mugem, whose remains are to be found in kitchen middings, on the banks of the Tagus. Accepting this view, it would be possible to regard the Aquitani as a less mixed race descended

(1) Les Basques. Memoires de la Société d'Anthropologie, 3d Serie, Tome 1, Fascicule 4, page 55.

from the Cro-Magnon type of Palæolithic times, and, therefore, not possessed of the same customs as the more mixed Iberian race or tribes. Sergi,(1) on the other hand, claims for the Iberian race a single African origin, and that as a uniform race it spread over Western France and the British Isles.

It would appear that in order to ascertain definitely who the dolmen builders were it is necessary first of all to determine clearly the origin and history of the Iberians, and this can only be done when the anthropology of the Spanish peninsula is as fully worked out as that of France.

(1) Ursprung und Verbreitung des Mittelländischen Stammes. Autorisierte Uebersetzung von A. Byhano Leipzig. Verlag von Wilhelm Friederich.

Corundum in Ontario. By Archibald Blue, Esq.

(Read 10th December, 1898.)

Just one hundred years ago, in a paper read before the Royal Society of London and published in its Transactions, Rt. Hon. Charles Greville established and named the mineral species Corundum, the crystalline oxide of aluminium; and we have it on the authority of Professor Judd that in an appendix to Greville's paper the Count de Bournon correctly defined the crystallographic characters of the species. The names of its gem-varieties, sapphire and ruby, had been in use from a much earlier time;(1) and the name corivindum, or corrivendum, had been given to it by Woodward, in a vaguer way, as early as 1714.

In the western part of Asia Minor, and in some islands of the Grecian Archipelago, the crystalline limestone which is interbedded with the schists and gneisses carries a blue corundum mixed with magnetite, which is the emery of commerce. The corundum occurs in smaller quantities as a constituent of granite and gneiss in Silesia, Auvergne and elsewhere in Europe; in a compact felspar rock in Piedmont; in dolomite with tourmaline at St. Gothard; in crystalline limestone, along with numerous other minerals, in Orange and Westchester counties, New York, and Sussex county, New Jersey, and at various localities in Connecticut, Massachusetts and Pennsylvania. It is said by Dana to be common at many points along a belt extending from Virginia across western North Carolina and Georgia to Dudleyville, Alabama.

In Burma, which became a British Province in 1886, ruby mines have been worked for a very long period. There the country-rock is chiefly gneiss, with bands of crystalline limestone of varying thickness and many miles in length. Most of the mining has been carried on in the hill-wash and alluvium carried down from the decomposed summits of hills and mountain ranges; and it has been observed that where the sands and gravels are mixed with a dark brownish earthy clay, which is a product of the decomposed crystalline limestone, they are richer in such gems as ruby and spinel. The explorations of Barrington Brown appear, indeed, to have satisfactorily established that in Burma the only rock in which rubies are found in place is crystalline limestone. "It is of the usual composition and character of ordinary crystalline limestones," says Mr. Brown, "being made up of finely crystalline or granular limestone in layers, together with irregularly shaped bands of very coarsely crystalline limestone of white and bluish colors, which are interfoliated with the gneissic rocks." Where a quarry has been worked, near Mogok, the matrix of the ruby is a coarsely crystalline, semi-opaque limestone of about twenty feet in width. The rubies are found over a space of six feet in width, extending almost vertically from the bottom of the quarry to the surface of the ground, and along the centre-line, where the rubies are most numerous, are small developments of a grayish diaspore enclosing small crystals of iron pyrites. As to the limestone itself, whether occurring as disseminated crystals through the gneiss or as great interfoliated masses, it is the opinion of Professor Judd that it has been neither organic nor due to direct chemical precipitation in its origin, but

(1) In the Burma Corundum every shade of colour, from white to the highly prized deep crimson or pigeon's blood, is found, and they are named according to colours instead of composition or system of crystalization,—the red variety as oriental ruby, the blue as oriental sapphire, the yellow as oriental topaz, the purple as oriental amethyst, and the green as oriental emerald.

has resulted from a metamorphism of the lime-bearing felspars; while during the process of change from basic felspar to scapolite, and from scapolite to hydrated aluminium silicates, and from these to aluminium oxide, "the slowly liberated oxide may assume the crystalline form, and thus give rise to corundum." Among other minerals found in the corundiferous limestone are pyrrhotite, hematite, apatite, graphite and spinel.

In Ceylon, in the peninsula of India, and in China, there are numerous occurrences of corundum in crystalline schists; and in almost every case the mineral is of the gem variety. As far as known to the writer, there are no deposits in Asia now exploited for use in the arts, saving the emery of Asia Minor.

In the United States corundum is confined almost wholly to the region of the Appalachian Mountains, along a belt that extends from New Jersey to Alabama. In the form of emery it is found at Chester, Massachusetts, in a chlorite belt about twenty feet wide, that lies between formations of hornblende-schist and talc, and traverses the mountains for about four miles. There is also a productive emery mine in Westchester county, New York, which ships from 500 to 700 tons of abrasive emery per annum.

Along the Appalachian mountain chain corundum is found in felspar veins and associated with chlorite in peridotite and serpentine rocks, in amphibolite, dunite and gneiss, as well as in gravel-beds. The principal deposits are found in association with magnesian rocks, chiefly peridotites, which occur as small lenticular masses in gneiss. As a rule, however, the corundum is neither in the peridotite nor in the gneiss, but in a narrow zone of chloritic minerals between the two. The largest known areas are in the south-western counties of North Carolina, where corundum was first discovered in 1870. This state has furnished nearly all the corundum of commerce for the United States, but the statistics of the mines and works have never been published. There has been much waste of effort in mining for the gem varieties, encouraged by occasional discoveries, but chiefly by the attractive colors in which the corundum is found. The whole process of mining and milling has had to be learned by experience; and the task has been made difficult not only by the character of the formations, which is not favorable to sinking or drifting, but also by the closeness with which the corundum crystals adhere to the matrix.(1) For abrasive use it is very important that the corundum should be free from particles of rock or mineral softer than itself; and for use as an ore of aluminium it should be free from all impurities, to make extraction practicable by present methods.

The first discovery of corundum in Ontario was made by the late Sterry Hunt fifty-one years ago, in the second year of his connection with the Geological Survey of Canada. Dr. Hunt explored part of the county of Lanark in 1847. He was joined in some of his excursions by Dr. Wilson, of Perth, who at that time enjoyed some local reputation as a geologist (the mineral wilsonite is named after him), and who is still remembered as a man who paid considerable attention to the natural history of his district. The first place visited by them was the fourth lot on the eighth range of the Township of Burgess, upon which Dr. Wilson a short time before had discovered a body of apatite. Near by, on the second lot on the ninth range, was a deposit of copper pyrites in crystalline limestone, and this was also visited. The only exploration work consisted of two or three blasts, and among the masses of rock thrown out were some consisting of silvery mica, with quartz, felspar or albite, and calcspar, holding a delicate emerald-green and almost transparent pyroxene of rare beauty, as well as crystals of a dark honey-yellow

(1) Mr. Alexander Rickard of New York, who is owner of a corundum property at Energy, in York County, South Carolina, says, in a letter to me of recent date: "All our corundums are very difficult to clean. While the gangue is soft, it is tough, and adheres to the grains of corundum when it is broken up. This reduces the cutting value, and also creates trouble by fluxing when making into wheels."

sphene. The mica was often aggregated in masses of small crystals, having a columnar arrangement,(1) imbedded in which, and disseminated throughout the rock, were a great number of crystalline grains of a transparent mineral, varying in color from a light rose-red to a deep sapphire blue. Dr. Hunt, in his report to Sir William Logan, said:—

"Their hardness, which is so great as to enable them to scratch readily the face of a crystal of topaz, showed them to be nothing else than the very rare mineral corundum, which from its colors is referable to the varieties known as oriental ruby and sapphire. The grains obtained were small, none indeed larger than a pepper-corn; but at the time I was on the spot they were not noticed, and the specimens were collected for the pyroxene, in only two or three of which I have since detected the corundum. It is probable that further examinations may develop larger and more available specimens of these rare and costly gems. It is in this crystalline limestone that they generally occur, and the corundum found in the State of New Jersey is in the same rock and with similar mica."

Yet it does not appear that this discovery in Burgess received further attention from Hunt or other members of the Geological Survey, and the mineral was practically re-discovered there a year ago by Professor Miller, of the Kingston School of Mining. It will be noticed from Hunt's account that the specimens were collected only for their pyroxene, and that the crystals of corundum were not noticed or identified until a later time.

The largest known deposit of corundum in the Province was discovered twenty-two years ago on the farm of Henry Robillard, in the township of Raglan, Renfrew county; but in this case twenty years elapsed before the mineral was correctly identified. According to Robillard's story, he was returning with his little daughter from a cranberry marsh on the wide flats of York river, and, in climbing a hill which rises about 500 feet above the river, he sat down upon a large boulder to rest. In telling me the story Robillard said:—

"Annie was kneeling behind me, and picked up a queer-shaped stone, and, showing it to me, said it looked like the stopper of a cruet-bottle. It was just like that; and I wondered what fool of a man had gone to work and whittled it out. Then I looked at the stone where I was sitting; and, bless you, sir, it was paved with cruet-stoppers. And here is the very boulder now," he added, as we reached the spot, about half-way down the hill.

Specimens gathered by Mr. Robillard were shown to several persons in Combermere, and one who professed to be a miner of phosphate of lime in Lanark county pronounced them to be crystals of that mineral. In 1884 one John Fitzgerald joined with Robillard in an application to the Crown for the mineral rights on the property, including several lots on the 18th and 19th concessions of Raglan; and for a number of years they sought in vain for a customer to buy an apatite-mine. The sturdy pioneers would brook no contradiction of their claim that the mineral was veritable apatite; and when a doubt was raised by two young mineralogists who visited the region about ten years ago in the interest of a capitalist, and a suggestion was meekly made that it might be emery, one of the pioneers cut negotiations short by threatening to "punch their heads." Last year, how-

(1) It is not improbable that these were decomposed or altered crystals of corundum. On the metamorphoses of the mineral Professor Judd says: "At the earth's surface, as is well-known, corundum or the crystalized oxide of aluminium is one of the most unalterable substances. Fragments found in river gravels and sands, though perfectly water-worn, show no trace of chemical alteration in their surfaces. On the other hand, there can be no doubt that conditions must exist in the earth's crust under which chemical change of this mineral does take place; this is abundantly proved by the frequency with which undoubted pseudomorphs of corundum occur. Among the minerals found replacing corundum as pseudomorphs are muscovite (damourite), various forms of spinel, andalusite. fibrolite, cyanite, margarite, chloritoid, zoisite, ripidolite and other chlorites, various vermiculites, kaolin, and other substances."

ever, these pioneers were overjoyed to learn on the authority of an expert that the mineral was not apatite, but corundum.

Eleven years ago Professor Coleman, now of the School of Practical Science at Toronto, picked up some boulders of nepheline-syenite in the vicinity of Cobourg, on the shore of Lake Ontario, which held crystals of corundum. A fortnight ago I showed Dr. Coleman several specimens of nepheline, rich in corundum, which I had taken from a large deposit recently discovered in the township of Dungannon, and he at once pronounced them to be identical with his own. "I feel sure now," he said, "that I know where my float-boulders came from!"

Twelve years ago, in 1886, Nesbitt T. Armstrong, a farmer and mill-owner in Carlow, discovered corundum on lot 14, in the 14th concession of that township, but he did not know its name, and did not suspect that it possessed any value. A sample was shown to a student of Toronto University, who thought it might be emery; and inquiry stopped there. But in 1893 Mr. W. F. Ferrier, lithologist of the Geological Survey, acquired by purchase a number of specimens collected by Mr. John Stewart, formerly of Ottawa, among which was a package labelled "Pyroxene crystals, south part of Carlow." On examining these specimens some time afterwards, presumably in 1896, Mr. Ferrier recognized them as corundum, and immediately took steps to ascertain the precise locality from which they came. In October, 1896, he was sent upon this mission by Dr. Dawson, the head of the Geological Survey, and, guided by Mr. Armstrong, he found the corundum in place upon the lot on which Armstrong's discovery had been made ten years before. Then for the first time the fact was established, on the best authority, that this mineral had been found to exist in Canada in commercial quantity, and that it was valuable as an abrasive material on account of its great hardness. But as it was too late in the season for field-work, Mr. Ferrier did not extend his explorations beyond that one locality.

The first geological reconnaissance of the district in which corundum has been found was made by the late Alexander Murray, of the Geological Survey, in 1853; but his notes of it are very meagre. Mr. Murray made two traverses of the country lying between Georgian Bay and Ottawa river—the first from west to east, by way of the Muskoka and Petewawa rivers, and the second by way of the Bonnechere and Madawaska, to the headwaters of the Trent. The source of the Bonnechere is within a mile of Kaminiskeg lake, on the Madawaska, near to where Barry's Bay station, on the Ottawa and Parry Sound Railway, now stands. Mr. Murray descended the Madawaska to the mouth of its principal tributary, the York branch, or York river; known, also, at that time, by its significant Indian name of Shawashkong, or Mishawashkong, the river of the marshes. The course of this stream, which Mr. Murray ascended, lies for more than forty miles within the corundum belt; and along its banks are numerous exposures of syenite, with occurrences of nepheline-syenite. But no reference is made in the report to the rock formations; and the record of levels for the first ten miles is of very doubtful accuracy.(1)

Forty years elapsed before another attempt was made to work out the geology of this interesting area, and the task was then entrusted to the very capable hands of Dr. Frank D. Adams. The area under examination is comprised in sheet 118 of the Ontario series of geological maps, and the four corners of it lie in the townships of Digby, Finlayson, Hagarty and Grimsthorpe respectively, embracing an area of about 3,500 square miles. In his first report, made for the season of 1893, Dr. Adams sketched briefly the geological features of the district, the northern portion of which he found to be occupied exclusively with the ancient crystalline rocks of the Laurentian system, and the southern and eastern portions with the

(1) The rock formations along the York River, however, are carefully noted on the maps which accompanied the report, as are also the waterfalls and rapids of the river from its mouth to its source.

limestones and gneisses of the Grenville series. "The discovery of so large an area of the Grenville series in this district," Dr. Adams says in his report, "is most encouraging, as indicating the probable occurrence in it of large and valuable mineral deposits." An extensive and remarkable mass of nepheline-syenite was discovered in the townships of Faraday and Dungannon, which was traced for a distance of over seven miles in an east and west direction. Dr. Adams says: —

"This is a rare rock, found in but few places in the world, and never before discovered in our Laurentian system. The nepheline is very abundant, forming in many places an almost pure nepheline rock. The mass is flanked on the south, along a considerable part of its course, by crystalline limestone, and it is also intimately associated with a fine-grained reddish rock, resembling aplite. It is of a prevailing gray color, and often has a distinct foliation, coinciding with that of the associated rocks."

The beautiful blue mineral sodalite was also found in a number of places, associated with the nepheline-syenite, in the form of veins and irregular masses; but no occurrence of corundum was observed.

During the past three seasons Mr. Barlow has been associated with Dr. Adams on the work of this field, and a very interesting and valuable report may be confidently looked for upon some of the most intricate questions of Archæan geology. Dr. R. W. Ells has also been engaged at intervals in surveying portions of the Ottawa valley east of the area on which Messrs. Adams and Barlow have been working, into which the corundum belt is known to extend as far at least as the Ottawa and Opeongo road. The two map-sheets, however, as well as the accompanying reports, will deal with the general geology of the districts, and notwithstanding the importance of the corundum discovery it is not likely that prominence will be given to that subject, if the usual practice of the survey is followed.

During the last two seasons Professor W. G. Miller, of the Kingston School of Mining, has been employed by the Ontario Government to make a special report on the field. Beginning last year with the study of the occurrence of the mineral at the place of first discovery in Carlow, he has been able to trace the corundum-bearing rocks eastward across that township, through Raglan and Lyndoch, to the shores of Clear lake, near the eastern line of Sebastopol, a length of about 30 miles. The breadth of the band varies from half a mile to three or four miles, and its total area embraces about 60,000 acres. The prevailing country-rock of the district is gneiss, composed chiefly of hornblende, biotite and felspar, and it is probably an altered gabbro. Numerous dykes or masses, consisting largely of felspar, cut through the older rocks, which sometimes have the character of coarse syenite, passing in places into nepheline-syenite. In both of these rocks corundum was found, as well as magnetite, pyrite, garnets, zircon and sodalite. In continuing his work this year Professor Miller has succeeded in tracing the syenite band continuously for about 75 miles, from the township of Glamorgan, in Haliburton, to the township of South Algona, in Renfrew, besides tracing it to a considerably greater width over the region explored last year. Corundum was found at a number of places in the western part of the belt, and a large and apparently rich deposit in a ridge of nepheline-syenite near the middle of it in the township of Dungannon. But as the rocks, over nearly the whole of their extent, are covered with sand, it is probable that many valuable deposits remain to be discovered. The total area of this band is about 300 square miles; and, as it lies in a Free Grant district, the mineral rights are reserved by the Crown in almost all the lots that have been taken up for settlement. In a few cases, where lands were sold more than thirty years ago, the mineral rights went with the surface rights; and since that time some lands have no doubt been sold or leased as mining lands. But it is safe to say that the Crown holds for disposal the minerals in at least 90 per cent. of the whole tract.

Two years ago corundum was found in a property that was being worked as a mica mine in the township of Methuen, in Peterborough county, about 45 miles southwest from the original discovery in Carlow. This locality has also been explored by Professor Miller this year, and the corundiferous band of syenite has been traced in a northeast and southwest direction about six miles, with a width of two miles. The range of hills over which it extends is known locally as the Blue mountains, and at its southwest end it reaches the shore of Stony lake.

I spent the last week of September with Professor Miller in going over the more northerly band, from the easterly end of it, on Clear lake, in Sebastopol, to the village of Bancroft, on the Hastings road, on the line between Dungannon and Faraday. Only a few of the principal properties were visited, including the Block location in Brudenell, the Robillard location in Raglan, the Armstrong location in Carlow, and a recent discovery in Dungannon, not far from the York river. All these are large deposits, easy of access, and favorably situated for mining operations.

Where the exposure occurs on the Block farm the crystals are in syenite, and are thickly studded in the face of the rock. Outcroppings of nepheline-syenite occur near by; and, owing to its resemblance to limestone, an attempt was made by the owner to burn it for lime. The crystals of corundum have a bronze lustre, and vary in size from half an inch to an inch in diameter. Numerous boulders are strewn over the face of the ground which carry a high percentage of the mineral; and in some cases the crystals are nearly pure white in color.

On the Robillard hill corundum may be traced for a mile or more along its southern face, wherever the syenite is exposed. The corundum crystals are frequently observed to run in strings several inches wide along the surface of the rock, and are of all sizes from half an inch to two or three inches in diameter, usually barrel-shaped, and ranging from an inch to four or five inches in length. On the western shoulder of the hill there is an outcrop of nepheline-syenite; and in this rock the crystals are finely shaped, but of small size—about a third of an inch in diameter and an inch or an inch and a half in length. An expert who has examined this hill estimates the corundum in sight at several millions of tons. There is certainly a large quantity, and in some places it amounts to from 30 to 40 per cent. of the rock mass. Along the foot of the hill are numerous large boulders of syenite, speckled over with crystals like plums in a pudding.

The Robillard hill is cut off by a stream upon its west side from a range of high hills that extends westward five miles into Carlow. Professor Miller has carefully examined this range, and has discovered corundum in it at a number of points. The largest showing, however, is on the Armstrong lot, where another stream cuts through, on its way to join York river. The rock has scaled off so as to show a perpendicular face about 300 feet in length and 30 feet in height, exposing a mass of syenite which has been thrust up through the gneiss, and which, in its turn, has been cut by a dyke of pegmatite. The gneiss has been thrown up to form an anticlinal arch over the syenite, but is cut through along the north side, where the syenite dyke is well exposed with a thickness of ten or twelve feet. According to Mr. Ferrier, it has been traced along the strike about 700 feet Crystals of corundum are numerous on the exposed face of the syenite, and are also found in the pegmatite nearest the syenite, which is composed chiefly of felspar. But where quartz comes in with the felspar, the corundum disappears. A lot of several tons, taken without selection from this location last year and treated at the Kingston School of Mining, yielded from 12.75 to 15.5 per cent. of corundum.

The last location I examined is in the township of Dungannon. It is in a ridge of nepheline syenite, having a width of 90 to 100 feet, and rising upon one side to a height of about 60 feet. My time only permitted me to follow it for a length of about 150 yards, but Professor Miller informed me that he had traced it for half a mile. The whole surface, as far as I examined it, was thickly strewn with small crystals of corundum, ranging in color from pearl to blue; but here and there parts of it were altered into white mica. A sample of it, assayed for me under the direction of Dr. Coleman, carried nearly 10 per cent. of corundum, and was remarkably free from iron. An ore of this character ought to be well suited for the production of aluminium, especially as the nepheline itself, the gangue rock, contains about 30 per cent. of alumina.

Here it may be remarked that, owing to the presence of iron and other impurities, makers of aluminium assert that native corundum is unsuited for the production of that metal. But it is safer to keep an open mind on problems of this nature. When one reflects that by the adoption of new and improved processes the cost of producing aluminium has been reduced, within forty years, from its weight in gold to 30 cents per pound or less, one ought not to assume that it is impossible to find a process for producing pure corundum at low cost, if not a process to make aluminium out of an impure ore. Professor DeKalb, of the Kingston School of Mining, was able last winter, with a small experimental plant, to extract corundum (99.61 per cent. pure) from rock that carried five per cent. of magnetic iron ore. What, then, might be expected from a large and well-equipped plant, capable of treating 50 or 100 tons per day, supplied with every device that the wit of man can invent, and especially with a good quality of rock to work upon? In one particular the Ontario mineral appears to differ from the mineral of the Appalachian belt; the gangue is brittle, and is easily broken up and separated from the corundum.

It will certainly add greatly to the value of the corundum deposits of Ontario if they can be used in producing aluminium as well as the material for abrasives, if the history of that metal during the last ten years is a fair index of its future. In the ten years ending with 1897 its production in the United States has risen from 19,000 pounds, valued at $3.42 per pound, to 4,000,000 pounds, valued at 37½ cents per pound; and so much progress in so short a time seems to be ample justification for the statement of Professor Richards, made three years ago in the preface to his admirable book on aluminium: "The abundance of aluminium in nature, the purity of its ores, its wonderful lightness and adaptability to numerous purposes, indicate that the goal of the aluminium industry will be reached only when this metal ranks next to iron in its usefulness to mankind."

None of the discoveries hitherto made in Ontario seem to encourage the hope that gem varieties of the corundum are to be found, although in some localities an occasional crystal is to be seen with qualities not unlike sapphire, being semi-translucent and of bluish color. Perhaps, if search were made in the crystalline limestones, it might be rewarded with better success; not that corundum of any quality has yet been found in the limestones, but because their relations to the gneiss are not dissimilar to those which obtain in Burma. When the source of the limestones has been worked out, it may be shown that, like those of Burma, they have been derived by metamorphosis from the felspar of the gneiss, or perhaps from the felspar of the syenite; and if so, the analogy would suggest that these rocks are worth prospecting for corundum in some of its more valuable forms. In a note received from Professor Miller on this subject, he says:—

"It is quite possible that corundum may yet be found in considerable quantity in crystalline limestone in Ontario, as in India and Burma. In India the mineral occurs under various conditions in metamorphic (limestones, etc.), and igneous rocks. Of course there need be no connection between the occurrence of the mineral in these two classes of rocks. If corundum occurs in our crystalline limestones, it is of a different origin from that occurring in the igneous rocks (the syenites)."

The crystals discovered by Sterry Hunt in Burgess, it will be remembered, were found in association with pyroxene in crystalline limestone.

In view of the extent and apparent richness of the corundum fields in the Province, the Government has taken steps aimed at developing the deposits and establishing a home industry. Regulations have been drawn up under which the mineral rights in lands lying within the two corundiferous belts have been withdrawn from sale, and hereafter the mineral and mining rights in such lands can be acquired only under the leasehold system—the rental for the first year being 60 cents and for subsequent years 15 cents per acre. Instead of allowing speculators to take up and hold lands with a view to sell out their interests to miners and capitalists at a large profit, it is proposed that the advantage of acquiring lands upon the lowest terms shall go to the miner and manufacturer direct; and in the case of parties who will undertake to conduct mining and treating operations on the largest and completest scale, and who can furnish satisfactory assurance that they possess the requisite capital for the proposed operations (including separation of the ore from its gangue, milling for abrasive uses, manufacture of abrasive goods, and the production of aluminium), the Government may concede a preference in the selection of mineral lands. It is also provided that the Government shall have power to require that all corundum mined from lands leased under the Regulations shall undergo certain processes of treatment and milling at works to be erected in the Province to prepare it for market; and may further require, from time to time, as circumstances appear to warrant, that works be established in the Province for the manufacture of all useful or commercial products for which the mineral or ore is economically adapted.

Notes on Prospecting for Corundum. By Willet G. Miller, M.A., School of Mining, Kingston.

(Read 10th December, 1898, in discussion on Mr. Blue's paper.)

When I first received instructions from the Director of the Bureau of Mines to make an examination of the occurrence of corundum in the township of Carlow, reported by Mr. W. F. Ferrier, of the Geological Survey,(1) I was not very enthusiastic over the prospect, especially as I was expected to search for other outcrops of the mineral. The district is situated rather near at hand to the chief cities and older settled parts of the Province, and, moreover, it occurs in a region which has attracted considerable attention from prospectors and miners during the last 35 or 40 years. It thus appeared to me that there could not be very much of the material in place in the district or some one would have noticed its existence years before. However, as my instructions authorized me to make notes on any other economic minerals which might be met with in the field, I thought that if I could not find more corundum I could at least get enough material for a report and spend my time to advantage in directing attention to some of the other numerous ore bodies which are to be found in Eastern Ontario.

For the first week after entering the field the outlook for the discovery of other occurrences of the mineral was not very promising. The district is a rather rough one, and the rocks are covered to a considerable extent by soil and timber, and the part of the field in which we first started to work happens to be cut through by two large river channels. Having once obtained the key to the mode of distribution of the deposits it was chiefly then only a matter of time and work to find other deposits. Drift deposits assisted us much in prospecting. In every case, I think, where we found boulders of rock carrying corundum we found the mineral in place a few miles to the northward in the direction from which the glaciers had come. We also soon became familiar with the different varieties of the rock which belonged to the same magma as the corundum-bearing variety, and knew how these different varieties shaded off into one another and into the corundum-bearing variety. We could generally tell when we were approaching the latter variety from the character of the other rocks. We also, of course, made use of the strike and other characteristics of these rocks.

The work on which we were engaged differed materially from ordinary geological field work. In the latter case one does not need to examine every hundred acres, nor in most cases every square mile or so. A fair outline of the geology of a district can generally be given by following the roads or canoe routes.

In the part of the field in which we worked in 1897 the outcrops of corundum rock occur in isolated areas. This made our work more difficult, as, being engaged in examining lands of which the mineral right in most cases belonged to the Government, we were anxious that no good deposits should escape us. It was as important for the Government to know where these deposits were situated, as it would have been for any private company which might have controlled the lands. A rather foresighted policy had been inaugurated in connection with the corundum

(1) Summary Report Geological Surv., Can , 1896, page 116.

deposits, it having been decided to withdraw from sale the promising areas found by us and thus prevent them getting into the hands of speculators, who might tie up the district for years by asking exorbitant prices. By thus withdrawing these areas from sale it was also made feasible to secure better terms, as to working the deposits, from parties securing them. I feel that under this arrangement our work was of as much direct value to the Province at large as it would have been to any private company had we been engaged by such a concern. Our work has increased the value of these Crown lands by enough to pay many times over the amount expended on the examination. My conscienece is, therefore, easy on the financial side of the subject, as the lands could be sold by the Province to-day for much more than they could have been sold for at the time we began the work on them. This ought to satisfy those people who are always asking for direct returns from geological work, and who are often unable to see that practically all geological work has at least an indirect bearing on economic questions.

In our work in 1897 we outlined a belt of country about 30 miles in length and two or three miles in breadth over which outcrops of corundum occur. In our last season's work, 1898, we have succeeded in increasing considerably the length of our belt of corundum rocks, and we have not yet come to the end of it. The rather contorted belt, as we now have traced it out, is over 75 miles in length, and there are two isolated areas of the rock on which I have done some work, but which time has not permitted me to attempt to connect with the main outcrops. One of these lies a considerable distance to the southeast of the eastern end of the main belt and the other area lies to the south of the western end. It might be possible, if one had time, to connect these different areas.

As it now stands, the belt of these rocks holding its irregular and sometimes narrow course through the other members of the Archæan crystalline series is one of the most interesting structures we have, I think I am safe in saying, in our oldest group of rocks. As yet we do not know exactly what this structure signifies. But I hope that when it is carefully worked out and studied in greater detail this group of rocks will aid in solving some of the problems which are now attracting the attention of petrographers.

In the highly metamorphic state in which many of the members of the Archæan occur it is difficult to make certain that igneous rocks, such as granites, syenites and diorites, which are found in isolated outcrops miles apart, belong to one eruption, but in the case of the corundum-bearing rocks we have a mark in the mineral itself which assists us in connecting and proving relationship between masses which would not otherwise have attracted attention as being related.

The corundum, as Mr. Blue has said, occurs typically in what we have called syenite. The rock often contains nepheline, which is the primary reason for speaking of the series as syenite. I have found by microscopical and chemical examination, however, that while the greater part of the rock in which corundum occurs may be called in general syenite, there are large masses of rock, consisting in one case of several square miles, which are more properly called gabbros or anorthosites. On the other hand, the syenite appears in some cases to merge gradually into the quartziferous variety, or into granite, in which, however, no corundum has been found. We have thus as products of one magma a series of plutonic rocks, ranging in acidity from granites to gabbros. And if one likes to make hair-splitting distinctions, he might work out representatives of about all of the plutonic group. I might also add that if there is any man who wishes to gain the questionable distinction of introducing a new rock name, I think he could get material for the purpose among this corundum-bearing series.

The first person to report the occurrence of these rocks, which have since been found to so commonly carry corundum, in the district, was Dr. F. D. Adams. In the summer of 1893 Dr. Adams found nepheline syenite in place in the township of Dungannon, Hastings county.(1) The mineral sodalite which so often occurs in this rock had been found in the district years before by prospectors. Dr. Adams and his associates outlined the occurrence of nepheline syenite in what were called three separate areas in the township of Dungannon and the adjoining township of Faraday, and an outcrop of the rock was also known in Glamorgan, to the west.(2) It was not, however, till October, 1896, that corundum was first found in the district by Mr. Ferrier, and it was not till June or July, 1897, that this mineral was known to be associated in the district with nepheline syenite, which had previously attracted considerable attention on account of its comparatively rare occurrence in most parts of the world and on account of the size of the nepheline individuals and the high percentage of the mineral carried by the rock.

In 1890 Dr. A. P. Coleman published a very interesting paper on the character of some glacial boulders which he had found in the vicinity of Cobourg.(3) Among these boulders were some which Dr. Coleman determined to be nepheline syenite. It was, therefore, known at that time that this rock occurred in place somewhere in the region to the north where it has since been found to be so widely distributed.

Although corundum is a mineral of considerable interest scientifically as well as economically, no discovery of it was reported in Canada after Sterry Hunt's discovery of it in the crystalline limestone of North Burgess in the later forties till Ferrier's find was made in the autumn of 1896.

After once having seen the corundum in the nepheline syenite of the township of Raglan, where this association was first found, it seemed to me likely that the mineral would be found to occur in the already known outcrops of the rock in Dungannon and the other two townships to which reference has been made. During 1897 time did not permit of a careful examination of these outcrops, but on the index map of the district published in my report(4) for that year, I outlined these outcrops and stated that the mineral likely occurred in place in these townships. Work during the past season, 1898, has shown that my predictions were correct, as we found corundum in place at several points in Dungannon and in other townships to the west. Moreover we have found that the previously mentioned areas of nepheline syenite in Dungannon and Faraday are parts of what is practically one continuous band of these rocks, but which is in places very narrow, and, therefore, difficult to follow. We have also traced this band fifteen or twenty miles farther west, and have connected these outcrops with the belt worked out in 1897. The relations of these outcrops and the different parts of the belt which have now been connected are shown on the map which Mr. Blue has exhibited.

Since the work with which I was charged was intended to be primarily of an economic nature, and, therefore, more closely connected with prospecting than with geology proper, I have not paid any more attention to the general geology of the district than what was required to enable us to prospect intelligently for the mineral for which we were in search. Moreover, the working out of the general geology of the district is provided for by the Geological Survey of the Dominion, and it seems to me that the work of the Province should be in the nature of applying information supplied from this source and making use of it in the working out of problems which have a direct economic bearing. We already have a fair general knowledge of the geology of the Province in the districts penetrated by and surrounded by our railroads, but the discovery at this late day of an occurrence of a mineral of economic value over such a large area in one of what may be called the older mining and prospected districts shows the possibilities there are of finding other economic products in our well-known mineral districts.

(1) Amr. Jr. Science, 1894, and Annual Report Geological Surv., Can., vol. vi. (N.S.)
(2) Summary Report Geological Sur., Can., 1896, vol. 50 A.
(3) Trans. Roy. Soc., Can., 1890.
(4) Part iii., 7th Report Bureau of Mines, Ontario.

We now know of the occurrence of a sufficient number of deposits of corundum to offer anyone desiring to work them considerable choice as to location. I have always been careful not to try to "boom" these deposits, as the abrasive industry is a very complicated one, and it cannot be well foretold what success would be met with on working the deposits. In any case I do not expect to see any corundum millionaires, but I believe there is a fair chance of an industry being established which would be a great benefit to the district in which the deposits are situated. The question of using corundum economically as an ore of aluminium is as yet an open one, and can probably only be settled by a series of prolonged experiments.

I brought with me a specimen or two of another mineral which we found in the field while searching for corundum. This mineral belongs to the comparatively rare columbate group, and as it is the first time one of these minerals has been found in Ontario I thought some of the members of the Institute might be interested in seeing specimens.

I have to thank Mr. Blue for the encouragement and assistance which he has ever been ready to give me during the progress of the work. That the energetic manner in which the development of the mineral industries of the Province has been carried on during the past seven or eight years, the time during which the Bureau of Mines has been in existence, is appreciated abroad is evident from a letter which I receivd a short time ago from one of the most prominent mining men in Eastern Canada. The writer of that letter made this statement:—"The policy which Ontario has adopted with regard to the acquiring of information respecting her minerals and the publishing promptly of reliable reports is a lesson to us which many of us here have been hoping might be copied in our Province."

And now I have to thank you, Mr. President, and the members of the Institute for the privilege you have afforded me, a non-member, of addressing these remarks to you. Since my student days in this city I have had cause to appreciate the encouragement which the Canadian Institute has offered to workers in science throughout the Province. I read some time ago an account of the plan which Mr. Bain has laid before the members of this Institute for the establishment of a Provincial reference library. I hope to see this plan carried out in its entirety, and it will be found it will receive the enthusiastic support of those of us who are interested in science and who live at a distance from the Provincial capital. When this library is established students of science throughout Ontario will be under a still further debt of gratitude to the Canadian Institute, which has now for so many years served as the centre of scientific thought in the Province.

THE INTERNATIONAL SCIENTIFIC CATALOGUE. BY JAMES BAIN, JR.

(Read 17th December, 1898.)

The discussion of the subject of a Scientific Catalogue is singularly appropriate in the Institute at this time, when the Library is being placed on a new footing and arranged for scientific work. The fifty years which have elapsed since the formation of this Institute have witnessed the establishment of an enormous number of similar societies, specializing their scope more and more, until few departments of scientific work are without their organization and printed transactions. It is estimated that there are now published, more or less regularly, 30,000 scientific journals, partly the production of 565 medical and 6,000 scientific societies, and partly published independently. The total number of papers included in these journals, transactions and memoirs is further estimated at 600,000 annually, or an issue of nearly 2,000 per day.

The reasons for the immense increase in this class of publication are not hard to find, and give no indications of a decrease in the immediate future. They are, first, the increasing number of abstruse, valuable papers, which journals dependent on subscriptions cannot see their way to print. These can only be of value to the few, and as scientific men are, as a rule, not wealthy, they are glad to get either the assistance of some society or direct aid from Government. This, freely given, has encouraged the development of memoirs in pure science. Secondly, our universities have so largely adopted the system of post-graduate courses, in which each graduate is encouraged to produce his thesis, and which are published under the name of university studies. And, thirdly, because science has become so specialized that men engaged on minute portions of the work are drawn together to support a special journal where their discoveries and discussions may be certain of a small but appreciative audience.

It is quite evident that no person is able to follow all the scientific publications of the day, even when restricted to one of the great divisions, and that the necessity exists for some means of obtaining a knowledge of at least the titles of those published within a fixed period, and that the catalogue produced by any one society would be both imperfect and expensive. Let us take the Canadian Institute Library as an illustration of what can be done with limited means. We have, in addition to the unbound Transactions, about 8,000 bound volumes, containing on an average twenty papers each. These would require, with a single entry under the author's name, 160,000 entries. An average cataloguer cannot do more than thirty per hour, if allowance be made for all necessary stoppages. This, at seven hours per day, is 210, which, divided into 160,000, gives as the time required for the completion 762 days, or, allowing for holidays, nearly three years. But every student knows that an author's catalogue is only of partial value, and that it must be supplemented by a subject catalogue. This, then, doubles the period, and shows the impossibility of doing such a work single-handed. Many of the older societies, such as the Royal, Antiquarian, Civil Engineers, or Archæological, have, at intervals of 25 or 50 years, printed an index volume to their publications; but the number of these and the long intervals at which they appear, render them useless for the ordinary student. Practical men have seen that the only escape from the difficulty was by co-operation in a joint catalogue. Professor Henry, Secretary of the Smithsonian Institution, was the first to propose a combined catalogue, in 1847.

and, following out the same suggestion, the Royal Society of London, in 1857, commenced the publication of the catalogue which bears its name and now comprises eleven volumes. After much negotiation, representatives from all of the civilized nations were invited to attend a meeting of the International Catalogue Conference, in London, on July 14, 1896. Sir John Gorst was called to the chair, and, after expressing his pleasure at meeting so many representatives of science, said: "Discussions have always been going on as to the best way of extending the catalogue, and of carrying it out in such a way as to make it supply the needs of scientific workers generally. About three years ago a Committee was appointed specially to take into consideration what appeared to be the only way of carrying out such a work in the future, viz.: to consider the preparation of such catalogues by international co-operation. The Royal Society realized from a very early period that it could not itself undertake such a work—that no single body could undertake it; and therefore invited the opinions of scientific men and scientific institutions all over the world. There was practically but one reply—that such catalogues were essential—and there was practically no doubt that the only way of carrying out the work was by international co-operation. The Royal Society worked at the subject during two years, and eventually this Conference was summoned at its instance, through the aid of Her Majesty's Government. If any proof were required of the importance of the work, I think the fact that this meeting is attended by so highly representative a body of delegates is in itself sufficient. . . The great object before us is to produce a catalogue available for use by scientific investigators throughout the world. It is a mere bibliographic work that we are seeking to perfect. We desire to produce catalogues, arranged not merely according to authors' names, but catalogues arranged also according to subject-matter; and a very large number of those who have considered the subject are of opinion that in these catalogues the subject matter must be classified not merely broadly, so as to deal separately with individual sciences, but much more in detail, so as to deal with sections of individual sciences, in order to meet the wants of specialists. Each index, therefore, must be a classified subject index; and many of us also believe that it must be an analytical classified subject index—that we must go beyond the mere titles of papers and consider the subject matter, so that such information is placed in our hands that we shall know practically what is in a paper wherever it may be published. . . But with regard to details—and there must be many details in working out such a scheme, especially when we come to consider questions of classification—it is quite clear that at this meeting we cannot do more than discuss broad principles. The details must be considered by committees, appointed either by this meeting, or by means of machinery set in action by this meeting. And in order that there should be a full study of all these questions, the Royal Society has proposed that the catalogue shall not commence until the year 1900. We have suggested that at least four years should be given to the preliminary work of organization. If means can be devised of leading authors, societies, and publishing bodies generally to co-operate in this work, it is clear that the central organization will exercise almost mechanical functions: it will, so to speak, sit at the receipt of custom; it will see that the scheme is carried out in a uniform way, but the material it requires will flow naturally towards it. In this way much will be done to economise both time and money. Later in the Conference, when we are clear what is the nature of the work to be done, it will be very important to consider what part each contributing country shall take in the enterprise in supporting it financially."

The Conference sat for four days, and agreed upon a basis of international work. English, French, German, and Italian were declared to be official languages, and resolutions were received in any of these. In printing the catalogue, it was resolved, "That English be the language of the two catalogues, authors' names and titles being given only in the original languages, except when these belonged to a category to be determined by the International Council."

The preparation of the catalogue is to be in charge of an International Council, to be appointed, and the final editing and publication shall be conducted by a Central International Bureau, under the direction of the International Council. Any country that is willing to do so shall be entrusted with the task of collecting, provisionally classifying, and transmitting to the Central Bureau, in accordance with rules laid down by the International Council, all the entries belonging to the scientific literature of that country. "In indexing according to subject-matter regard shall be had, not only to the title (of a paper or book), but also to the nature of the contents."

The catalogue shall comprise all published original contributions—periodical articles, pamphlets, memoirs, etc.—to the mathematical, physical, or natural sciences, "such as, for example, mathematics, astronomy, physics, chemistry, mineralogy, geology, botany, mathematical and physical geography, zoology, anatomy, physiology, general and experimental pathology, experimental psychology and anthropology, to the exclusion of what are sometimes called the applied sciences—the limits of the several sciences to be determined hereafter."

The system of collecting and preparing material for the catalogue in each country shall be subject to the approval of the International Council.

"The Central Bureau shall issue the catalogue in the form of 'slips' or 'cards,' the details of the cards to be hereafter determined and the issue to take place as promptly as possible. Cards corresponding to any one or more branches of science, or to sections of such sciences, shall be supplied separately at the discretion and under the direction of the Central Bureau. The Central Bureau shall also issue the catalogue in book form from time to time, the entries being classified according to the rules to be hereafter determined. The issue in the book form shall be in parts corresponding to the several branches of science, the several parts being supplied separately, at the discretion and under the direction of the Central Bureau."

It was also decided that the Central Bureau shall be located in London, and that the Royal Society appoint a Committee to study all undecided questions relating to the catalogue and to report later. As it was thought that the necessary guarantee fund could be raised by private subscription, it was decided that no appeal to the Governments of the several countries represented was necessary.

At the adjourned meeting, which took place in October, 1898, the above was confirmed, with some slight alterations. The first of January, 1900, was fixed as the date for beginning the new catalogue, and the recommendation of the Royal Society was adopted, that, "In 1905, in 1910, and every tenth year afterwards, an International Convention shall be held in London to reconsider, and, if necessary, revise the regulations for the carrying out of the work of the catalogue."

The Toronto Magnetic Observatory. By R. F. Stupart, Director.

(Read January 14th, 1899.)

On the recommendation of the Royal Society and the British Association the British Government determined in 1840 to establish a fixed Magnetic Observatory in Canada, and it was decided that it should be placed under the general supervision of the Ordnance Department of the Army. Arrangements having been completed, Lieutenant Charles James Buchanan Riddell, R.A., was selected for duty in Canada. Leaving his detachment, consisting of four non-commissioned officers of the artillery to embark with the instruments on a vessel bound direct to Quebec, he proceeded himself to Canada by the more expeditious route of the United States. Having waited on the Governor-General at Montreal to present a letter of introduction with which he had been furnished by the Master-General of Ordnance, and having communicated with the commanding engineer, to whom he was the bearer of instructions and authority to build an Observatory, he proceeded to examine different localities which were suggested as convenient sites. The preference was finally given to Toronto, where a grant of two and a half acres of land belonging to the University of King's College was offered by the Council of the University. The first Observatory building was of logs, rough cast on the outside and plastered on the inside ; it was completed during the summer of 1840, and the observations were begun in September. The operation of the Observatory as an Imperial establishment was brought to a close in the early part of the year 1853, and was resumed under the authority of the Provincial Government in July of the same year.

In the autumn of 1853 the present Observatory was commenced, to take the place of the old building. Very great care was taken during construction to insure freedom from magnetism in all the stone used, and all nails and fastenings were of either copper or zinc. For twenty-three years the position of the Observatory was, as far as known, faultless ; observations were carried on systematically and carefully, and results were given to the scientific world which, with those obtained under the old military régime, have made the Toronto Observatory famous in the history of Terrestrial Magnetism.

In 1876, however, trouble began with the erection of buildings close to the Observatory, causing some very small changes in zero values. Then followed a few years later electric light circuits, which produced a change in the force instruments whenever the currents were turned on and off ; this difficulty was in part overcome by the Light Company courteously agreeing to arrange their wires in the vicinity of the Observatory in such a manner that the currents would counteract each other. The next difficulty occurred when a large addition was made to the neighbouring buildings before mentioned, tons of iron were used in construction in all too close proximity to the magnetic instruments, and much time and labor have been required to determine the precise effect of this "iron mine" on the various instruments. It was not, however, until the autumn of 1892, when the trolleys began to run, that we began to suspect that sooner or later the Magnetic Observatory would have to be removed to another site.

The magnetic instruments in the Observatory consisted of those brought out by Lieutenant Riddell in 1840, of which eye readings have been taken six times each day, and of another set of instruments, consisting of a bifilar for the measurement of the horizontal component, and a balance needle for the vertical force, and a declinometer, all of which record photographically.

Electric cars first ran in Toronto on August 17th, 1892. The line first put in operation was that on Church Street, which was followed on September 5th, by one on King Street, between George and Dufferin Streets. During the first few weeks, while a very small vibration of the needle was discernible on the V. F. curve, it was generally almost inappreciable, and it was not until September 20th that the movement increased to an extent sufficient to really impair the value of our magnetic curves. A marked increase of current must have been used on that day and afterwards. On October 10th the cars first ran on Yonge Street, and there was only a very small increase in the vibration, but a decrease of about .000070 of a dyne was observed when the current was on.

About 10 a.m., January 14th, there was a marked increase of vibration, and the vertical force increased about .000200 of one dyne. This disturbed period was only temporary, and shortly after 5 p.m. on the 17th there was a reversal to the smaller vibrations. This continued until May 15th, when larger vibrations began again, and continued with varying intensity during the summer, while the decrease of the vibration with the current ranged from about .000200 to .000500. This disturbance was very great between September 12th and October 17th, and at intervals during the following year; but there was no radical change in conditions until December 17th, 1894, when a decrease of V.F., while the current was on, was changed to an increase, this occurring when the cars first ran on McCaul St. Throughout 1895 the vibration and amount of permanent deflection was very nearly as it has been since; but on October 15th, the increase of V.F. with the current was again changed to a decrease, this occurring at the time that the railway company made certain changes in the feed wires. It is noticeable that, although several changes occurred in the V.F., it at times having been less with the current on and at other times greater, the horizontal force showed a decrease on all occasions with the turn on of the current. This decrease during the past two years was .000200 to .000500 of a dyne. No appreciable deflection of the declinometer magnet was noted, the only effect being a continuous vibration, which rendered the curves very ragged and difficult to read with accuracy.

A study of the traces during the times that the various electric lines were put in operation, showed that, with the currents ordinarily used, there was little effect at three-quarters of a mile, and a further survey with a portable instrument afforded further evidence in the same direction.

Before definitely recommending that the Magnetic Observatory should be removed from Toronto, the Director wrote to various well-known magneticians, present at the meeting of the British Association in August, 1897, requesting the favour of their presence at the Observatory to inspect the photographic magnetic curves there obtained with the view of expressing an opinion as to the advisability of continuing the records at the present site, or of removal to some point distant from electric tramways. Professor Rücker, F.R.S., Professor Carey Foster, F.R.S., Professor Fitzgerald, F.R.S., Dr. Van Rijckevorsel, and Professor Frank Bigelow, were the gentlemen who courteously accepted the invitation, and were pleased to sign a statement that, in their opinion, the value of the magnetic observations at Toronto had been seriously impaired by the trolley system, and advised removal to some other site.

It then having been decided to remove the Observatory, a point was chosen nine miles northeast of the former Magnetic Observatory, latitude 43° 47′N., longitude 79° 16′W., easily accessible by railway, and yet very unlikely to be invaded by the trolley system. At present there is no electric railway within seven miles, and little prospect of one within five miles for many years.

The new Observatory, which was commenced in June, and finished during the early days of September, consists of two parts—a circular stone cellar and an above ground structure. The cellar is nineteen feet in diameter, the walls two feet in thickness, the floor concrete, and the roof covered with felt and gravel, in which, on stone piers sunk in concrete to a depth of six feet below the floor, are placed the self-recording photographic instruments: namely, the declinometer for recording changes in the direction of the magnetic needle, and the bifilar and vertical force instruments for registering, respectively, changes in the horizontal and vertical components of the earth's magnetism. Above ground and connected with the Observatory by a flight of steps, is an erection which is divided into two portions, in the larger of which absolute magnetic determination will be made, piers being provided on which to place the necessary instruments, and an adjustable opening on the roof for transit work; the smaller portion is an office, which will be heated by a copper stove.

Observations were first made in the new Observatory on September 10th, and by Oct. 1st all the instruments had been adjusted in their new position, and everything was running smoothly. Results already obtained show that values will differ but slightly from those obtained at the old Observatory, and a very careful comparison was made before dismounting the old eye-reading instruments in Toronto.

Very great care was taken in selecting materials for the building. Every stone used was tested for magnetic effect, and none but copper and zinc nails and fastenings have been used.

There appears to be every prospect that the new Observatory will be admirably suited for the purpose for which it was designed, and there is strong reason to think that the series of observations at Agincourt will be practically a continuation of the old and valuable series of observations made in Toronto. All photographic records will be sent for development to the Toronto Observatory, which continues to be the central office of the Meteorological Service of Canada.

The Great Sun-Spot of September and October, 1898. By Andrew Elvins.

(Read February 18th, 1899.)

The present year has furnished us with one of the finest groups of sun-spots which I have ever observed ; it has attracted the attention of observers throughout the world, and I have thought, that as I observed, and made drawings of it on each day when clouds did not render observation impossible, it might be of sufficient importance to bring it before the Institute.

The spot must have been on the eastern limb a day or more before I saw it. My first observation was on the 4th when it was inside the limb a day, or perhaps two days distance. I was struck by its large size, and the black umbra, and as I thought it would be an important spot I sketched it. On the 5th the umbra was seen to be composed of four parts ; (*as some think*), formed by the photosphere throwing portions of itself across the dark umbra which is regarded lower than the photosphere ; such divisions called "bridges" or "tongues" are seen in nearly all large spots. I think they are breaks or divisions in matter lying on, or above the photosphere ; which permit the photosphere to be seen through the openings or breaks.

The spot had a small spot on the north preceding side very near the penumbra of the large spot, two or three on the north following side, also very near or joined to the penumbra of the large spot, and also two following between the spot and the limb.

On the 7th the umbra was greatly changed ; I could only see three dark umbra divisions instead of four, the two small groups which followed on the 5th had become much larger and contained many black points in a penumbral shading which enclosed the whole.

On the 8th the three umbras had disappeared, and one large black mass existed in the large oval penumbra, the north preceding spot was more distant from the penumbra of the large one than on the 7th, and all the following spots in the train had become larger and more distinct ; there were also fragments of penumbra, scattered through the intervals between the trains, larger spots, and a number of black points on the photosphere too small to show any details.

Being near the sun's central meridian I estimated its size in the following manner, roughly of course, but not far from the reality.

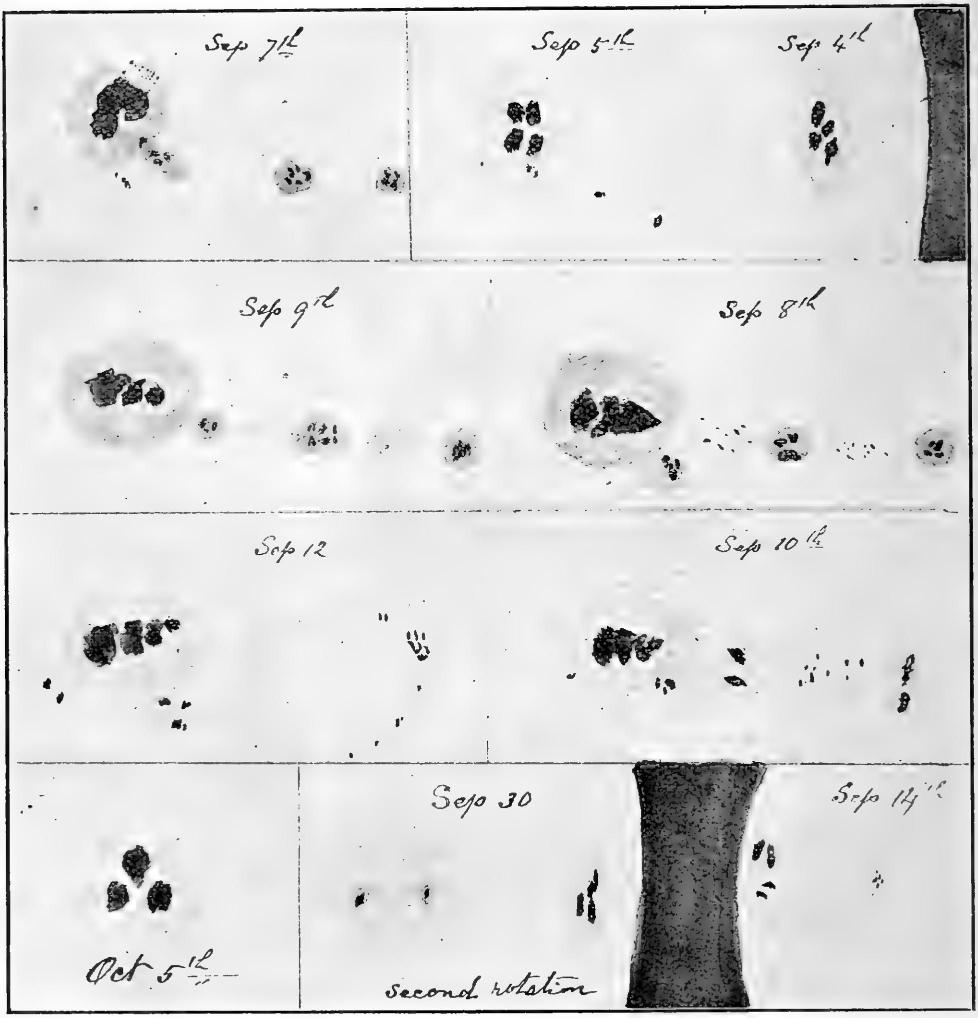
Sun's diameter 800,000 miles, length of group one-sixth ($\frac{1}{6}$) of sun's diameter, =130,000 miles, large spot about one-third of the length of group, equal 43,000 miles.

An extract from a letter written September 9th by Prof. David E. Hadden will throw additional light just here.

"When I first observed this spot, but a mere line of light separated it from the edge of the limb, no penumbra being visible except on the north and south edges of the long umbral line, (a bright aurora was seen the same evening.) On the following day penumbra was visible on all sides of the umbra, . . . the changes from day to day were quite marked. Owing to atmospheric conditions the spectroscope could not be used until the 6th, when but little or no disturbance could be noticed in the vicinity of the spot. On the 7th though, a sudden outburst occurred. When the spectroscope was adjusted at 11.40 a.m. central time, the entire region just preceding, and for some distance following, the spot was greatly agitated, the H_a line being reversed and distorted, small black jets projecting from each side of the line were noted in several places, and on opening the slit slightly, the flame and spike-like figure of the disturbance could be clearly seen. At 12 noon, intensely brilliant flames were observed over the large spot extruding from the umbra to the umbra to the edge of the penumbra on the east side. This phenomenon was particularly striking—the intensely bright scarlet flame nearly in the centre of the dark absorption band of the spot spectrum being very interesting ; the D_3 line was bright.

and D_1, and D_2 and many other lines widened. At 12.05 p.m. a small dark line attached to the H_a line extended obliquely toward the red end of the spectrum in the region just preceding the main spot. At 1.40 p.m., the entire disturbance had almost ceased."

September 9th.—The central spot in the train seems to be nearer the large spot than on the 8th, and the nuclei in all have kept changing; many fine black points are still visible along the line of the train.



September 10th.—The central spot in the train has moved onward and is now quite near the large spot. I think the spots must be situated at different depths in the solar atmosphere, and be moved by currents moving at different rates. Perhaps a cyclonic motion in a vertical plane nearly parallel with the sun's equator might best explain the motion.

I was not able to get a sketch on the 11th and I much regret it, for two sketches made on the 12th are very remarkable. The central group which was nearing the large spot on the 10th, has quite disappeared; has it ceased to exist?

or has it passed beneath the great spot and been eclipsed by it, or in some way mingled with it?

I hope photographs which have doubtless been taken will answer these questions.

On the 14th it was bad seeing but I made a rough sketch; the large spot was near the limb, one part of the penumbra was on it and only one spot could be seen following it; it probably passed over the limb on the 16th which was just fourteen days crossing the disc, and it came on on the 2nd.

The motion of the earth in its orbit adds about two days to the time which the sun's rotation alone would require to enable us to see a spot which is on either limb of the sun until it returns there again, about twenty-seven days together, and as this spot was on the east limb on the 2nd, it should be there again on the 29th. It appeared at the proper time but greatly decreased in size, and quite shorn of the fine train of spots seen when it was last visible.

Two spots, however, preceded it; the first must have been on the limb on the 27th. I saw it on the 28th and stated in a letter that the large spot had returned; I was mistaken in this, it was too early; the great spot was on the limb on the 29th and my first sketches were made on the 30th.

But the smaller spots which preceded it may have special interest. We noticed the fact that the spots in the train following the large one when it was last seen approached the large spot and seemed to coalesce with or pass beneath or above it, and it is possible that the spots which followed it, may precede it now; if the westward motion continued during the fourteen days when they were invisible to us they would have passed to where we see them now.

On October 1st the great spot was well in on the disc; it contained three pretty round black umbras and the penumbra was nearly circular, and two spots preceded it, the foremost one the largest.

From this time the size and activity of the spot gradually diminished, though occasionally very bright bridges, and bright points were seen. On the 6th the three umbras divided, and on the 8th four were plainly visible, the spaces between them being intensely white. I saw it last on October 10th, near the western limb; it was cloudy on the 11th and on the 12th it had disappeared.

I should note that the small spot preceding became more widely separated as time passed on.

I wish to state here as I have often stated before, that I see no evidence in this spot of spots being deep hollows in the photosphere; the drifting of the groups in the train in September toward the large spot, and the drifting of the spot preceding it in October, *from* the large spot render it far more probable that dark matter floating and drifting in the sun's atmosphere cuts off the light of the photosphere below, and is seen by us as a spot.

It is more than twenty years ago since I called the attention of this Institute to the influence exerted by sun-spots on the earth and its atmosphere. Prof. Loomis of Yale was working at that time on the subject, and had shown that *magnetic disturbances* and our *auroras* are more numerous when sun-spots are numerous than at other times; but whether they were directly influenced by solar disturbances, or are caused by cosmical conditions which affect both earth and sun was by no means certain. In the case of the present spot there has been a very marked magnetic disturbance just as the spot passed the central solar meridian, and at the same time, September 9th, brilliant auroras were seen in Europe, and also very generally through the Dominion of Canada.

Dr. Vedder and Mr. Shearman have noticed auroras and magnetic storms, when spots were near the eastern limb of the sun; European observers have noted such displays when the spots were on the sun's central meridian.

In the case of this spot, in Canada auroras were reported from thirteen stations on the 2nd of September, and from twenty-one on the 9th, and again on the 28th and 29th, when the spot had made one complete revolution and was again on the east limb, auroras were reported from many stations. So in this instance we have a plus of auroras when the spot was on the eastern limb and also when near the centre, whilst very few are reported at other dates. In this case both the American and European observers may be right as to the facts; and our theories of the cause of the coincidence will have to *include both.*

But it is just here that we have found the record of the disturbance of the magnetic needle of great importance ; for the photographic tracing of the Toronto Observatory, which Mr. Stupart has placed at the service of Mr. Harvey and myself, shows a great disturbance just at the time when the spot crossed the central meridian of the sun. This shows, (or at present seems to show) that the solar energy passes *radially* from the sun to the earth, and that the outbreak of spots causes an *immediate* transmission of energy through the solar system.

I long ago called the attention of this Institute to the fact that HURRICANES have been far more numerous near the period of sun-spot maxima, than minima. This is so true that taking the four years near the maximum, we find more than double the number of occasions when the wind moves more than thirty miles per hour at Toronto than we get in the same number of years at sun-spot minimum.

The spot of September, 1898, broke out during the minimum period, and this enables us to trace the coincidences with a better chance of seeing and detecting *real connections* from chance coincidences than at a time of spot maximum.

In this connection it may be of some importance to notice the fact that a terrific hurricane swept the Windward Islands on September 10th, just the time when the spot was crossing or very near the central meridian, and we also had a most destructive tornado in the Niagara district when the spot was on the eastern limb or near it.

It has been found that as a rule spots at the commencement of a new cycle are far from the solar equator, and that they gradually approached the equator and were as a rule near it at maximum. The spot of September was, however, near the equator, though we must be near the minimum of the sun-spot period.

The Occurrence of Gold in Some Rocks in Western Ontario. By J. W. Bain, Esq.

(Read April 22nd, 1899).

Of many speculations on the origin of metalliferous lodes, perhaps none has attracted more attention than that which is known as the theory of lateral secretion, and the object of this note is to discuss in brief its possible application to some ore deposits of Western Ontario.

Delius in 1770 and Gerhardt in 1781 concluded that rain penetrated the earth, taking up any soluble material in its path, and, afterwards collecting in the fissures and cavities, gradually deposited the dissolved matter with the formation of a metalliferous lode. This is a fair description in general terms of the theory of lateral secretion, and for the next ninety years the idea lay fallow. In 1873, Sandberger in Germany commenced a series of investigations for the purpose of determining whether the theory were tenable, and the ores, veinstones, and country rocks of a number of veins, were subjected to careful analysis, particular pains being taken to detect and estimate small quantities of certain elements. The hornblende, augite, olivine and mica of the rocks were isolated, and in them could be detected appreciable quantities of almost all the elements commonly occurring in metalliferous veins. Space will not permit of any lengthened description of these interesting researches, which resulted in the author's adoption of the theory, but attention may be directed for a moment to the United States, where steps were being taken to collect evidence upon the subject. Geo. F. Becker was commissioned by the Geological Survey to examine the Comstock Lode, and during the work an investigation similar to Sandberger's, though on a much smaller scale, was carried on. The results which were published in 1882 led the geolgist to the belief that lateral secretion would satisfactorily account for the origin of the lode.

J. S. Curtis, reporting on the Silver Lead deposits of Eureka, Nevada, concluded that the theory was capable of explaining the origin of these ore bodies also, and S. F. Emmons, in a monograph on the Geology and Mining Industry of Leadville, Col., describes some experiments which led to a similar view.

These opinions were witnessed by an array of analytical results, which dealt almost entirely with gold and silver, gold being determined only qualitatively. In view of these facts, it was decided to make some investigations upon Ontario ores. The methods were rendered as accurate as possible, and, although they differ somewhat from others which have been used, the changes were confined to details, with, it is believed, beneficial results.

The samples examined were country rocks, taken from 6 to 10 feet distant from the vein ; the following are the results :

Foley mine—gold	6c. to 17c. per ton.
Mikado " "	12c. to 28c. "
Regina " "	3c. "
Sultana " "	none.
Granite, protogene, at least 500 feet from any vein—gold	none.

In endeavouring to estimate the value of these results, it must be remembered that more than one interpretation may be placed upon them. If we assume that the mineral-bearing solution can permeate the rock with a certain degree of freedom, and this premise is one which we can make with confidence, solutions from underground sources capable of depositing minerals would impregnate the country rock for some distance and produce a condition, close to the vein, resembling that which would result from lateral secretion. For this reason, a series of samples taken at points increasingly remote from the deposit, would yield results of much value, if it were possible to estimate with great precision the amount of gold and silver in each. This, unfortunately, is a difficult task; the amount of silver present in the rocks and gold ores of Western Ontario is comparatively small, and the determinations are not sufficiently exact, in that case, to inspire confidence; while the amount of gold is often many times less than that which is commonly reported by assayers as a trace. In addition to this, the examination of the samples is tedious, and the limited time at my disposal was only sufficient for the attainment of the results above mentioned; it is almost superfluous to add that in such questions as this, the evidence can not be too abundant, and should as a minimum comprise many times the number of results which have been stated.

It is too soon yet to arrive at any definite conclusion, but we may state as a step towards the final result, that certain country rocks in our western mining district contain small but determinable quantities of gold.

Colonel Mahlon Burwell, Land Surveyor. By Archibald Blue, Director of the Bureau of Mines, Toronto.

(Read April 22nd, 1899).

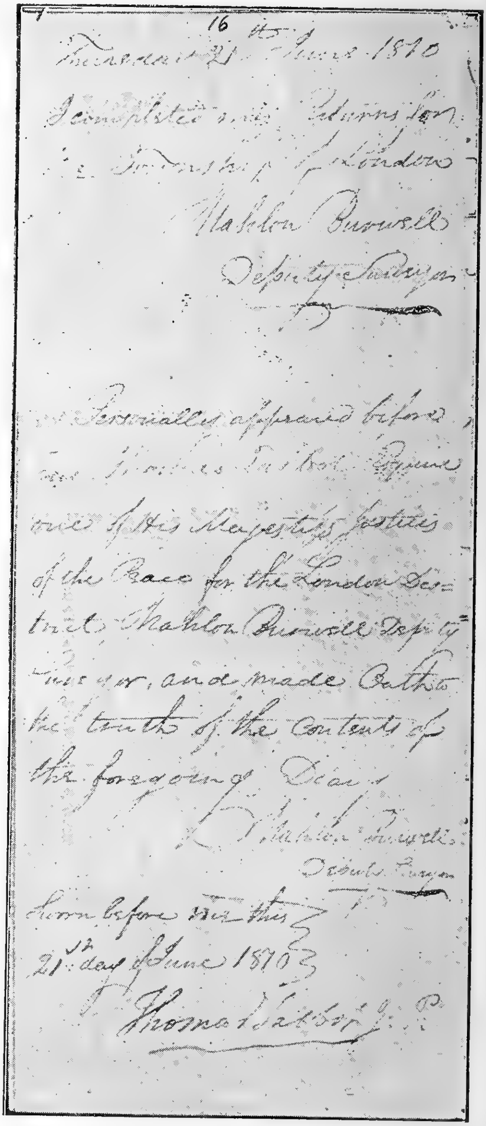
I have read all the letters and journals of Mahlon Burwell to be found on the shelves and in the vaults of the Surveys office of the Crown Lands Department, and if in the use of them I were to follow the example of Carlyle in his Oliver Cromwell I would make a large book. But Burwell has been dead only a little more than fifty years, and his journals and letters have not yet attained a richness of age, not even those of ninety years ago. The paper is but slightly yellowed, the ink is but faintly faded, and the penmanship is neat and flowing. I was going to say that they are as legible as if written yesterday, but that would be an odious comparison in view of the fact that in our time and in our own city good writing, like spelling and reading, has gone out of fashion, if it has not become a lost art. By the end of the twentieth century the old records of the Crown Lands Department will begin to have value, and if the Burwell papers are preserved until then some writer on Canada in the Nineteenth Century will find them out and make them live again in history. But will they be preserved? A few of the letters and more than one-half of the journals are already missing from their place, as a consequence, I have no doubt, of a lack of motive to keep the records of the office complete, and of the frequent movings of the seat of Government during the years of the Union of Upper and Lower Canada—to Kingston, to Montreal, to Toronto, to Quebec and to Ottawa.

Mahlon Burwell.
(From an Oil Painting).

I am to write of Mahlon Burwell as a Land Surveyor, and therefore I shall say little upon other matters in which as a man active in affairs he took some part. The letters and journals indeed deal closely with the business he had in hand, and only at rare intervals is there a gleam of personal or human interest to lighten up the official soberness. I shall make two or three lengthy quotations from the official instructions and from the journals, to illustrate the methods of ninety years ago, and how difficulties were faced, and how work was done as the methods required. Those were days of military ideas in Canada, and men of the Civil Service, outside as well as inside, discharged their duties with the courage and precision begotten of military discipline. They were not all exemplary men in the highest ranks. Some took advantage of their opportunities, seeking especially to enrich themselves by securing valuable tracts of the public lands either as gifts from the Crown's representative whose favorites they were, or by paying for them at a nominal price; and the Crown's representative himself was not always a man above suspicion. But in the case of Mahlon Burwell I have not discovered the suggestion of an improper act. He appears throughout all the papers and letters as a modest, faithful servant, and as a dignified and highminded man.

It has been said of Queen Victoria that she reigns but does not govern. This could not be said of the Governors of Canada in the days before responsible government, when George the Third was King. Francis Gore, who was Governor of Upper Canada from 1808 to 1816, was every inch a Governor, and the administration of the country was in his hands down almost to the smallest detail. He kept a watchful eye upon the public domain, and, following the good example set by Simcoe, he sought diligently to promote its settlement.

In May, 1803, Col. Thomas Talbot commenced the settlement known by his name on the shores of lakeErie, in what is now Elgin county. Next year an expenditure of £250 currency was made under his direction in building a road through his lands. When Gore became Governor a memorial was addressed to him by Talbot, praying for a plan of settlement similar to the one adopted in the formation of Yonge street, which in Talbot's opinion would result in completing the road to the full extent of the first intention. The matter was referred to the Executive Council, who reported to the Governor that the district to be served by the proposed road was very thinly inhabited, that in no other part of the Province was the want of facility of intercourse more sensibly felt and experienced, and that the money already expended would be entirely lost to the public if the design of continuing the road was frustrated. Besides, it was felt that a highway extending through the country and occupied by a good class of settlers would add to the value of the large adjoining block of land which had been set apart in Southwold, Yarmouth and Houghton as the source of a fund for public schools. It was therefore advised that a grant of lots of 200 acres should be made to persons willing to become settlers on each side of the projected road, subject to these conditions, viz: (1) That within two years from the time each settler was permitted to occupy a lot he should build thereon a good and sufficient dwelling house of at least 15 by 20 feet in the clear, and occupy it in person or by a substantial tenant. (2) That within the same time he should clear and fence ten acres, and clear and open up one-half of the width of road in front of his lot, and cut down all trees within a hundred feet of the road. But as the lots proposed to be granted under this scheme were parts of the lands set apart for public schools, it was recommended that land of equal extent and value should be appropriated elsewhere for the same object.


16
Thursday 21st June 1810
I completed said Town line of the Township of London
Mahlon Burwell
Deputy Surveyor

Personally appeared before me Thomas Talbot Esquire one of His Majesty's Justices of the Peace for the London District Mahlon Burwell Deputy Surveyor, and made Oath to the truth of the contents of the foregoing Diary
Mahlon Burwell
Deputy Surveyor
Sworn before me this 21st day of June 1810
Thomas Talbot J.P.

A PAGE FROM THE LONDON TOWNSHIP JOURNAL.
Reduced to ⅔ size.

The office of Surveyor General was vacant at this time, and was occupied by Messrs. Chewett and Ridout as acting Surveyors General.* They were commanded

*December 26th, 1810, Secretary William Halton was commanded by the Lieutenant Governor to inform Thomas Ridout, Esquire, Surveyor General, that he had been pleased to appoint William Chewett, Esquire, to be first clerk in the Surveyor General's office from the first of July last, in the room of Mr. Ridout himself, promoted to the office of Surveyor General from the same date. Mr. Ridout held the place about eighteen years, and again Mr. Chewett became acting Surveyor General, but he never attained the full rank.

by the Lieutenant-Governor—his orders were always in the form of commands—to send a surveying party into the London District to survey and lay out the new road, and upon the recommendation of Col. Talbot the post of surveyor was offered to Mahlon Burwell, being his first commission from the Government. The instructions, under date of March 24th, 1809, were in the following terms:

"In obedience to His Excellency, the Lieutenant-Governor's commands to us, bearing date the 17th February, 1809, to send a surveyor and a sufficient party, as soon as the season will permit, to complete certain surveys in the London District recommended by the Executive Council and approved by His Excellency the Lieutenant Governor, upon a petition submitted to the Board from Thomas Talbot, Esq., of Port Talbot, who has recommended you to carry the said survey into execution.

"You are hereby required and directed without loss of time, as soon as the season will permit, to survey and lay out a road to pass through the aforesaid townships upon the principle of Yonge street, by making the said road in breadth one Gunther's chain, and laying out lots thereon of 20 chains in breadth on each side of the same, leaving a road on the side lines of each of the said townships, and a road between every five lots in each of the same, of one Gunther's chain.

"For this survey your pay will be 7/6 per day, with an allowance in lieu of rations of 1/3 Provincial currency per day.

"Your party is to consist of eight men, that is to say, two chainbearers and six axe men only, considering the country through which you have to pass is lightly wooded, by having little or no underbrush.

"The chainbearers will be allowed 2/– per man per day. The axemen will be allowed 1/6 per man per day, all Provincial currency, and you will be allowed for each ration furnished to your party 1/3 Provincial currency per man per day.

"The ration to be of the following species, viz., 1½ lb. flour, ¾ lb. of pork and ½ pint of peas.

"You are to understand that this allowance to you of 1/3 Provincial currency per man per day for each ration is to cover all expenses whatsoever, such as transport, batteau hire, camp ketttes, axes, tommyhawks, tents, bags, snowshoes, etc.

"The chainbearers must be sworn to the faithful discharge of their trust before they enter upon their operation. This you are authorized to do yourself, under an Act of the Province of Quebec, no law in the Province of Upper Canada having been made to the contrary; but it will appear more solemn and have a better effect to have it performed by a magistrate.

"The whole of your party, being eight in number, are actually to be employed in the field without any subterfuge, as you will be obliged to make oath to this fact. But should you not be able to engage the whole of your party—that is to say eight men, including axemen and chainbearers—you are to bear no more men on your pay list than those who are actually employed in the field.

"Should you be under the necessity of discharging any of your party before the survey is completed, you must keep four open pay lists for that purpose, which the person so discharged must sign, whose signature must be witnessed by some person of respectability (if possible), and those who remain with you are also to be borne on the said pay list, a form of which is herewith enclosed for your guidance, so that the whole of the expense incurred on your survey shall not exceed the number of men your party is rated at, which must be sworn to according to the form given.

"You must keep a field book of the whole of your operation, noting everything worthy of remark, but in particular the white and yellow pine, and the lots on which it is to be found, which must be so clear and distinct that the whole thereof may be traced on the plan, not only by a surveyor but by any person who can read writing, which must also be sworn to and returned with your pay lists and vouchers.

"You must keep a diary or journal, clearly explicit, as how you have expended your time, in which you must enter everything worthy of remark, particularly the white and yellow pine fit or not fit for masting according to the best of your knowledge and belief, and such mines and minerals, etc., that you may pass in the course of your operation, noting the lot and concession whereon the same may be found, as directed in your field book, and you must be particularly careful in your diary or journal to enter the time and names of the persons whom you engage and discharge, according to their respective dates, so that the same may correspond with your pay list, which also must be sworn to and returned with your vouchers.

"Your pay list and vouchers for your pay, ration and abstract must be in quadruplicate.

"The rough plans of Yarmouth, Southwold and Houghton, herewith sent to assist you in your operation, on which are laid down imaginary lines upon which the courses of the road are supposed to run, the situation of which must be determined by measuring on the side lines of the several townships from lake Erie, until you intersect the road you are to lay out, when it is completed, which must be returned with the fair plans of your operation, on which must be laid down in a clear and distinct manner the mountains, hills, rivers, marshes, meadows and swamps, or whatever else may occur that may be remarkable for its singularity or utility.

"The principle on which Yonge street is laid out is, that the lots are 20 chains in front by 100 chains in depth ; therefore it is requisite to observe that whatever obliquity you may have occasion to make from the concession lines of those townships hereafter to be run, making Yarmouth as the centre township the governing one for the three townships, then you will have to calculate the obliquity of the same on the angle or difference deviating from the concession lines of the township of Yarmouth, which Mr. Chewett will explain, and show you the method of calculating should you be unacquainted the nature thereof. The plans of Southwold, Yarmouth and Houghton, sent with these instructions, will point out how far this can be carried into execution.

"You must always have in remembrance that you cannot approach nearer to lake Erie with the rear boundary forming the concession on the road to be laid out than the rear boundary of the 7th concession in Yarmouth, nor the rear boundary line of the 4th concession in Southwold from the river Thames, which have been so far conceded.

"You must not, however, set out to commence your operation until such time as you have reason to believe that the waters have sufficiently left the woods, that there may be no plea of delay by being obliged to hire your party and to commence your operation at an unseasonable time of the year.

"A reasonable time when you arrive at Port Talbot will be given to you for the hire of your party and purchasing your provision, which it is supposed may be done at one and the same time, and also for going to and coming from your place of residence to Port Talbot, and for making up your plans and vouchers, and no more, and every exertion that a surveyor is capable of in carrying the same into execution with accuracy and dispatch is expected from you."

A party of surveyors usually consisted of ten men besides the chief, but as the woods in the west were supposed to be more open than elsewhere, Mr. Burwell concluded that he could effect the work with eight men, and so that number was placed in the instructions. He apprehended, however, that men could not be hired at the Government rate of wages, as they were accustomed to receive more from the farmers. Accordingly the Governor in approving the instructions agreed that "should it be impossible to procure men to assist the surveyor at the usual price, Col. Talbot must be requested to certify the lowest wages they are to be had for, which will be allowed upon this location." The regular rate continued without alteration for a long period. In 1797 it was the same as in 1809, but in 1815, after the close of the war, rates were increased, owing to the higher cost of living. "The notice you have taken of the prices of Labor and Provisions having risen within the last three or four years is very cogent," Mr. Burwell wrote to Mr. Ridout from Southwold, in November, 1815. "Provisions are dear here and Labor is high, which I expect is pretty generally the case throughout the Province. Farmers are giving from fifteen to eighteen dollars per month to laborers, which will make it difficult, if at all practicable in the present state of affairs, to execute the Surveys required at the former established rates. As to myself, I must confess that it is an arduous undertaking to be in the Wilderness exposed to the inclemencies of the Weather long at a time. It certainly impairs one's health. An increase of pay is desirable—but it would be indecorous for me to state my humble opinion of what it ought to be. The circumstances which lead you to mention it, are sufficiently known to yourself as Surveyor General, and I shall be content with such additional pay as the Lieutenant Governor in Council shall deem expedient to establish." The scale was made 10s currency per day for surveyors, 3s 9d for chainmen and 2s 6d for axemen, with the usual allowance for rations. In 1818 a new scheme was introduced. Surveys of townships were let under contract, and payment was made in a percentage of the lands. The common allowance was 4½ per cent., but if the land of a township was shown to be marshy or the quality of it poor, the percentage might be drawn from lands elsewhere.

Economy was enjoined upon all surveyors, and the records show that it was rigidly exacted. "You will pay the strictest attention to the economy of your time," Surveyor General Smith advised Abraham Iredell in 1803, "as the most minute scrutiny will be made in respect of the same." There was an audit of the accounts in Toronto, and afterwards an audit in London before they were finally passed, and for this reason all accounts and vouchers were required to be made out in quadruplicate.

It will easily be understood that on the allowances for wages and rations a surveyor could not be generous. In most cases he went into the woods without even a tent, and when it rained the men peeled bark from the trees and made a rude shelter of it. But as the bark will not always peel, it would happen that the party had to lie down without any covering, and in the journals of Mr. Burwell there are frequent notes of this kind of experience. There was no allowance of tea or coffee with the rations of flour, pork and peas, and the early records do not give a hint of any other beverage. But twenty years after Burwell's earliest venture as a land surveyor, when Roswell Mount of Caradoc was provisioning a party to lay out a township on the St. Clair river—it was named St. Clair, but has since been divided into the townships of Sarnia and Moore—he began with the purchase of a barrel of pork, a barrel of flour and a barrel of whiskey.

We have travelled far since those early days, as witness some articles in the allowance of stationery supplied to the surveyor of ninety years ago, for which he gave to the Surveyor-General a detailed receipt. One item is 25 quills, for although steel pens were made before the close of last century, they did not come into general use until the middle of the present one. Another was a stick of sealing wax to seal letters, long before the days of the envelope. A third was a piece of mouthglue, so completely gone out of use that a specimen of it would be a curiosity now. A fourth was "one Indian rubber," and a sample in my possession is as dry and hard and brown as a mummy of the days of old Rameses. There were also papers of ink-powder, black and red, but men under sixty may remember the use of ink powders. Some of us, whose faces have not lost the country bronze, who lived in the country school sections, twelve miles away from the nearest general store, may even recall memories of the fluid we helped to compound in an iron pot from the inner bark of the swamp maple, with green vitriol and sugar added—ink of just a slightly deeper shade of purple than Emperors were wont to use in writing their names, which shone like varnish on the paper and crackled like burning brush when the copy-book was opened, and was viscous enough to arrest a house-fly. I think that I could identify that swamp-maple ink upon the written page after a lapse of ninety years ; yet, in spite of the scrutiny and microscopic economy of the audit office, I am sure that Mr. Burwell was never forced down to the level of using it, at all events not in his official correspondence nor in his journals. But the records afford not a few illustrations of the infinitesimal mind that directed the audit office when Francis Gore was Lieutenant Governor. One is reminded of Elia's man, John Tipp, of the South Sea House, who thought an accountant the greatest character in the world, and himself the greatest accountant in it. Auditor is Accountant writ large.

The surveyors often were annoyed by delays in the passing of their accounts, although it happened sometimes that the Receiver General was more to blame than the Auditor—when there was no money in the Treasury. This, however, is slightly a diversion, and I come back again to the subject.

Mr. Burwell was enjoined to read his instructions carefully, and not to leave Toronto until satisfied that he understood them ; and he was directed without loss of time, as soon as the season might permit, to proceed with the work, but not until he had reason to believe that the waters had left the woods, so that there might be no fear of delay by commencing at an unseasonable time of the year, with himself and his men idle while under pay. "I have perused my instructions and looked over the plans," he wrote on April 1st, "as carefully and as much as I possibly could for the short time I have had them in my possession, and see nothing to prevent my putting the instructions into execution as soon as time will allow." On the same day he drew the allowance of stationery, and having gone to his home in Bertie township he began to fit out for the enterprise in hand about the middle of May. Four days were spent in making out voucher forms, a field book and plans of the townships, and then he was ready to begin the journey to Port Talbot. I quote a few pages of the journal.

"Sunday 21st May. Could not set out with a Boat on account of the Ice being wafted to the North side of the Lake.

"Monday 22d May. Believing it would be difficult to hire men enough at Long Point or Port Talbot for my Party to consist of, and being ready to set out I engaged three, by name, Edward Kerr, John and Robert Burwell. Kerr for a Chain Bearer at 2/6 currency per day, and the Burwells at 1/6 per day each. Set out from Fort Erie and reached Point Industry. It rained all Night."

Point Industry is west of Point Abino and Sugar Loaf. It is lot 14 on the lake shore, the most southerly land in Wainfleet, and was patented to David Morgan in 1817. It seems likely, however, that Morgan was an old squatter here, as in the first edition of D. W. Smith's Topographical Description of Upper Canada (1799), Industry Point is also called Morgan's Point.

"Tuesday 23d May. We set out early in the morning, had contrary Winds, and it rained all day, however, by being assiduous we reached Oustine's Creek.

"Wednesday 24th May. Set out early. Winds still contrary, but reached St. Gust at 11 o'clock a.m., and the Wind breezed up so strongly from the South that we had to put into the mouth of the River for Safety."

St. Gust is one of the several aliases for the most southerly point of Walpole. In Smith it is called St. Dusk or Sangas, and the same name is given to the stream which empties into the lake just east of it. On the U. S. Lake Survey chart the stream is called Sandusky river, and the point itself Peacock Point.

"Thursday 25th May. Reached Colonel Ryerse's in Woodhouse, with some difficulty, by rowing against the West Wind. I embraced the afternoon to enquire for men to engage, but found none.

"Friday 26th May. The Boat I went up in went no farther than Long Point. I went to Dover in quest of one, and of men to assist me, but all to no effect.

"Saturday 27th May. Was told that Stephen Bartow of Charlotteville had a Boat. I went to get it, but he wanted it himself. Made enquiry elsewhere, but could not hear of any in the vicinity of Long Point, and I found no men to engage yet. Mr. Mitchell the schoolmaster informed me that Col. Talbot had taken considerable of pork to his place, and he presumed part of it was intended for me, also that I could get a sufficiency of Flour there, and finding that I could not get a Boat, I concluded to set out on Foot. I could not engage any Men.

"Sunday 28th May. Rained severely the whole day, that I could not start.

"Monday 29th May. Rained until 2 o'clock P.M. I offered two Indians the wages allowed, but they said it was too little. We travelled to the house of Thomas Welch, Esq., tarried all night.

"Tuesday 30th May. Set out early. Mr. Welch sent his son to pilot us to Big Creek, there being no Road to that place. Found the creek very high in consequence of the great fall of rain. Travelled on to within four Miles of Big Otter Creek and encamped. Rained smartly in the night.

"Wednesday 31st May. Hindered some time crossing Big Otter Creek, had to fall a large Hemlock Tree across it, which would have failed us, had not the Creek been narrower below, that the Banks interfered as it swam down. We had to fall a tree across Catfish Creek also and encamped on good land a mile to the Westward of the creek.

"Thursday 1st June. Travelled on to Kettle Creek and had to fall timber across it,—reached Port Talbot after Sunset and it rained in the Night."

At the mouth of Big Otter creek is now the village of Port Burwell, named after surveyor Mahlon Burwell. At the mouth of the Catfish is Port Bruce. This stream was formerly called by its French name, Barbet river, and a line drawn due north from its mouth was the western boundary of Norfolk county. At the mouth of Kettle creek is Port Stanley, at first called Stirling. The name of this stream, like the one east of it, has also been anglicised, it having been known in the days of the French occupation as the Chaudiere river.

"Friday 2d June. Colonel Talbot engaged William Coyl to go with me at 2/ per day it being the lowest he could be engaged for. Finding it impossible to get either Provisions, or men enough to constitute my Party at Port Talbot, I set out for Long Point in a Bark Canoe, that I might be at the return of the Boats from Fort Erie and engage one to take my Provisions to Port Talbot. The Weather somewhat unfavorable, that we only reached Catfish creek. After conversing with Colonel Talbot I found myself much at a loss how to act, his wishes differed so very much from the tenor of the Instructions I received from the Surveyor General's office."

This difference seems to have been owing to undue haste on Colonel Talbot's part, for the letters show that when he had perused the instructions he did not disapprove the plan.

"Saturday 3d June. Left Catfish Creek early but were soon interrupted by a head Wind, however we proceeded on to the Three Gun Battery and encamped."

The Three Gun Battery is not now known as a geographical term on the shore of lake Erie, and I have not found it mentioned elsewhere than in Burwell's journal. It is again referred to in connection with a traverse of the front of Houghton. "Proceeded from Big Otter creek down to the Three Gun Battery," the Journal of July 4th notes; "here are immense Sand hills above the regular high Banks, from the summit of which is a prospect of all the surrounding country." Most likely it was a name given to the sand dunes in Houghton, ten miles west of Big creek in Walsingham, eight miles east of Big Otter creek in Bayham, and near to the hamlet of Houghton. There are three hills, which extend for three-quarters of a mile along the lake, and apparently have been built up with the sand blown by winds from the beach. The largest, which is on lot 10 and lies between the other two, is 990 feet long, 300 feet wide, and rises to 195 feet above the water's level. The lake bank itself rises to 70 feet, which is about the average height from Port Dover west as far as the county of Kent. Mr. John Alton of Houghton, to whom I am indebted for this description, has forwarded a sample of the sand, and states that the material of the hills and of the beach is as nearly as possible the same. It is composed almost wholly of grains of silica, with small percentages of felspar, limestone and garnet, all finely rounded. "You may wonder from its appearance," Mr. Alton remarks, "why it does not blow away. But it has the peculiar trait of holding moisture well, and during a season of drought one can kick out moist sand at a depth of one or two inches from the surface." The effect is to keep the hills solid and compact, and there has been little change in their form within the memory of the oldest settlers. They command the best view of lake Erie to be obtained at any point along the coast, and a number of tourists visit them every summer.

"Sunday 4th June. Proceeded on the way, crossed the carrying place, and arrived at Col. Ryerse's at night."

The carrying place from the lake to the head of Long Point bay at the end of last century was a flat of sand about eight chains wide, according to Smith, which sometimes was sufficiently overflown to be used as a passage for small boats. As late as 1832 there was little or no change in its condition, according to Bouchette, there being a passage for boats through a small brook when the waters were high, and when they were low boats were easily hauled across the slender isthmus. Now Long Point is separated from the mainland by a wide channel of shallow water.

"Monday 5th June. Went in Quest of a Boat and men to assist me, was at the General Training of the Militia and engaged Cornwall Ellis and his Boat to take my Provisions to Port Talbot.

"Tuesday 6th June. I went to Townsend to hire men to go with me, but did not meet with any.

"Wednesday 7th June. I was fortunate enough to procure three Men, by name John Bacon, John Rice and Jesse Millard. I agreed with Bacon for 2/6 per Day with Rice for 2/, and with Millard for 1/4 per Day.

"Thursday 8th June. I engaged Jeremiah Wolfen to go with me for 1/8 per Day and was all in readiness to set out for Port Talbot, but the Wind blew contrarily that I could not proceed, and then Wolfen refused to go at all, and I could not complete my party, but determined to proceed in the morning.

"Friday 9th June. Loaded the Boat early and rowed against the Wind to the carrying place, or Isthmus of Long Point. We took everything across to be ready in the morning.

"Saturday 10th June. Loaded the Boat early and rowed against the Wind to Big Otter Creek; the Wind blew hard and we lay by. About 6 o'clock P.M. it calmed and we rowed up to Catfish Creek by 10 o'clock P.M. there was a heavy swell and when entering the mouth of the Creek the Boat had like to have filled and my Trunk and my Papers got wet, by which some drawing Paper was considerably injured.

"Sunday 11th June. There was such a violent sea that it was impossible to proceed on the way.

"Monday 12th June. The Lake raged most tremenduously all day that we could not move out of the mouth of the Creek. So I searched for the limit between the Townships of Yarmouth and Houghton, on both sides of the creek, but all to no effect.

"Tuesday 13th June. Early in the morning I set out with a pretty rough Lake and we rowed hard until 2 o'Clock P.M., when we reached Port Talbot.

"Wednesday 14th June. It rained very hard all day that I could not proceed into the Woods. Colonel Talbot altered his opinion respecting the operation and did not wish to deviate from the intent of my instructions and I regretted that I had written the Acting Surveyor-General on the subject."

These extracts from the journals show the difficulties and dangers which beset the early surveyors of our Province in parts of it which were the most easy of access by the best transportation of the time. To reach Port Talbot from Fort Erie with assistants and provisions, Mr. Burwell was occupied twenty-four days, and during much of that period himself and the men were exposed to the stress of weather, without shelter, and sometimes in peril of their lives; and journeying slowly on as best they could, on foot through a wilderness of brushwood and briars, or in open boat coasting a shore of high bluffs on the most treacherous of all the great lakes, which in the months of May and June is peculiarly liable to gales that sweep it for an unbroken length of more than a hundred miles from the south and west. Today a party can leave Toronto in the morning, take a run of 120 miles in a railway coach, drive fifteen miles across country along a finely graded road, and arrive at Port Talbot early in the afternoon of the same day. That fifteen miles embraces the first section of the Talbot road which Mr. Burwell was employed to survey. Some of the best farming land in Canada is to be seen there; and if on reaching the Southwold and Dunwich townline the traveller enquires, he may have pointed out to him the house where Col. Mahlon Burwell lived with his family for a third of a century, as well as the little building of red brick where he kept the register of titles for Middlesex county; and beyond these the quiet churchyard by the roadside where, under the shadow of great forest trees, is a grass-covered mound and a stone with this inscription:

SACRED
TO THE MEMORY
OF
MAHLON BURWELL
WHO DEPARTED THIS LIFE
THE 25TH DAY OF
JANUARY A. D. 1846
AGED 62 YEARS
11 MONTHS AND 7 DAYS.

HE WAS FOR SEVERAL PARLIAMENTS A MEMBER OF THE HOUSE OF ASSEMBLY FOR THE COUNTY OF MIDDLESEX, AND FOR ONE PARLIAMENT MEMBER FOR THE TOWN OF LONDON.

In the plan of this paper I have purposely entered into details of the beginnings of Col. Burwell's work as a land surveyor, to illustrate the value of his letters and journals as materials of history, but without a pretence to elaborate them into literary form—for history is not written hastily in broken hours at the end of a day's work. What remains to be done is the harder task of presenting within the limits of a few pages a clear idea of the extent and nature of Burwell's labors during the next twenty or more years of active career as a surveyor; or down to the time when, though still in middle life, his physical powers had decayed and he was no longer able to execute a commission from his chief. "Should His Majesty's Government require that this township (Dunwich) should be re-surveyed," he wrote to Acting Surveyor-General William Chewett on February 24th, 1832, "may I beg that you will not order me to perform the service, as my health would really not permit me to go into the woods at this time,"—and he suggested the name of another to whom the order might go instead. After that time it does not appear that Mr. Burwell attempted any work for the Government except to finish the surveys of one or two townships which he had commenced long before. A list of his undertakings from 1809 to 1835 includes surveys in whole or in part of the townships of Wainfleet, in Haldimand; Houghton, Middleton and Townsend in Norfolk; Bayham, Malahide, Southwold and North Yarmouth, in Elgin; Caradoc, Ekfrid, Lobo, London, Mosa and Westminster in Middlesex; Harwich, Howard, Orford, Raleigh, Romney, Tilbury East and Zone, in Kent; and Colchester, Gosfield, Maidstone, Mersea, Rochester, Sandwich and Tilbury West, in Essex. The list also includes surveys of the towns of London and Chatham (the latter being a re-survey); of Talbot Road East, from the west line of Southwold to the east line of Middleton; of Talbot Road North, from the west line of Southwold to the junction with the Longwoods Road in Westminister; of Talbot Road West, from Port Talbot to the town of Sandwich on the Detroit river; of the Middle Road, midway between lake Erie on the south and the river Thames and lake St. Clair on the north, from the east line of the township of Orford to a point of junction with the Talbot Road in the township of Sandwich; of the Brock Road in Wellington, from Guelph to the rear of Flamboro; of the north limit of lands purchased from the Chippewa Indians in 1827, from the northwest corner of Garafraxa to lake Huron; besides several Indian reserves in the counties of Middlesex and Lambton.

The survey of Talbot Road East, or Colonel Talbot's Road, as it was first called, occupied the whole of the season of 1809 and part of 1810; and the work was pushed on without cessation every day the party was in the woods, the only days of rest being the rainy days. The limits between Dunwich and Southwold, Southwold and Yarmouth, Yarmouth and Houghton, and Houghton and Walsingham were first traversed, the western boundary of Yarmouth being intended as a governing line, and the most eligible points of intersection for the road were found in this way. No difficulty was experienced in discovering a suitable location across Southwold and Yarmouth, and only two courses were necessary in the former, made to avoid a marsh in which Talbot creek had its source. The southern part of Yarmouth had been surveyed in 1799, where a grant of 5000 acres was made to Hon. James Baby and his brothers. In the instructions to Surveyor Jones Yarmouth was described as situated between Southwold and Houghton. The original intention was to run the road through the seventh concession, but Mr. Burwell's explorations showed that a more favorable route was one on the line between the eighth and ninth concessions. He reported it as "an extraordinary place for the Street to pass, there is but Four Chains of Swamp the whole way and that not bad." To the east of Yarmouth the country along the projected line was broken by gullies and swamps. "All the creeks of any account between Port Talbot and Long Point," Mr. Burwell observed in one of his letters, "come from the North East to within about eight miles of the Lake, and then run nearly a South course into it." This was the real cause of the difficulty of finding an easy route across Houghton—whose western boundary at that time was the east line of Yarmouth—for the direction of the road was nearly parallel to the main streams in their upper reaches, and it crossed many of their tributaries. But a fairly good route was obtained in the end, which for the last thirty miles eastward lay in a splendid forest of pines. The terminus of the road was at the eastern line of Middleton, where the village of Delhi now stands; but the name of Talbot Road has been applied to one extending eastward through Cayuga in Haldimand.

Mention has been made of the difficulty Mr. Burwell had in procuring supplies of provisions for his first campaign. He was destined to have more experience of the same sort before the end of the season. The quantity which he at first thought sufficient to complete the survey was entirely expended at the beginning of September. Everything was in such a situation that the whole party had to march out, as clothes and shoes were required as well as provisions. The first day they travelled twenty miles and encamped on Big creek. Going by way of Townsend, the settlement on the lake was reached on the third day. But all the flour there had been sent away, and the only thing to be done was to thresh wheat and get it ground. A team was hired to carry a barrel of pork from Col. Ryerse's to Townsend, and on the fifth day the men threshed seven bushels of wheat and took it to Sovereign's mills. But the miller was not at home, and as a last resort on the seventh day the grist was ground by one of Burwell's own men.

On Sunday, September 10th, Mr. Burwell records in his journal, "I took a Boy and Two Horses whom I had engaged to Pack the Flour and Pork to the Survey on the Old Road, had much trouble on account of Logs, Brush, Briers, &c., but Reached Big Creek." Next day the provisions were packed into Houghton, "and it took us faithfully all day to proceed Seventeen Miles." There a deposit was made, and taking a supply they proceeded to resume work at the point they had left twelve days before. Such is an instance from life in Norfolk county ninety years ago.

In 1810, besides finishing the survey of Talbot Road East, Mr. Burwell surveyed the southern part of the township of London, which was believed to be suitable for the cultivation of flax. "I kept a Proof Line in the centre of the Township," he wrote to the Surveyor General's office, "that my Survey might be as correct as possible, on which I Proved every Concession Line that I run, by measuring on the said Proof line, and can say that the operation is very correct." This was the origin of the name of the road which leads out of the city of London to the north boundary of the township. He also received instructions to survey the vacant land between Houghton and Yarmouth, and to divide it, if sufficiently extensive, into two townships, under the names of Malahide and Bayham. The work was done accordingly, and under date of February 12th, 1811, the Lieutenant Governor commanded his secretary to acquaint the Surveyor General that "the townships of Malahide and Bayham are to be annexed to the county of Middlesex." In making this survey Mr. Burwell selected a block of land in Bayham at the mouth of Big Otter creek, a part of which was subsequently surveyed for a town plot and called Port Burwell. Writing of that region to the Surveyor General in June, 1815, he said: "Otter creek discharges more Water than all the small Rivers which disembogue themselves into the North side of lake Erie excepting the Grand River. When a few drifts are cleared out of it, Boats may descend from the Mills in Norwich to its mouth, at almost any Season of the year. There are beautiful Groves of White Pine Timber, on each side of the Creek, interspersed with Groves of other Timber, alternately; there is therefore no doubt, but what ere long considerable quantities of Lumber will be conveyed down that stream, from Norwich and other places to the Lake. It would appear as if Nature had intended the mouth of Big Otter Creek for a place of greater importance than any other in the District of London. In my mind it is highly probable that such will be the case before many years. I am about to lay out what Land I own on the East side of the mouth in a Town Plot." At the same time he encouraged the Government to lay out an adjacent lot held as a reserve for the same object; and "if it should meet with the approbation of His Excellency the Provisional Lieutenant Governor, it would much facilitate the future growth of that part of the Province, to have it laid out by the Government, for a Town at the mouth of Big Otter Creek." But these bright anticipations have not been realized, and although the town is beautiful for situation, it has been for many years a finished town. Like its neighbor town, Vienna, on the same stream, its glory departed when the last of the Big Otter pine was cut.

The north branch of Talbot Road was laid out in 1811, the object of it being to connect the main line of the Talbot Settlement with the road through Westminster. Its western end is at the Dunwich and Southwold line, where the village of Iona now is, and it extends eastward through Southwold parallel with the main road, to a point where five roads converge, long known as Five Stakes, but now called Talbotville Royal. Thence the road runs north to join the Talbot Longwoods Road in Westminster at a place formerly known as the Junction, but now called Lambeth, six miles from the city of London.

An instruction was received the same year to survey under the direction of Col. Talbot a road from Port Talbot west near the shore of lake Erie to Amherstburg on the Detroit river, to be known as Talbot Road West. "In surveying the Road through Dunwich and Aldborough," Mr. Burwell wrote to the Surveyor General on October 24th, "Colonel Talbot directed that I should begin to number the Lots from his Mills and continue to the westward, which I have done, and also continued numbering them in succession as far as the Survey extends at present; without regard to the Townships through which they pass." Work was commenced on August 26th and was carried on until September 8th, when the survey reached lot 90, near the west side of Howard, and was then discontinued for the season.

It is likely that Mr. Burwell had before this time left his home in Bertie, as a deed dated February 25th, 1812, from Col. Talbot to him of a small piece of land in lot 24 of the 11th concession of Dunwich, describes him as of Port Talbot.* But the war between the United States and Great Britain, which had been threatening for several years, broke out in the summer of 1812, and until peace was again established surveying operations near the frontiers of this Province were suspended.

Only a few references to the war occur in Mr. Burwell's official letters, and no information is conveyed in them that he was engaged in military service. The report of the Loyal and Patriotic Society states, however, that he was active against the enemy on all occasions and became odious to them. The letters show that he was at the Niagara frontier in 1812 and 1813, when fighting was going on there, and that in the following year, when a small body of American soldiers ravaged the Port Talbot settlement, he was carried off as a prisoner of war and his maps and instruments destroyed. A map of Malden had been given by him to Proctor when that General was on his way to take command at Amherstburg in 1812, which was afterwards taken by the enemy and destroyed, with his papers. "The Plans of the other Townships I had deposited, with the Instruments and other appendages of my Surveying Establishment, at a person's House, where I thought they would not be likely to be suspected or discovered, but when the plundering party came through which swept the whole Settlement and captured me, all was taken and destroyed—and I have not been able to get properly equipped with Instruments yet." This was in explanation to the Surveyor General (November 4th, 1815) of the loss of plans of townships traversed by the projected Talbot Road West. One other reference to the war is worth quoting. It is found in Mr. Burwell's journal of the Talbot Road West survey under date of September 18th, 1816. "I passed the place in Front of Lot No. 177 (Tilbury East) where Major Holmes of the United States Army had encamped a Day or two, when on their intended expedition against Port Talbot in time of the late War. I find here, as well as upon every other occasion, when they have remained all night in our Woods, they have felled large Trees flat to the Ground all round their Encampment, to serve as a Breast Work in the event of an attack. Two Field Pieces and ammunition Waggons were left here by Major Holmes, which were destroyed by the Loyal Essex Rangers. The Carriages were burnt, and the Guns and ammunition were carried back and deposited in a Black Ash Swamp where they remained until the Treaty of Peace." The Major Holmes of this record is no doubt the same officer as the Colonel Holmes commanding at Amherstburg, mentioned in Sir Gordon Drummond's dispatch of May 27th, 1814.

The survey of Talbot Road West was resumed by Mr. Burwell in the summer of 1816, and under instructions the western terminus was fixed at Sandwich instead of Amherstburg. The final report upon it was not sent in until the end of 1824.

The first settlements in Kent county were formed upon the river Thames, and after the Talbot Road began to be opened up a scheme was proposed to the Government by Col. Talbot for a main road to follow as nearly as practicable the height of land between lake Erie and river Thames across the county. This was referred

* Mr. Gill, the registrar of London, informs me that Mr. Burwell was appointed registrar of Middlesex in 1811, and that the first deed was registered by him May 28th of that year. The first registry office for the London and Western Districts was established February 20th, 1801, and the seat of the office was at Turkey Point, with Thomas Homer as registrar. The office was afterwards removed to Vittoria, and again to Princeton

to Mr. Burwell, and reporting thereon to the Surveyor General in August, 1821, he expressed the opinion that the laying out of a Middle Road on the highest ground or dividing ridge would tend much to quicken and consolidate the settlements between those waters. The work was entrusted to himself, but as the road as finally laid out extended from a point of junction with the Talbot Road in the township of Sandwich eastward to the county line between Kent and the present county of Elgin, it was not completed until September, 1825. The last division of the survey is the most easterly, being in the township of Orford, and as the height of land there is very irregular it was found necessary to alter the direction of the road frequently. There are in all twenty-eight courses across the township, which has a width of 6¾ miles, and only one lot has a straight front. A large tamarac swamp was met with on the way, and there is a tradition that Mr. Burwell was nearly defeated in the effort to find a pass through it. The situation was reported to Col. Talbot, who with his usual urbanity directed the surveyor to follow the ridge. "Follow the ridge, if it takes you to—Hades." But I need not say that Col. Talbot used another word.*

There are many matters of interest connected with surveys of the townships north of the Thames, and of Indian reserves there and on the St. Clair river and lake Huron in Lambton county; and there are also some interesting observations of natural history that deserve attention. But these must be left unnoticed in this paper, in order that its short remaining space may be devoted to the largest of Mr. Burwell's undertakings in his later years as a land surveyor.

The Government of the Province in 1825 made provisional terms with the Chippewa Indians of the London and Western Districts for the surrender of 2,200,000 acres lying to the north and west of former cessions, and about the same time it entered into an agreement with the Canada Company for a transfer of 1,000,000 acres of the same land, in a block which afterwards became famous as the Huron Tract. By order from the Surveyor General's office of July 6th, 1827, the survey of the northern boundary of the new purchase was undertaken by Mr. Burwell, and the work was carried on and completed during the months of September, October and November. Provisions for the expedition were purchased at Guelph, and were packed northward to the starting point of the line, at the northwest corner of Garafraxa. A journal entry of September 19th reads: "Met Mr. Galt near Guelph, who invited me to dine on Friday the 21st Instant at his House near Burlington Bay;" and under the latter date is this entry: "Went to Dine with Mr. Galt at his House—was civilly treated—an agricultural party—Mr. Galt proposed that I should be a member of the Agricultural Society of which he is the head. I declined. Did not know that it was an agricultural meeting until after the cloth was removed. Left Mr. Galt's about 10 o'clock P.M. and slept at Mr. Beasley's." This is the nearest approach to a supercilious tone that I have discovered in all of Mr. Burwell's official writings. But no one could have more heartily enjoyed the scorn of the land surveyor than John Galt himself.

The survey of the line was commenced on October 4th. Ten days were spent in running 18⅝ miles, as progress was much hindered by dense swamps of cedar, tamarac and spruce. Then the head waters of the Menesetung river (now called the Maitland) were reached, and a very fine country was entered. During the next ten days the line was run 29½ miles, and the river was crossed frequently. In four days more, during which the survey bore away northward from the river, lake Huron was reached at 59 miles 39 chains from the starting point. Storms of rain, hail and snow were frequent, and the actual running time was only nineteen days.

The return journey occupied six days, and was made disagreeable by storms of rain and snow, and by the swollen waters of the river, which had to be frequently forded. The stores of provisions which had been left at various points for the return trip were found to be destroyed by wild animals, and it was observed that bears, wolves, foxes, fishers and martens had followed the party along the line. A note of Natural History is entered in the journal of November 3rd, upon the authority of the Indians. "The Deer all appear to have left Lake Huron, some time ago, for the Shores of Lake Erie, where the Snow does not fall so deep, and

* I heard this story from the late John Sinclair, who moved from Aldborough into Orford in 1832, and took up a lot on the Middle Road. My father, the late John Blue, was the second settler on this road in Orford, having been located by Col. Talbot late in 1826 or early in 1827. His nearest neighbor was four miles away, and the woods were alive with turkeys, deer and wolves.

this the Chippewa Indians inform me is uniformly the case with them every Autumn, to avoid being taken by the Wolves during the deep snow of this neighborhood, which is frequently crusted over." This is doubtful, and I do not think it has been confirmed by observation elsewhere in our country.

The instances are exceedingly rare in which the land surveyor unbends himself in the letters and journals of Mr. Burwell, and one might suppose that the beauties of landscape and of woodland scenery were unappreciated by him. But over the Huron Tract he grew almost eloquent. "Notwithstanding the fatigues and privations attendant on such a tour," he reports to the Surveyor General, "I have had great pleasure in Surveying the purchase line—the country through which it passes is magnificently fine. The River Menesetunk is about half the size of the Thames. It is a fine River of pure clear water. Its banks afford numerous eligible situations for country seats to the right and left, sufficiently elevated and in variety to add beauty to their appearance, and in general they are easy of access, and the Flats extensive. When you are in possession of the Field Notes, Map, and report of the Survey of the purchase line, and the exploring expedition for the Canada Company in detail you cannot fail to feel a deep interest in this part of the country."* It would be a wonder indeed if a stream of so much picturesque beauty flowed on forever without a poet to write a verse in praise of it. The Menesetung has its singing lover, and although I think his genius has been nurtured overmuch on the metrical version of the Psalms of David, he sings out of the heart with a swelling note and a touch of Robert Burns.†

Unknown to fame thy waters run,
  Past groves of living green ;
And all obscure they gently flow
  Thy leafy banks between ;
Thy beauties ne'er have found a voice,
  Thy charms are yet unsung ;
Be mine to sing in humble strains
  Thy praise, Menesetung.

No tumbling torrent roaring down
  Its rocky bed art thou ;
Thy peaceful waters murmuring low
  Kiss soft each nodding bough ;
The sombre cedars bathe their limbs
  Thy crystal depths among ;
And mirror'd hemlocks sigh to thee,
  Oh, fair Menesetung !

The dappled trout in many a pool
  Their speckled beauties hide,
Or, startled from their shy retreat,
  Swift down thy current glide ;

* Menesetunk, as the word was written by Burwell, is stated by him to signify in the Chippewa language a large, open harbor. In a private letter to Ridout he says : "The Canada Company have called it the Nocton, after an estate of the Father of Lady Goderich in England, and they have called the mouth of the River Goderich Harbor." Mr. J. C. Bailey, the railway engineer, who is one of the best of our local authorities, writes in reply to an enquiry : "Goderich, or in that neighborhood, was called by the Indians Ma-ne-se-tung. So, if the Maitland river was called after the village—as the rivers generally are—it should have the word 'se-be' after it, which means a river, and should then read Ma-ne-se-tung-se-be. Me-nis means an island; Me-nis-ing, in, at or on an island ; Me-ne-ting, an island in a river ; Me-ne-te-goje-wun, an island in a rapid." At about 25 miles from the starting point of the purchase line survey it is described by Burwell as "a fine River with Islands, gentle banks, and Stoney bottom."

† The writer is my associate in the Bureau of Mines, Mr. Thomas W. Gibson, who was born in the v[illage] of Wroxeter, on the banks of the Maitland.

The wild canary builds her nest,
 And rears her timid young
Upon thy calm sequestered banks,
 Oh, sweet Menesetung!

No lordly ships thy bosom bears,
 Slow-moving, one by one,
Unknown, obscure, thou turnest still
 Thy bright face to the sun;
But while my heart within me beats
 Till life's last change is rung,
I'll love thee still, and love thee well,
 Oh, dear Menesetung!

But if an idea that once possessed some leading men of the Canada Company had taken substantial shape, the "lordly ships" might have become a moving feature on the bosom of the Menesetung. Mr. Burwell was strongly impressed with the practicableness of the scheme; and in his report to the Surveyor General he ventured the opinion that the river might be the means of affording greater facilities for making a canal to pass between its banks and communicate between lake Huron and lake Ontario than any other that could be selected for the purpose. This river, he observed, passed through a very fertile tract of country, and discharged itself at a good position into lake Huron, so that a canal in its direction could not fail to produce very great advantages as well in a commercial as in a military point of view. "In producing the purchase line from its place of beginning, after crossing several rills trending in Northwesterly directions, I crossed the Menesetunk in the 21st Mile at which place it is 80 links wide, and 18 inches deep, coming from the North East and affording I should think a sufficiency of Water for a canal. Between the 21st mile and the 45th mile, the line crosses the Menesetunk, which constantly increases in size, seventeen times alternately, when it leaves the line and trends southerly to where it disembogues itself into lake Huron. Its general course is westerly, watering equally well the tract of country not yet conceded to His Majesty's Government with the late purchase. The rapidity of its current will compare with that of the River Thames, or Grand River, excepting that for several miles above the outlets of those rivers, their waters are apparently dead while the current of the Menesetunk continues to within half a mile of its entrance into Lake Huron. The Grand River having its source nearly upon the summit level of the lands between Lake Ontario and Lake Huron, and being sufficiently large to afford feeders to a canal to both right and left, I conceive that the difficulty of connecting its waters with those of the Menesetunk and the 12 Mile creek might be accomplished with more ease, and at less expense of excavation than might be at present anticipated. I should think that a position some ten, or fifteen miles above the Falls of the Grand River might be the best; from whence a connection could be made with the waters of the 12 Mile creek, along the side of which the canal could be taken to Lake Ontario. Should such a work be undertaken, and a position selected for crossing the Grand River at, or near the Falls, the feeder could be brought from a sufficient distance up the Grand River to avoid any increase in the expense of excavation save that of the feeder, and then if it was thought expedient, the Canal might be taken past the Town of Guelph, and connected with head waters of the 12 Mile creek in Flamboro' East, not far from the Road which has lately been surveyed from Guelph to the rear of the Flamboro's, or if no obstacle should prevent it, pass directly to the Canal at Burlington Bay." But nothing was attempted, and however feasible the project might have been when the whole country was in forest, and the streams were full and strong-flowing throughout the year, it is scarcely possible under present conditions that it can ever be revived.

There are a number of other interesting matters in the Burwell letters and journals that I would gladly have touched upon, but my paper is already much too long. In the preparation of it one of my aims has been to direct the attention of others who have more leisure than myself, and who possess historical tastes and gifts, to a treasure house of material which no one has yet ventured to explore or work over, and of which the Burwell letters and journals are a very little part. But whoever will undertake to exploit that treasure house with any degree of intelligence and thoroughness will soon become convinced that there is necessity for a new departure in the care of its contents, which ought to be treated as possessing great historical as well as official value. If we cannot have a Reference Library for the Province, with a Librarian possessing industry and genius in charge of it, established upon the scheme conceived and matured by the Canadian Institute, let us at least have a Provincial Archivist, whose office should be the collection and care of every paper, and letter, and record, and document that concerns the public and official business of the Province.

BIOGRAPHICAL NOTE. The Burwells are an old family, whose homes in England were in Bedford and Northampton. More than two and a half centuries ago some of them came to America, settling in Virginia. They were loyal to Charles I. throughout the Civil War, and some were loyal to George III. in the American War of Independence. In Sabine's Loyalists a sketch of one James Burwell of New Jersey shows that he served the King seven years, having enlisted in 1776, that he came to Upper Canada in 1796 where he received 200 acres for himself and each of his children, that he removed to the Talbot Settlement in 1810 and died there in 1853, aged 99 years five months. He was probably related to Adam Burwell, but that is uncertain. The latter was also a native of New Jersey, and came to Canada with his wife and family after the war. The records show that he settled in the township of Bertie, and that in 1797 he received a grant of 850 acres of land for military service; but the petition in which his claims were set out appears to be lost. There is a tradition in the family that he had large possessions in New Jersey, and that they were confiscated by the Government of the United States. Adam Burwell spent the later years of his life with his son, Col. Burwell. He died in 1828 at the age of 79, and was buried beside the walls of the English church in St. Thomas. His eldest son was the Mahlon Burwell of the foregoing paper, who was born in New Jersey February 18th, 1783, studied land surveying, and through the influence of Col. Talbot got professional employment from the Government. In 1811 Mahlon Burwell was appointed Registrar of land titles for the District of Middlesex, and in 1812 he was elected to represent the Districts of Middlesex and Oxford in the Legislative Assembly of Upper Canada. He held the rank of Lieutenant Colonel of militia at this time, and during the war of 1812-14 was active against the enemy on all occasions, and became odious to them, although there is no record of his being in any battle of the war. In 1814 a band of Americans raided the Talbot Settlement, and although Col. Burwell was in his bed, ill of fever and ague, he was carried off a prisoner and held for many weeks in Ohio or Kentucky. In a second raid his buildings were destroyed by fire and his family was driven off. In 1815 he was established in Southwold, where the Talbot Road crosses the townline between Dunwich and Southwold, afterwards known as Burwell Park. A new Registry building was erected there in which the office was kept until by authority of an Act of the Legislature it was removed to London in May, 1843. Col. Burwell was re-elected to represent Middlesex and Oxford in 1816 and again in 1820. A redistribution took place before the next general election in 1824, and John Matthews and Dr. John Rolph were chosen to represent Middlesex. They were successful again in 1828, and referring to this contest in a private letter to Hon. Thomas Ridout (Aug. 22nd, 1828) Col. Burwell wrote: "Our Election lasted 6 days—when the Poll closed the votes stood—for Rolph 340—Matthews 317—Burwell 305 & Hamilton 275. Matthews 12 over me, and many of my Friends not allowed time to vote, although returned to the poll two or three times for that purpose." In 1830 Burwell was successful in Middlesex, but was defeated in 1834, and in 1836 he became the first representative of London town. During the whole of this period he held the offices of Registrar and Postmaster, and was almost constantly employed by the Government as a surveyor of Crown lands. But in those days the provisions of the Act for the Independence of Parliament were not as rigid as they are now. Col. Burwell had a family of seven sons, all but two of whom were named after great soldiers, viz., Alexander, Hercules, Isaac Brock, Leonidas, John Walpole, Hannibal and Edward. He had also two daughters, Louise and Mary. Of these only Edward and Mary are now living. All except Alexander and Louise are named in the will, which was executed eight days before Col. Burwell's death, and Alexander is no doubt the child referred to in a pathetic note to the Surveyor General (Dec. 20th, 1817) written to explain delay in reporting a survey in Westminster. "You would have received the report long since, had it not been for a most dreadful circumstance which occurred in my Family in October last, which deprived me of the use of my right hand for more than two months—A little son of mine two and a half years old was scalded to death, and in taking him out of the boiling water I scalded my Hands as related, but my right hand the worst." One ambition of Col. Burwell's life was to found a family, and with this object he memorialized the Governor in Council in 1829 for permission to extinguish his claim for 10,000 acres of land held in small isolated areas and receive in lieu thereof a block of 10,000 acres on lake Huron, adjoining the southern boundary of the Canada Company's territory, wherewith to make an entailed estate to his heirs forever. But no action appears to have been taken in the matter, and the records do not even show that the memorial was considered. But the idea possessed Col. Burwell's mind to the end, and by the terms of his will it was provided in the case of each of the sons that the lands bequeathed should be held to himself and his male heirs forever, and in the event of anyone of the sons dying without issue the lands should descend to the next son and his male heirs. "I have willed thus to fasten the before mentioned freehold estates upon my children and their heirs forever because my own experience, which has been extensive in this Province, and History have shewn me that children place less value on that which is given them than that which they acquire by their own care and industry; and because I have acquired the estates so willed and devised by a steady perseverance and laborious industry in my profession as a surveyor of lands, of which my heirs can never be sensible: I exercise this moral, legal and conservative right for their benefit: And when advanced in age my heirs in all time to come if they be sensible persons will know how to appreciate the soundness of my motives." Ermatinger, who has written unjustly and unkindly of Col. Burwell (Life of Col. Talbot), says he was tall in stature and dignified in appearance.

THE ILLECILLEWAET GLACIER IN THE SELKIRKS. BY ALBERT PENCK.

From The Journal of The German and Austrian Alpine Society.

(Translated by D. R. Keys, Toronto, Canada.)

(Read April 29th, 1899.)

The Cordilleras of Canada separate a well-watered coast from an arid interior. The moist winds, which blow from the northern Pacific into the interior, on meeting with the individual chains of the mighty mountain system, give up their moisture and then pass on, dried out like the Swiss Fohn, over the valleys beyond, until they have to ascend anew in order once more to lose their aqueous vapor. Each of the different chains, which, running north and south, form the Canadian Cordilleras, has, like the Cordilleras themselves, its weather side and its dry side. This is seen plainly in the course of the snow line. It lies lower on the west slope of the chain than on the east side. He who would view the Cordilleras as a snow-clad chain must observe them from the west; from the east they appear as a rocky chain, the "Rocky Mountains."

It is a bare, bald wall which rises above the great plain of North America. When first seen in lat. 51° N., not far from Calgary on the Canadian Pacific Railway, it resembles the Karwendel chain south of Munich, and although here reaching a height of nearly 3,000 meters, it is below the snow-line. It is the same in the National Park near Banff, so rich in beautiful landscapes. Not till we approach the watershed between the Atlantic and the Pacific streams, do we see snow-fields and glaciers. Near the height of land we can see from the railway the glittering ice upon the flanks of Mount Stephen. It is barely 200 meters higher than the highest mountains around Banff, and if capable, like its neighbors, of supplying ice streams, this is due less to its height than to its western position. Its situation brings it further into the snow limit which here must be sought considerably below 3,000 meters, (somewhere between 2,700 and 2,800 meters high).

The chief range of the Canadian Cordilleras, the Selkirk chain, lying in the bend of the Columbia river, likewise appears free from snow when seen from the east. These are broad-shouldered mountain masses, which rise to the west of the broad valley of the upper Columbia near Donald. The scenery here reminds one of the wide valley of the Inn with the Patscherkofel above Innsbruck, and the railway line which leads up along the Beaver Creek encloses landscapes like those of the Brenner railway. The top of the Roger pass (1314 m.) is, however, a narrower cut in the mountain than the Brenner; on both sides rocky peaks tower up to 2,800 or 2,900 meters. Then it descends into the valley of the Illecillewaet, the railway making the descent by a series of loops. At the same time a magnificent glacial landscape is unfolded and soon the train stops in sight of the splendid Illecillewaet glacier at the station called Glacier, (1256 m.) This station was the headquarters of William Spotswood Green * and Topham, Emil Hueber, † and Carl Sulzer, ‡ as well as H. P. Nichols § and Charles E. Fay ‖ in their ascents of the mountains and glaciers of the Selkirks. The passenger trains of the C.P.R. make this their mid-day station. Those on board here enjoy a

*Explorations in the Glacier Regions of the Selkirk range, British Columbia. Proc. of the Royal Geographical Soc., London, 1889, p. 153. Among the Selkirk Glaciers, London, 1890. (This book I had not at my disposal). Climbing in the Selkirks and the adjacent Rocky Mountains, the Alpine Journal XVII., 1895, p. 289

†Im Hochgebirg von British Columbia, Jahrb. Schweizer Alpen-Club. XXVI., 1890-91, p. 258.

‡Bergfahrten im Far West. Ibid., p. 290.

§Back Ranges of the Selkirks. Appalachia VII., 1893, p. 101.

‖Up to the Crags of Sir Donald. Ibid., p. 157.

spectacle such as can be seen on no other artery of the world's travel. Scarcely 2½ kilometers from the station above the dark pine of the primeval forest shines a glacier in the perfection of purity. On the left Sir Donald (3250 m.) raises its proud summit of rock, from which a comb extends in whose cirques twinkle snow fields and tiny glaciers; the Eagle and Avalanche peaks stand out boldly. On turning around you see the beautifully formed pyramid of Mount Cheops, which although only 2,704 meters high conceals a couple of glaciers on its flanks. If the loop of the Brenner railway at Gossensass extended as far as Innerpflersch and the Feuerstein glacier came to meet it at Stein, then one would have a European parallel to the magnificent surroundings of Glacier House, which the C.P.R. has erected here, with every comfort in the immediate vicinity of its line.

I could not indeed quite fully enjoy this scenery when I reached Glacier Sept. 3rd, 1897. I came as a member of one of those exceedingly instructive excursions under excellent guidance, (our guide was the Director of the Geological Survey of Canada, Dr. Geo. M. Dawson), which were connected with the meeting of the B.A.A.S. in Toronto. Heavy clouds were collecting over the mountains and from time to time showers fell. The plan of some enterprising members of our party, to climb Mount Abbott (2,380 m.) behind the hotel immediately after the train arrived, proved impracticable and all our attention was concentrated on the Illecillewaet glacier, which was introduced to the travellers as "The Great Glacier of the Selkirks." The position of its tongue makes it certain that the snow line here lies very deep. In view of the small glacier on Mount Cheops and of small ones figured by Green on Mount Abbott, I should estimate it at from 2,200 to 2,300 meters at the highest, which, considering the dryness of the territory lying further west, appears remarkably low.

The way to the glacier leads through the primeval forest with its lofty trunks, under cedars, Douglas firs, Canadian pines, hemlock trees and balsams, which conceal it from view, until we leave the wood. There to the south of the road lies a great boulder which affords an excellent view of the ice tongue, (Point P5 of the diagram). It reminds one to some extent of the Rhone glacier; rising with a gentle slope it is traversed by only a few radial fissures. Above there is a precipitous ice cascade. Here the glacier is broken up into individual *seracs.* The higher glacial field, the nevé does not become visible. It leads across to the Geikie glacier. A moraine, 70 to 150 m. broad, extends around the tongue and continues up the sides in two lateral moraines. The one on the right, near the foot of the wall over which the glacier descends, rises some 30 meters above it, the one on the left is considerably higher and steeper. This ground, which it is plain has only lately been free from ice, is surrounded by a space twice as broad, on which there is nothing but low underbrush. Then follows the forest with its giant trees in which lies our point of observation.

There can be no doubt that the glacier is retreating fast. The flat form of the tongue shows this, and still more the moraine in front of it. It can only recently have been free of ice, otherwise it would certainly have been occupied by the luxuriantly growing plants of the land. As a matter of fact one of Notman & Son's magnificent photographs taken in 1888 does not show the moraine. At that time the ice reached close up to the underbrush, and was surrounded by a low wall of boulders which now encircles the space free of ice with a terminal moraine perfectly well defined although only a few meters high. We have therefore indubitable evidence of the fact that the retreat of the ice only began after 1888. This is further confirmed by eye-witnesses. When the Rev. W. Spotswood Green explored the neighbourhood of Glacier House in 1888 it seemed to him that the ice tongue was advancing, for it had overturned some bushes at the northeastern extremity.

At the same time, however, the Rev. Mr. Green says that at the time of his visit all the glaciers in the Selkirks bore evidence of retrogression. He mentions the huge boulders which are met with on the road from the Glacier House to the glacier, and considers them moraines of an earlier glacier, made up of the Illecillewaet and Asulkan. The lofty tree trunks of the neighbouring forest would show the period of this giant glacier to be centuries ago, granting Green's explanation of the boulders to be correct. But there can be no doubt that the glacial high tide (Gletscherhochstand) of the end of the eighties has been preceded by one of no long duration. This is shown by the brushwood that girdles the tongue. There must have been a state of affairs here not so long ago which hindered the growth of trees. The form of the land together with the numerous boulders, sometimes arranged like a wall, makes it certain that the glacier lay here at one time. Just how long ago can be estimated by the botanist who is familiar with the rapidity of the growth of plants in the Highlands of British Columbia. If it were in the Alps I should not hesitate to describe the brushwood-covered plain as the growth of some twenty years—it reminds one vividly of the bushes on the former site of the lower Grindelwald glacier. But the luxuriant growth of the primeval forest of British Columbia suggests the idea that everything grows more rapidly there than with us. Be that as it may, it cannot be so very long since that advance of the glacier took place to which the sharp boundary between brushwood and forest so plainly points and which is confirmed by the form and configuration of the land. It certainly belongs to our departing century. But it must have been the greatest advance for centuries, for it carried the ice forward to a wood with lofty trunks which, measuring at times two or three meters, must be centuries old. We have thus evidence in the distant Selkirks pointing to the same conclusion as in the Alps, viz., that the glacial advances in our century have been the most important for several hundred years.

Visitors to the Illecillewaet glacier are struck by the great purity of its upper surface, which is specially noted by Green. We have to do with one of those not uncommon glacial tongues which have no superficial moraines. This is no wonder, for the nevé has no rocky masses behind, it fills a long valley up to a height of about 2,700 m. and has besides the Illecillewaet glacier to the north, an outflow to the west in the Geikie glacier. The same arrangement is repeated in a similar valley not far to the south, where the Deville snowfield supplies both the Deville and the Grand glaciers. These conditions bear witness to a peculiarly low snow limit on the rainy side of the mountains. This lack of upper moraines is by no means accompanied by a lack of ground moraines. On the contrary, the whole plain now free from ice is covered with them. Immense quantities of glaciated stones lie around ; one sees the markings plainly on great boulders. This mass of material must have been brought along under the ice. Near to the edge of the glacier it seems as if it had been rolled with a broad roller. Broad, flat furrows are seen extending in the line of movement of the ice and separated by low-arched ridges. The two lateral moraines consist likewise of ground moraine material. So we have in the main the same conditions as those of the Sonnblick glacier which I described last year to the readers of this journal. We see again that the formation of the ground moraines is independent of that of the upper moraines. To those versed in the subject this is nothing new.

All the small glaciers that I saw about Glacier House are deeply sunk in their lateral moraines, and therefore seem to be retreating. The phenomena on the Illecillewaet glacier might therefore be generalized to a certain extent. Its special accessibility allows us to hope that it may often be observed in the future. It was therefore my intention to mark its position as observed on September 3rd, 1897.

But unfortunately there was no coloring matter or tar to be found either at the station or at the hotel. So I tried to sketch the position of the tongue in its relation to the surroundings as far as was possible by counting steps and the use of the compass. The result is the accompanying diagram on the scale of about 1:10,000.

I reckon the length of a step on the very uneven surface at 0.75 m. I determined the direction and the distance from the ice of three very marked erratic boulders, P_1 P_2 P_3 as well as of the Point (P_4) where the glacial creek leaves the space that is clear of ice. These are :

	For P_1	P_2	P_3	P_4
Magn. North	200° 72 steps.	N. 220° 26 steps.	N. 200° 20 steps.	N. 110° 225 steps.
True N.	226° 54 m.	246° 20 m.	226° 15 m.	136° 169 m.

I measured the heights with one of Naudet's large pocket aneroids. They are referred to the bridge over which the foot path leads to the glacier. Its height was 195 m. above the station Glacier. As the weather was uncertain this estimate, according to which the glacial tongue would be 1,461 m. high, can lay no claim to accuracy.

The tar marks made by Green I was unable to find. At P_7 however I saw a boulder with the mark COE. 1895, and at P_6 an arrow on a block. I could not find out who had made these marks. A railway labourer undertook to paint my marks (P_1 P_2 P_3 P_4).

The pictures on pp. 56 and 57 are prepared from photographs by Notman & Son in Montreal.* That on the left shows the glacier in 1888. The ice projects as far as the bushes and is still comparatively high in the arch. The one on the right, which I owe to the special kindness of Messrs. Notman & Son, was taken in October, 1897. The standpoint in both pictures is almost the same. Again one sees the high woods on the right and the girdle of lower brushwood, with the same inner border as in the other picture. But the ice has retreated. A wide strip of rubbish lies between it and the glacier. One can plainly recognize the great erratic boulders which are marked P_1 and P_3. The tongue has not only receded, but is also very much shrunken. The lateral moraine on the left has at the same time increased in size. Above the rocky drift which separates the upper and lower glacial masses, the ice has also been retreating.

*These are not reproduced in this translation.

Observations Made on a Tour in Canada. By Albert Penck.

A Paper Read on March 16th, 1898,

With 12 illustrations in the Text.*

From the 38th Vol., No. 11, Society for the Extension of Natural Science, Vienna, 1898.

(Translated by D. R. Keys, Toronto, Canada).

The British Association for the Advancement of Science met from August 18th to the 24th, 1897, for the second time on Canadian soil, at Toronto, on the north shore of Lake Ontario. The Government of the British Dominion of Canada and of the Province of Ontario, the Council and population of the city of Toronto, the great railway companies and all the scientific circles throughout the wide extent of British North America vied with one another in order to make the stay of their guests from the Mother country upon Canadian soil as pleasant and as instructive as possible, and in order to give them the most agreeable impression of the country. Connected with the meeting were extended excursions, partly in the neighbourhood of Toronto, partly under distinguished guidance across the continent as far as the island of Vancouver on the coast of British Columbia, the El Dorado of the present and near future.

A week before the meeting of the British Association for the Advancement of Science at Toronto, the American Society of the same name met from August 9th to the 14th, at Detroit, on the strait between Lakes Erie and Huron. It was a sign of the excellent relations between Britons and Americans that each society invited the other; first, the British were the guests of the American Association, which, realizing the pan-American idea, has members on both sides of the forty-ninth parallel, then the Americans attended the British Association, which represents the intellectual unity of the world-wide British Empire. Thus it was that within a short space of time an excellent opportunity was offered of meeting with American and British scientists in two places which, for that country, are not far removed from each other. While at Detroit a large number of American investigators had met with a considerable number of their British fellows, the meeting at Toronto offered such an assembly of British and American scholars as has probably never before taken place. One may say with confidence it was a meeting of the most eminent English-speaking scholars; one got not only the idea of a British world-empire, but still more of the actual existence of an English world-speech.

It was my privilege to be invited as an honorary guest to the British Association, and I also attended the American meeting in the same capacity. Never can I forget the days which I passed, first in Detroit and then more especially in Toronto, in a circle of illustrious men. The excursions connected with the British Association mark an extension of my geographical horizon such as I had never before experienced. But the recollection of all this scientific gain is rivalled by the memory of a truly magnificent hospitality which I enjoyed from my place of embarkation to the New World, that is, from Liverpool across the Atlantic and from its western edge across Canada to the Pacific.

The shortest, although not the quickest, way from Europe to Canada leads across the North Atlantic to the Straits of Belle Isle, which afford an entrance between Labrador and Newfoundland to the Gulf of St. Lawrence. By this summer route of the Canadian steamships from Liverpool to Montreal, one comes within 800 kilometers of Iceland and 500 kilometers of the south point of Greenland, and arrives at the most inhospitable part of the coast of America, that of Labrador. It is washed by the cold Labrador current, which bears the icebergs of Greenland away south to the Banks of Newfoundland. On the evening of August

* It is unfortunately impossible to reproduce the illustrations in this translation.

3rd, 1897, the *S. S. Laurentian* had reached this cold current. The temperature of the water, which is taken every two hours, fell suddenly, it became unpleasant on deck, and on the afternoon of the 4th the first icebergs came in sight. Three peaks arose from the waves like a mountain chain on the horizon. They shone with dazzling whiteness over the gloomy sea. Then a new one hove in sight further back. We came considerably closer to it and so it made a more imposing effect. Finally in the evening a magnificent white pyramid was sighted. The day after the cold current made itself felt by a thick fog, which lay heavy over the sea. The *Laurentian* had to stop frequently to avoid collisions with icebergs; several floes drove past close by. By noon the observation showed us to be near Belle Isle, but no land in sight. The steamer stopped again and sounded the fog horn every twenty minutes. Finally in the evening, when the fog lifted a little, we saw the light of Belle Isle, after the cannon shots which we heard from time to time had made known to us already the nearness of this dreaded island. The captain, however, would not risk a night entrance into the cliff-bound straits, and we lay to again. The next day, fog again, the *Laurentian* advanced at "stand-by," in order to stop again presently. Then all at once a light streak became visible in the fog, and in a few minutes it was certain that the land was just in front of us. A dark mass of rock rose from the sea, the beach still spotted with snow, although it was only August 5th. Such is Belle Isle.

For a time we continued our way past ice-floes and icebergs, gloomy land in the distance and an oppressive fog over it all. So the first impression of America at this point, where it is bathed by the waters from the Pole, was exceedingly unfriendly. Soon, however, upon entering warmer water, the weather cleared and the rest of the passage through the Gulf of St. Lawrence was very beautiful.

We seldom lost sight of land. In the north we saw the round humped mountains of Labrador, and of the northern part of the Province of Quebec. In the south the forms were quite different—long extended ranges with few divisions and high level plateaus on top. Such was the north coast of Newfoundland as we saw it during the rest of August 5th, and such too as seen on August 6th, were the mountains of St. Anne, 1200 meters high, on the peninsula of Gaspe, forming the southern shore of the long funnel shaped inlet which already at this point usually receives the name of the St. Lawrence river. On the northern shore rounded mountains about equal in height still prevail. We are here much impressed with the fact that we are travelling along one of the most important lines of disturbance in the geological formation of eastern North America. This is the St. Lawrence and Champlain line, which separates the primeval Laurentian land in the north, the protaxis of the American continent or the Laurentian shield, with its occasional covering of irregularly deposited palæozoic strata, from an old much-folded mountain chain composed of palæozoic rocks. By this contrast in form the journey up the St. Lawrence (whose waters are salt as far as Quebec) acquires a picturesque quality which is very attractive. The forest, which avoids the coasts of Labrador and Newfoundland, now comes down close to the sea in thick groves, only here and there destroyed by forest fires. Another feature of the landscape impresses itself at once on the attentive observer; parallel lines extend along the shore at varying distances from the water. Sometimes they appear as indentations in the declivity, sometimes as terraces in the openings of the little valleys of the precipitous Gaspe, as well as of the northern coast. These are the shore lines of an earlier sea, indented by the force of the waves, or heaped up by the rivers, after the great ice age when the land lay one or two hundred meters lower than to-day, and gradually but unsteadily rose with frequent interruptions. To every period of rest in its rise corresponds one of those terrace-like levels on which the Canadian French are so fond of building their little white houses.

Below Quebec at Grosse Isle is the real mouth of the River St. Lawrence, that is the place where the fresh water is severed from the salt. From here to Montreal the landscape is more monotonous, the mountains retreat on both sides and the shores become lower as we go further inland. The river itself often divides into numerous branches. Yet the journey is not uninteresting. Only we must not lose sight of the fact that we have travelled almost 300 kilometers up the river into the country on a great ocean steamer, and that the river has only by artificial means become the magnificent waterway that it is to-day. In various places canals have been made.

Our progress into the interior of the continent made itself apparent by an increase in warmth—August 8th brought great heat, all the more unendurable because a few days before we had been fairly frozen among the icebergs. In the winter, however, it becomes bitterly cold; every year the St. Lawrence freezes, and that so hard that they can carry the railway over it at Montreal. Still I could not discover any effect of the moving ice upon the form of the river bed, or upon the transport of boulders. The river bed has the same form as that of streams which have but little ice, and the accumulation of boulders on the shore is confined to places where the clay has been washed down. Near Lotbinière only, it rushes along between heaps of boulders, and evidently it here traverses a mass heaped up in its bed during the ice age.

At midday on August 9th I landed in Montreal after a journey by steamship of 5146 kilometers. I was strongly tempted to stay in the neighbourhood of this city, where a boss of eruptive rock breaks through the superincumbent Silurian strata to form Mount Royal, which again bears glacial marine deposits almost to its summit. But, it seemed to me more important to go on at once to Detroit in order to meet the American investigators. Thither I hastened, merely making a short stop in the capital of Canada for the purpose of viewing the collections of the Geological Survey of Canada. I had then for the first time the pleasure of meeting with its director, Dr. Geo. M. Dawson, who afterwards guided the great excursion across the continent.

In Detroit the opportunity, for which I had been secretly longing, arrived, that is to make an excursion under approved guidance to the shores of the great North American lakes. These waters are of sea-like dimensions, on their shores the waves wash down cliffs as on the coasts of the oceans and cast up beaches, while the current along the coast forms spits and sandbars. All these phenomena have been excellently described by Gilbert, and it was a matter of great importance to me to see them as well as a number of other phenomena. Above the present shore line, for instance, there extend others belonging to an earlier period of higher water levels. The investigations of Gilbert, Spencer and Taylor have shown that they are not parallel with the present water line, but have a regular ascent towards the northeast. This fact is theoretically of great importance, for it leaves but one deduction possible, that of a general rise of the land which was stronger in the northeast than in the southwest. Therefore American scientists speak quite confidently of great elevations of the land, of a warping, a bending of the earth's crust, while Ed. Suess in Europe gave quite another significance to the phenomena on the Scandinavian coast, and being dubious as to any general rising of the land referred them to a movement of the surface of the sea.

To my great good fortune Grove Karl Gilbert himself met my wishes and conducted me around the phenomena which he discovered and described. After attending the meeting of the A. A. A. S. on August 10th to 12th, and visiting some sunken valleys near Detroit under Taylor's guidance, I found myself on the 13th in Buffalo, where I was to meet Gilbert. We first visited the counties on the south shore of Lake Ontario in New York State, where, like the fingers of a hand a number of long narrow lakes lie between pleasant shores, then we travelled to the western extremity of Lake Ontario in order to proceed along its northern bank to Toronto.

At the very start our journey afforded us an interesting phenomenon. A long sandbar entirely separates the western end of Lake Ontario from the lake itself, so that a wide bay stretches along beside the inland sea. On this is situated the flourishing city of Hamilton, built upon a terrace which evidently represents an old lake shore. From this terrace a broad dike, thirty-four meters high, and scarcely forty meters wide on top, extends like a railway embankment towards the north, separating marshland from the bay already mentioned. It has been cut through in the middle, and one can see that it consists of coarse gravel resting on fine sand, underneath which lies clay. It is a recent accumulation that we have here. The inhabitants of Hamilton have no doubt as to its origin. They regard the dike rightly as the sand bank of a Lake Ontario which stood thirty-four meters higher and which created also the present site of their city. Beside this older sandbank runs a recent one that converts the west end of the lake into a great bay. From here on we followed without interruption the old shore line—Gilbert's Iroquois line. Everywhere it is easily recognized, here as a cliff, there as a high strand line (strandwall), then again it develops into a spit or a dike—an old sandbank—across the front of a little valley. We were thus convinced that we were following the same higher shore continually. After following it for forty-five kilometers we measured its height at Cooksville, finding it forty-five meters above the lake, and when I was visiting the interglacial deposits at Scarboro' Heights with Prof. Coleman a few days later, I met the Iroquois shore line sixty-nine meters above the lake. It rises, therefore, thirty-five meters within a distance of seventy-five kilometers as the bird flies, that is to say in round numbers 0.5 m. per kilometer in a northeasterly direction. The old surface of the lake as shown by the Iroquois shore line is inclined towards the present one at an angle of almost two minutes. It is out of the question that such an inclination of a water surface could exist, or that at the time of the formation of the Iroquois line the surface of the lake could differ to such an extent from that of to-day. We must therefore assume that since the origin of that shore line the district has been tilted up by a movement of the earth's crust. This is the same movement indicated by the beach lines in the Gulf of St. Lawrence. Canadian geologists have found that the marine formations here ascend in the direction toward southwest. Their greatest height (250 m.) is reached in the neighbourhood of Quebec. This is the middle point in a great arch-like upheaval, which has affected the whole St. Lawrence region along with the great lakes of North America since the ice age, and which, as Gilbert has lately shown, is still going on.

The excursion with Gilbert, several trips around Toronto under Prof. Coleman's guidance, finally an excursion which a number of members of the British Association took to Niagara Falls on August 22nd, all gave me an excellent opportunity to learn the character of the shore of Lake Ontario. It is gently rolling and cleared to such an extent that only a few patches of the original primeval forest remain. Everywhere stretch waving fields of grain, the well-to-do farmers' houses are often hidden in orchards, and indeed even the vine is successfully cultivated in Canada in the Niagara Falls district. The soil is almost everywhere fruitful. It is formed for the most part from the glacial deposits of the ice age, which are distributed over flat Silurian strata. On the northern shore of the lake these strata are of shale, on the south they are of limestone, giving a configuration to the country like that of the Swabo-Franconian Jura. This is the Niagara limestone formation at the foot of which Lake Ontario occupies a position similar to that of the Neckar district at the foot of the Rauher Alp. At the point where the Brock monument is built upon it, giving a wide lookout, this peculiar situation of the lake was very well shown on Aug. 22nd by Prof. Wm. Morris Davis, the distinguished American physical geographer. He expressed the opinion that the land surface around Lake Ontario, as indeed in all the region of the great lakes (except Lake Superior) has the features of a steppe-like landscape formed by subaerial denudation, and not much modified by glaciation, although the latter, as the disclosures at Scarboro' show, has been twice repeated. It has blocked up the old water-courses, as for example, a valley that coming from the west emptied into the lake near Hamilton. The rivers have thus been obliged to find new channels, and have not yet fully cut them out. The mighty Falls of Niagara bear witness to the youthfulness of its course. It has not yet cut through the Niagara limestone formation.

The various trips on Lake Ontario were only a prelude to the great excursions which were arranged for the members and guests of the British Association after its close. There were four of them. They all had as their objective point the island of Vancouver on the west coast of the British Dominion of Canada, but to send all the numerous participants thither at the same time would not only have been mechanically impossible, but also from scientific reasons impracticable. For a scientific excursion to be instructive must be strictly limited in its numbers. Consequently the company was divided into groups, each of which had a specialist as guide. One left Toronto as early as the 26th, conducted by Dr. Wm. Saunders, director of the Experimental Farms of Canada. It was specially intended for botanists and geologists. The next day the geologists and geographers set out. Our guide was the distinguished geologist of Canada, Dr. G. M. Dawson, who presides over the Geological Survey with equal practical intelligence and scientific breadth of view. He had himself explored a great part of our route, and as the geologist in America is generally obliged to take topographical observations, he was in every way a competent guide over wide regions whose geographical features had been recognized by him with great clearness. Moreover, his personal amiability and constant approachableness helped to make our long journey one in every way enjoyable. With him too was Dr. Coleman, Professor of Geology in Toronto, and State Geologist of the Province of Ontario, who likewise knows great stretches of our route by personal explorations. The C.P.R. assisted us by many favours and placed at our disposal a large sleeping car in which we lived the next nine days. There were twenty-seven of us. Among them I may name the former director of the Geological Survey of India, Dr. Blandford ; Mr. Lampleigh, of the Geological Survey in Great Britain ; the mineralogist, Prof. Miers of Oxford ; the Professor of Mining and Mining Inspector, Le Neve Foster ; the explorer of Kafiristan, Sir George Robertson ; and the explorer of the Amoor territory, Prince Kropotkin ; further, the secretaries of the Geographical Societies of London and Edinburgh, Dr. Scott Keltie, and Colonel Bailey, the librarian of the London society ; Dr. H.R. Mill, the Professor of Geography of Harvard University ; Dr. W. M. Davis, the director of the Museum of Natural History in Manchester ; Dr. Hoyle ; Prof. Armstrong, the chemist ; and the technicists, Prof. Beare and Dr. Harden of London ; as well as the Breslau physiologist, Prof. Hurthle. Our two leaders and guides were assisted by the Canadian geologists who were working in the district. Mr. A. E. Barlow was awaiting us at Sudbury, and Mr. McInnes joined us on the road to Rat Portage. Finally in Banff we met with Prof. Macoun, the botanist of the Geological Survey. We had thus every opportunity of being shown a very great deal in a very short time. While our company was not of one profession, we were one in the eager desire for knowledge. The wives and daughters of some of the members accompanied us, and took a friendly interest in the magnificent landscapes and broad, scientific impressions which we enjoyed.

We first went north in order to reach the line of the C.P.R. The richly cultivated land on the north shore of Lake Ontario was soon left behind, and we entered the immense primeval forest which extends from the great lakes northward to Hudson's Bay. The boundary between the horizontal beds of the Silurian formation and their subjacent strata, the primeval Laurentian and Huronian rocks, has offered a barrier to the extensive progress of clearing, and will to all appearance continue to do so. The Laurentian land has been smoothed off by the glaciers of the ice age, stretches of bare rock appear in smooth, humped barrows, the hollows between filled with loose débris and boulders. This rock, however, does not produce a fruitful soil like the Silurian slates and limestones ; it weathers very slowly, and since the ice age it has scarcely formed a humus. Besides the climate is very severe. The same conditions prevail as in Sweden and Finland, of which countries we are also reminded by the character of the extensive Laurentian forest. Rounded mountains of moderate height rise irregularly. Only here and there where they meet with specially hard rock do they take the form of ridges. Between stretch marshy plains or lakes full of islands, the only natural interruptions of the gigantic forest in which we travelled nearly 48 hours, almost 2000 kilometers.

A visit to a couple of mining districts on August 28th and 30th made a break in our long journey. At Sudbury, the point where the "Soo" line branches from the C.P.R. to Minneapolis, there is a rich deposit of iron pyrites on the boundary between the Huronian and Laurentian rocks. Along with the iron it contains copper and especially nickel, and is at present being worked with great energy. In the neighbourhood anthracite has lately been found in peculiar old slate deposits, upon which discovery the people of Sudbury are basing hopes that are probably too high. We were pressed by our amiable hosts to go there. An engine drew our sleeper some kilometers on, a stop was made on the line, and having taken to some rather rough wagons without springs, we continued our way to Vermilion Creek. Here we were divided up among a number of Indian canoes and heavy boats in order to row to Vermilion Lake. All the poetry of the Leatherstocking Tales at once came vividly back to mind as I was gliding forward upon the peaceful, mirror-like water between the trees of the primeval forest. Then our way led on by a narrow Indian path, a so-called trail into the lofty forest, now clambering over fallen tree trunks, now scrambling through them till we reached the spot in the middle of the woods where they were in the act of sinking a shaft. There under noble trees stood a puffing engine and several men were working in the midst of that lonely forest at what seemed to me a hopeless undertaking. In the neighbourhood, however, some settlers had already taken up their abode on the good alluvial soil. The forest was burned over, only a few charred rampikes rose here and there; plain log houses were built in which, however, there was an air of comfort. We also came upon a school in the midst of the forest as we returned.

At Rat Portage also, on the boundary between Huronian and Laurentian rocks, gold appears. Consequently this little town at the northern end of the Lake of the Woods is growing rapidly and the lake is crossed by numerous steamboats. The principal deposit lies on a little island in the lake; this mine, the Sultana, was the object of an excursion for which we were as much indebted to the municipality of Rat Portage as we had been to that of Sudbury two days before for the trip to Vermilion Lake. A little steamer took us through the labyrinth of islands and narrow channels past Indian camps and burial grounds to the Sultana, where most of the labourers are Scandinavians. We had a jolly picnic, viewed the galleries and workings of the mine and then the active members of the party hurried to the highest point of the island which had already been cleared of wood. The view from above was wide and striking—the lake in the woods, the wooded islands in the lake, rising as smooth, polished, rocky humps like the point on which we stood, and a cloudless sky above it all. Toward evening we went to another little island where peculiar breccia appears in the Huronian slate, the so-called agglomerate; whilst next morning Prof. Coleman showed us Huronian conglomerate in the town of Rat Portage. They can be recognized as such at once on the surface of the rounded humps, but one cannot strike off fragments from them. They leave it certain that the material of the Huronian slate has here orginated in the destruction of an old land. Undoubtedly we have in this case a clastic formation. However, the so-called Laurentian gneiss made the impression on me of a rocky mass, consolidated at a great depth, of a bedded granite somewhat like the Central gneiss of the Alps. The occurrence of the gold of the Sultana mine reminded me forcibly of that of the Hohen Tauern. There, too, the gold is found on the border between bedded granite and dark slate, the so-called Neuern, which is exactly like the Huronian of Canada. The exposures themselves did not seem to me, however, at all remarkable, only I was obliged to marvel how they could be discovered. This applies also to the nickel and anthracite of Sudbury. Only a very close investigation of the country could lead to their discovery. Such an investigation is in fact carried on by the "prospectors" who traverse North America in all directions even to the depths of the remotest forests in their search for iron and coal.

Between Sudbury and Rat Portage we came on the most beautiful landscapes of the Laurentian country which, with all its charms, is in general monotonous. In the night of August 28th-29th we crossed the watershed, some 400 or 500 meters high, between the Ottawa and Lake Superior, which latter we reached at noon the next day. The Laurentian country rises 200 or 300 meters above it and descends towards it with a bold fringe of precipitous rocks. Its valleys run under the water, the inlets of the lake extend far into the land. The railway winds along the shore for about 300 kilometers. Now it ascends the foot-hills from which a delightful prospect unfolds itself upon the sea-like lake which covers more space than Bohemia, Moravia and Silesia together; now it passes around charming bays in some of which are friendly havens.

A way had been prepared for it by the earlier shore line of the lake; the whole coast up to 120 meters above the level of the water is terraced in the plainest possible fashion by the old shore lines; gorges are to be seen in the foot hills, and piles of débris in the bays. It is the declivity of a mountain range along which we are travelling. But from the Nipigon Bay on the scenery changes. In front of the Laurentian heights with their irregular rise and fall, lie table mountains of a peaceful form. They consist of irregular beds of pre-Cambrian age, whose mighty tops are of trap. The boundary between this table mountain material and the Laurentian rocks is very remarkable. At the station, Mazokama, one can see how the latter is continued with its irregular upper surface under the former. One gets the impression that its typically characteristic irregularity dates from pre-Cambrian times. The same thing is seen in the northwest of Scotland, where the irregular wavy surface of the old gneiss dips under the irregularly deposited cover of Torridonian sandstone. To this, too, the stratified rocks of the Nipigon Bay have the greatest resemblance. We have thus in two widely separated parts of the earth's surface indications of a pre-Cambrian land surface which was afterwards renewed.

Towards the west the rounded landscape of the Laurentians gradually disappears under younger formations. At the same time the forest growth recedes, it is confined more and more to the singly rising rounded hills and finally disappears altogether with these. The meadow land, which at first only appeared along the overflowed districts, begins to be the rule. Within about an hour's journey by rail, this transition from primeval forest to prairie is completed ; Rat Portage is in the midst of the forest, Winnipeg, the capital of Manitoba, lies amid wide level meadows which take in the bottom of the former Lake Agassiz.

This is magnificent farming land, producing the very best wheat. Immense as was the forest before, the fields are now equally boundless, interrupted only along the rivers by wooded meadows. The land—an old lake bed—lies there as level as a table ; the railway, no longer obliged, as in the Laurentian district, to wind in continual curves around the numerous rounded hills, now pursues its way as though it had been drawn with a ruler. Instead of stopping as in the forest once an hour at the little group of houses made up of station, hotel and shops, undeserving the name of village, the train now passes prosperous villages often inhabited by Scandinavians, and draws up every twenty minutes at a station beside which rises a huge granary or elevator. The harvest is just over. The fields are mowed in a week, the corn is already threshed and the elevators are filled. Meanwhile the news has arrived of a failure of the harvests in the old world. Joy reigns in Manitoba. They speak of millions that must pour into the land.

The journey continues about 100 kilometers over the almost level bottom of the old Lake Agassiz before the road, which at Winnipeg attained a height above the sea of 210 meters, rises as high as 250 meters. Then certainly a slope becomes apparent. We must ascend the plateau of the cretaceous formation which extends through Western Manitoba. We soon reach a height of 500 to 600 meters, and for 500 kilometers this level is maintained with scarcely an appreciable rise or fall as we descend into the valleys of the rivers or ascend the water-sheds. The soil is still as fertile as before ; alluvial clay prevails. It has just been turned by the plough. Here and there we meet settlements with good prospects such as Regina, the capital of the District of Assiniboia. Further west the land changes. Previously level or rolling it now becomes hilly. It consists of a number of closely crowded eminences separated by level marshes.

One perceives at the first glance that the Missouri coteau which we cross between Mortlach and Ernfold is a true moraine landscape. But how different it appears here where it lies in a dry climate, from what it is in our richly watered land. Not a pond, not a pool, not a bog between the hills, nor any forest on them, not even a tree or bush ; no little brook winding its way through the landscape ; only a monotonous "up and down" covered by a comfortless steppe. For miles the dry vegetation is burnt away. The land is black with its charred remains ; only the white erratic boulders gleam ghostlike from the black plain. Here and there where the water has been able to remain some time on the level, a little green appears, the white crusted plains beside it are the remains of a dried up salt marsh. A group of larger salt lakes, the Old Wives lakes, persists from year to year ; the bottom of a freshwater lake now drained (Rushlake) serves as a farm. Not a house is to be seen for miles, perhaps once an hour the train stops at a wretched station. In other respects too the land is desolate, since the herds of buffalo which once inhabited it have been slain. At the station one sees great piles of their bones which have been collected on the steppe to be ground into bone meal. The very bare desolation of the land, however, aids us even in passing to get an idea of its structure. Several groups of moraine ramparts can be recognized, sometimes having a heap of débris lying in front of them. One is strongly reminded of the Alpine relationships ; but the whole Missouri coteau seemed to me like a dried up Baltic lake plateau.

This great terminal moraine rampart, like its European equivalent, does not indicate the end of the moraine formations. For not less than 500 km. to the west up to the foothills of the Rockies there is erratic material of Laurentian origin, such as boulder clay with polished stones. But the predominance of these glacial forms in the landscape is past. They become secondary features of the scene, the chief features of which receive their character from the irregularly laid cretaceous, and superimposed old tertiary (Laramie) strata. The latter form table rocks between the valleys, *e.g.*, the Cypress Hills, which bear the only forest in a wide circumference. A zone of moraines covered with loess is not present; the loess in America as in Europe does not reach above 300 to 400 meters. From the Missouri Coteau, which marks an ascent of over 100 meters, the C.P.R. keeps at a level of over 700 m.; only at Medicine Hat, where we cross the Saskatchewan, does it descend to 655 m. This is the great steppe country on the east of the Rockies—a land that offers the best prerequisites for cattle raising. The cattle here are replacing the buffalo, which is extinct. On the literally immeasurable plains one still sees tribes of Indians with wagons and some cattle wandering on their broad paths.

Yet even this is but an artificial accident in the natural scenery, which with all its uniformity makes a deep impression on the most rapid traveller. When the sun sinks and its parting beams suffuse the dry hills with a subdued glow and the shades of night creep into the hollows while the western sky is still gleaming with bright gold—it is then one feels the indescribable magnificence of this scenery and learns to comprehend that the dweller on the steppe loves his poverty-stricken land scarcely less than the sailor loves the sea. This landscape, indeed, is somewhat like the sea.

In the night of September 1st-2nd our sleeper was uncoupled at Calgary from the transcontinental train in order to be taken on to the Rockies after daybreak as a special train. Clear and sharp on the western horizon of the capital of Alberta was descried the broken rocky wall, forming in truth the Rocky Mountains.

If one could imagine the Karwendal chain advanced to the very border of the Upper Bavarian plateau, one might get such a view as we had during our subsequent ride, now from the windows of our sleeper, now from the windows of the caboose, and above all from the locomotive itself, in all parts of which our members had posted themselves in order to admire the magnificent mountains. Their vicinity was proclaimed by the geological formation of the land through which we were passing. Strata of the cretaceous system which had accompanied us so far in flat deposits appeared upright and in some places in a folded position. They form a few not very high ridges parallel to the mountain chain, the so-called foothills which take the place of a foreland to the mountains. After a journey of 80 km., during which we had only ascended at the Bow river 200 m. above Calgary (i.e., 1,250 meters altogether), our train stopped on an open stretch at the foot of the Rocky Mountains. Before us rose its bare, bald walls to a height of 1,000 to 1,500 meters. They consist for the most part of palæozoic limestones which have been shoved out over the cretaceous strata of the foothills. At the same time they have been pressed together confusedly whilst the former just at this point have been only slightly disturbed. On the border of the Rockies one sees old rocks turned upside down some kilometers away above the younger ones, and this fact lends a peculiar interest to the profile of the Kananaskis.

After a short stop we went on through the gate of the Bow river, "The Gap," into the mountains which here show a rare regularity in their geological structure. Every chain represents a block of Devono-carboniferous strata which is raised in the east and declines in the west. In consequence the same succession of strata is repeated over and over again as is typical for the isoclinal structure. Between these palæozoic stratifications extends a trough of cretaceous deposits which the Bow river follows for some distance to the neighborhood of Banff. The palæozoic strata encroach upon it again from the west, as one can plainly discern from the profile of the three peaked mountain which bears the name of the Three Sisters, (2,957 m.) Not far away is the highest mountain of the region, Wind Mountain, 3,170 m. high. These lofty peaks exhibit the forms of great mountain chains. The intervening valleys are broad and level, having their sides bordered with moraines. The latter attach themselves to the slope of the mountains stretching away in a regularly curved talus. At the same time they support the beautiful forest of that region whose farthest outposts extend to a height of 2,400 meters, *i.e.*, somewhat higher than in the central Alps which are 4° further south. Perpetual snowfields are confined to the very highest peaks. In this region is the Canadian National Park, its central point is the little town of Banff, where our excursion spent September 2nd. Soon after our arrival the more active hastened to Sulphur Mountain, (2,270 m.) It is a typical isoclinal mountain, with its peaks breaking off precipitously to the east and the surface of the strata, which might belong to the carboniferous (I found a productus on the top), sloping less steeply to the west. The summit is rounded as may be seen from a photograph taken by Prof. W. M. Davis. The glaciers of the ice age passed over it and left relics of the moraines. On the east at its feet lies the well wooded valley of the Spray, 900 meters deeper. Here bubbles up the warm spring which gives the mountain its name of Sulphur Mountain. It probably indicates the line of cleavage east of which the strata buckle up again into the Rundle mountain, (2,980 m.) To the west beyond the wooded Sundance valley, there rises another isoclinal rampart, the Bourgeau range (2,990 m.) Here cirques have been cut in the mountain ridges, between them the forest ascends much higher on the sides of the mountain than in the domain of their débris-filled floors. A portion of the valley of the Bow river running in a transverse direction cuts off the sulphur mountain and its neighbours to the north. In the broad, woody valley the river meanders along with many windings and in several places backs up so as to form a lake, while beyond rise new isoclinal mountains, among them the splendid rocky form of Cascade Mountain (2,986 m.) This transverse valley continues to the east, but on reaching the trough of cretaceous formations above mentioned the Bow River leaves it. Evidently it once followed this valley through the Devil's Gate out into the plain. The magnificent surface of Lake Minnewanka (Devil's Lake) some distance away indicates its deserted course.

For a long time we remained on the top of Sulphur Mountain lost in the contemplation of the magnificent beauty of the panorama. The almost geometrical regularity of the stratification, which showed only here and there by slight curves, as at Cascade Mountain, that it is due to a folding process, impelled one irresistibly to the consideration of the problem of mountain formation. But the geographer was enchained no less by the regularity of the internal form, the alternation of almost rectilineal valleys both longitudinal and lateral, and many peculiarities in the course of the valleys. Indeed the outermost advance post of Rundle Mountain is quite cut off by the Bow River as the Tunnel Mountain. The opinion was generally expressed that it is scarcely possible to imagine a finer field than the neighborhood of Banff for special study in stratigraphic geology, geotechtonics and geomorphology. The basis has been already laid by the topographical and geological survey of Canada. The former prepared a special map of the National Park on the scale of 1 to 40,000, the latter had a transverse profile taken through the whole Canadian Rockies so as to cut through the region about Banff, by R. G. McConnell, and Dawson himself has explored the neighbouring cretaceous trough. At the same time the C.P.R. hotel offers headquarters comfortable enough to satisfy the claims of the most exacting.

From Banff the railway continues up the Bow river, then for a short distance in the transverse valley mentioned above, then again in a longitudinal valley running close by the watershed here formed by the Rockies. In the west one sees their proud snow covered heads which now regularly exceed 3,000 meters in height and bear considerable glacial areas on their shoulders. Mount Lefroy 3,353 meters is the highest. That the chain rises further north to 4,785 meters in Mount Hooker, and even to 4,880 meters in Mount Brown, as is given on our maps, is very much doubted by Sulzer and Hueber who during their journey among the Selkirks nowhere saw any such giants rising from the Rockies. The Hector Pass, a very narrow gateway 1,614 meters high, affords a passage from the Hudson Bay Territory to that of the Pacific. This height is easily attained from the east. We follow the Bow river to Laggan (1,503 m.) without having any real engineering difficulties to conquer, with an average ascent of only 2.8 per cent. Even then it is only a matter of ascending 111 meters in a distance of 11 kilometers, and we are in a saddle in which many cones of deposition display themselves. But then we must descend 348 meters in only thirteen kilometers. This is undoubtedly the magnificent portion of the whole C.P.R., where the train in three quarters of an hour running time with a fall of 27 per cent. loses all the height it had gained from the foot of the Rocky Mountains. Slowly it glides down the steep slope, incessant is the grinding of the brakes. Only with difficulty has room been found for the road on the steep rocky walls which descend to the foaming and rushing Kicking Horse River. It pierces through them in tunnels and leaps from one side to the other on lofty bridges. The deeper it descends, the higher rise the mountains; at Field our next stop we have the beautifully formed pyramid of Mount Stephen (3,188 m.) rising almost 2,000 meters close above us.

The stratification of these highest portions of the Canadian Rockies is comparatively simple. Enormous Cambrian strata appear to lie almost as they were deposited. In consequence they recall to some extent the Ampezzaner Dolomites, the names often indicating their regular architectural structure: thus we have a Castle and a Cathedral mountain. They offer difficult problems to the climber; in the neighborhood of Laggan the first accidents of Canadian mountaineering have happened. Further west near the Columbia river the mountains become more irregular in their build. The fall of the strata becomes more precipitous and is almost exclusively eastern. At the same time Silurian deposits appear, hemmed in by the Cambrian ones. According to this the structure of the Rockies taken as a whole is about as follows: Younger palæozoic strata, Devono-carboniferous in the east and Silurian in the west, dip on both sides towards the middle of the mountains. There we find the oldest palæozoic rocks prevailing in more or less irregularly disposed undulations. But this holds good only for the Rocky mountains in Canada. When I crossed them afterwards on the Great Northern Railway, south of the Canadian boundary, I found only strata inclining to the east. The whole zone of the chain as at Banff is lacking at the Maria Pass. In the valley of the Kicking Horse River we descend from Field at first rather rapidly, and from the many windings of the road we enjoy various splendid views of the proud glacier bearing peaks of the Rockies. Then we enter a narrow gorge whose walls rise threateningly several hundred meters above us. The road winds so that we can occasionally see the whole train from our car window. Nowhere any inhabited places, the stations are only watchmen's houses. Then all at once another picture. We come out of the narrow gorge into the valley of the Columbia river, lying only 770 meters above sea level. It is broad and wide, along its slopes stretch broad terraces like the Mittelgebirge in the valleys of the Inn and the Adige, a heavy forest covers its floor which the river traverses in many windings. One has the impression of having reached an important boundary line in the mountains. As a matter of fact one has on the east the Rockies formed exclusively of palæozoic strata, and on the west rise the various chains which Dawson calls the Gold Ranges. They conceal the rich gold deposits of southern British Columbia, especially the Kootenay district, only recently opened up, in which the town of Rossland arose in the shortest time on record, as well as the older Cariboo district. Also the Klondyke of the north, which was opened up last summer and electrified all America, seems to belong to this zone. There appear in it, alongside very old sediments perhaps belonging to a pre-Cambrian age, also archæan rocks. Our line of demarcation may be followed morphologically for a long distance. From Donald, where we are first convinced of its significance, we can follow it on the map for 700 kilometers in a northwest direction, as a great longitudinal valley to which the Upper Fraser and the Peace River belong, and in a southeast direction to the Upper Kootenay and then into the valley of the Flat Head River for another 600 kilometers at least. This is a magnificent parallel to the great valley-gorge which separates the northern Alps from the Central Alps, and the resemblance holds good also as to scenery.

If the journey through the Rockies reminded me often of the Alps, now of the Alps in North Tyrol, now of the Kofel of the Dolomites, the rest of the journey through the first of the Gold Ranges, the Selkirks, reminded me often of the Brenner road. The railway passes through a narrow defile, such as seems to characterize the openings of the tributary valleys of the Columbia River, into the Beaver valley. Then it runs along the slope of the now widening valley, strikes into a neighbouring ravine and after an ascent of 540 meters, distributed over thirty-two kilometers, we reach the Rogers Pass (height 1,310 meters), a deep saddle in the mountain, while the peaks rise steeply on both sides to a height of 2,700 and 2,[illegible] meters. An outlet between the precipitous walls seems scarcely possible; then all at once the train rounds a corner and far below it appears the Illecillewaet River, to which it must now descend in great loops, passing frequently over high frail-looking trestles. As we do so quite a surprising mountain panorama is unfolded. Glaciers here recline against mountains only 2,700 meters high, and in the neighbourhood of the highest peak of the group, Mt. Sir Donald (3,250 meters), they cover considerable space. A turn of the road brings us quite close to the magnificent Illecillewaet glacier whose tongue only ten years ago reached immediately up to the lower shrubs, from which it has now retreated a distance of almost 170 meters. Not far from this glittering tongue, which is remarkably free from débris, rise the mighty giant trees of British Columbia. Evidently the snow line is here very low. Its height must be reckoned at 2,200 or 2,300 meters, that is lower than upon the summit of the Rockies, where it must be put at 2,700 to 2,800 meters, and far deeper than on the eastern edge of the chain, where peaks of 3,000 meters in height fall below it. The snow line sinks considerably from the interior of Canada to the Pacific. At the same time it is much lower on the west side of every chain than on the east side.

As at Banff in the National Park and at Field below the Hector Pass, so, too, at this supremely picturesque point, the C.P.R. has built an excellent hotel near the station Glacier, only a few kilometers from the end of the Illecillewaet glacier. This place is frequently made the headquarters for mountain tours in the Selkirks as well as being an excellent point to break the long continental journey. Our excursion also stopped here, but bad weather prevented us from making any use of September 4th. We were obliged to content ourselves with a visit to the tongue of the Illecillewaet glacier, of which I gave an extended account in the Journal of the Alpen Verein for 1898.

As at the Hector Pass, so, too, at the Rogers Pass the ascent from the east is easier than the descent to the west. The westward flowing river is in both cases the stronger; it works away with energy at the deepening of its upper channel and as at the Kicking Horse River, so, too, at the Illecillewaet the railway has difficulty in reaching the level of the valley. This is done by a fall of fifteen per cent. in a stretch fourteen kilometers in length. Then road and river descend together until the latter must enter a deep defile to reach the Columbia. It was here dammed up very high with driftwood. The track follows it with difficulty. At Revelstoke both have got down to the level of the great water-artery; it has circumvented the Selkirks in a great curve to the north and descended to a height of 450 meters in doing so. This is a level which we had passed away back on the prairies near Winnipeg, 1,200 kilometers from the eastern foot of the Rocky Mountains, and higher than this we scarcely get as we continue our journey westward. Even the chain west of Revelstoke, with its glaciers and peaks 2,700 meters high, which separates the waters of the Columbia from those of the Fraser river, is crossed in the Eagle Pass at a height of only 610 meters. Here we pass quite gigantic moraines with quite enormous erratic boulders.

The valleys within the Canadian Cordilleras lie considerably deeper than the prairie and steppe-land on their eastern borders. At the same time they are partly submerged, that is, they are occupied throughout their entire breadth by long and deep lakes, which not only follow the long valleys, especially in the region of the Columbia River, but also often assume very complicated shapes; the Shuswap Lake, which the Thompson River drains into the Fraser, reminds one, for instance, of Lake Lugano. Great deposits of sediment, as well as old deltas and shore lines, of which we counted not less than six at Revelstoke, reveal the fact that these lakes were once far more extensive. These deep valleys, rich in lakes, are really confined to the Canadian Cordilleras; farther south in the United States the space between the Rockies and the Sierra Nevada has not been broken up into valleys but appears as a uniform unbroken highland. This difference may probably be attributed to climatic causes. The Canadian Cordilleras are richly watered and supply mighty rivers. The regions to the south are dry and have no channels that reach the sea. But in consequence they have no way of being cut through, while such a power is working in the Canadian Cordilleras to a great extent and, as it-results, the valleys, prove, has been operative in the past also. This cutting up of the Canadian Cordilleras in comparison with the American is under such circumstances an indication that the general arrangement of the rainy districts on the west side of the Pacific has experienced no essential change for a considerable time but only oscillations.

It was already evening when we passed the Shuswap lake on the 4th of September, and that night we went past the Kamloops lake. Thus those of us who did not return by the C.P.R. lost the impression made by these great lake surfaces with their peculiar surroundings which form the rather dry plateau of the Canadian Cordilleras, lying enclosed between the Coast Chain and the Gold Range, an outpost of the great arid territory of the United States and like this latter distinguished by the outcrop of late volcanic rocks. On the morning of September 5th we found ourselves far down on the Fraser River which, for a while, follows a cretaceous trough on the eastern border of the Canadian Coast Range. These mountains rise not far from its banks to a height of 3,000 meters. But their proud heads were concealed in the clouds ; our view was confined to the valley which indeed had enough to offer us. As a mighty stream the Fraser rushed along ; we follow it upon a terrace of varying height. In several places, as for example at Hellgate, the valley narrows to a gorge, its walls rise over 1,000 meters from the river, which above such places seems to be dammed up, and has left plain highwater marks twenty meters above its September level. Laboriously and by astonishing feats of engineering skill the railway finds room. Here and there in the distance one sees Indian camps, inhabited by fishing parties and surrounded by platforms full of dried salmon. Besides these there are Chinese immigrants. They travel in bands along the railway line. The forest grows more and more luxuriant, the single trees rise like giants. Everything combines to make the journey through the Fraser canyon, as the magnificent valley is called, a most magnificent one, full of unique experiences.

The Fraser River gives the C.P.R. an outlet to the sea. It finds its way there south of the Canadian Coast Chain, where this range makes an obtuse angle with the North American Cascade Range. At this point it has descended to a level less than sixty meters above that of the sea and is bordered by broad alluvial plains. The projection of its great delta lies in the above-mentioned obtuse angle. Here rises beside it the volcano Mt. Baker, 3,256 meters high. A heavy rain shower as we were passing deprived us of this fine scenery ; our view was confined to the delta, in whose great gravelly masses were embedded numerous tree-trunks which the river had brought down. A dense and lofty wood extended originally on all sides, but is now already cleared to a considerable extent. Here in an angle of the Straits of Georgia which the River Fraser has not yet filled up is the city of Vancouver, and here in a forest of gigantic trees still preserved in part, and within sight of the mountain is the terminus of the Canadian Pacific Railway. The line across the continent from Montreal to this point measures 4,677 kilometers ; it is a journey of five days and six hours. Of this 946 kilometers and thirty hours' travel are taken up in traversing the Cordilleras. Certainly the longest mountain road in the world and everywhere uncommonly beautiful, more than three times as long as the longest of the Alpine railways—the Brenner line.

A large river steamer brought us from Vancouver through the Georgia strait in eight hours to Victoria, on the Island of Vancouver, the capital of British Columbia. It was an uncommonly instructive journey. The sky cleared, and the continental Coast Chain, 2,000 meters high, and the almost equally high mountains on the Island of Victoria became partially visible ; between them we glided along over a surface smooth as a mirror, approaching a few small islands, which consist of evenly deposited cretaceous strata, and passing rapidly by the low alluvial land. All the banks are bordered with driftwood, brought down by the Fraser to the sea, which its muddy current troubles for a long distance from its mouth. By this one could realize vividly the geographical conditions under which originated the cretaceous strata that traverse the Canadian Cordilleras. They must have been deposited in narrow arms of the sea like the Strait of Georgia, in the neighbourhood of great river mouths which provided the wood for their coal deposits. Thus the present topography of the country still preserves features of times long gone by.

I got a very convincing assurance of this by a visit to the Nanaimo district and the Wellington coal mine, on an excursion participated in on September 7th by all the members of the various parties which had now re-united in Victoria. There at Nanaimo I saw conglomerates, which were evidently the product of the rolling action of the stream, old river pebbles, and I collected at the rubbish heaps by the coal-pits impressions of the leaves of trees. Nothing here indicates the nearness of the cretaceous sea, but south of Nanaimo in the same complex formation a rich marine fauna has been found.

The trip from Victoria to the above-mentioned coal district marks the end of my journey in Canada. Once more it led through a highly interesting landscape. The Island of Vancouver, which forms the fifth zone of the great Canadian Cordilleras, only partially rising above the waves, is covered in its deeper parts with a forest, the equal of which it would be hard to find. The Douglas firs, sometimes 100 meters high, form dense groves; with the prevailing dampness, forest fires, of which the Rocky Mountains afford many sad traces, can hardly arise. The train steams along under giants centuries old; only in a very few places have clearings been successful. They still rise in close proximity to Victoria, where the friendly and comfortable frame houses of the European settlers have a dwarflike appearance beneath them.

Here in Victoria where the excursionists enjoyed the friendly guidance of the inhabitants, there are still very striking traces of the glaciation of the ice-age, which, proceeding from the continent, covered the lower parts of Vancouver Island with ice. It crossed the fjord-like bay which forms the geographical reason for Victoria, at a right angle and therefore the bay cannot be considered the work of the ice. It is a submerged valley which shows that a sinking of the land has taken place. This sinking has now changed into a rising. The coast between Victoria and Nanaimo is accompanied by extended terraces. Thus we have on the Pacific coast the same phenomena as on the Atlantic shore of the great British Dominion in North America. As far as the traces of the ice-age extend the coasts are embayed, the outlets of the land valleys are under water and we find at the same time shore lines which betray the fact that a rise has taken place since the ice period. It has not been strong enough to obliterate the effect of the preceding sinking. The land that is in process of rising has the outlines of one that has been submerged.

Canadian Surveys and Museums and the Need of Increased Expenditure Thereon. President's Address. By B. E. Walker, Esq., F.G.S.

(Read 11th November, 1899.)

We find ourselves possessed in Canada of a country vast in its dimensions, but of which the population is as yet comparatively small. If, therefore, we have good reason to believe that the natural resources of our territory are in any respect commensurate with its area, we may look forward with confidence to a great future. But in order that this may be realized properly and soon, we must devote ourselves to the exploration and definition of our latent wealth, and to the solution of the problems which inevitably arise in the course of its utilization under circumstances which are often more or less entirely novel. For this purpose we are provided at the present day with methods, appliances and an amount of accumulated knowledge not previously thought of, but which we must be prepared to enlist in our service if our purpose is to be achieved.—George M. Dawson, C.M G., etc., Director Geological Survey of Canada. Presidential Address, Royal Society of Canada, 1894.

It is my intention to confine my address to the subject of national surveys and museums. If a private individual were to become the owner of five or ten thousand acres of diversified virgin territory he would, presuming that he was what we call a practical person, make or have made a careful examination of his estate in order to know its resources and possibilities. He would keenly examine the various soils as to their suitability for agriculture, the timber as to its immediate or prospective value, the clays and sedimentary rocks as to possibilities of building materials; or if his estate lay in a mineral area he would look eagerly for an Eldorado. He would consider the lakes and streams and the water powers and watersheds of his property, and the nature of the drainage or the necessity of artificial drainage. In a word, he would take stock of his purchase just as a merchant or manufacturer would of his goods. Now, a new country is but an enlargement of this diversified five or ten thousand acres, and the people of a new country are but an enlargement of this practical individual. If they are as able to recognize their interest in the national problem as he is in the individual problem, they will wish to know of what the national domain consists, what are its resources and its future possibilities. Clearly, they will wish to know what can in any particular part of the domain be first and most profitably marketed or put to use in manufacture as raw material. Just as clearly they will want to know what raw material they possess which although not marketable now will eventually help to build up the national wealth. Also if they are reasonably intelligent they will desire to know the extent of the so-called waste places which have apparently no present or prospective use or value measured by money. I need not tell you that at this moment I cannot stop to discuss the enormous value to man of the waste places of mother earth, so dear to the artist, the sportsman, the naturalist, and the truly intelligent man of any class. I have purposely begun by making a bald statement in defence of national surveys which will be admitted by all because it is based on economic grounds which are recognized by all, and it will be a surprise to many to be told that clear as is the truth of this bald statement, we possess within easy distance from long settled districts vast areas about which we know nothing, or nearly nothing. For some of this ignorance there is adequate excuse; for much of it there is no excuse whatever. But in addition to the knowledge which is so clearly due to the people on economic grounds, there is knowledge, much of which upon a wide consideration of national interest it would be a true economy to possess, but which may be better understood by being regarded as what is due to the intelligence of the people rather than to their pockets. As an intelligent people we are entitled to learn gradually all that there is to be known about the natural phenomena of our country, and as an intelligent people we are entitled to possess museums in which may be exploited, not only the materials for national wealth, but also the entire range of natural phenomena as far as it can be exhibited objectively. Doubtless, no one in this particular audience will question this last statement, but we should always keep before us the fact that in a new country the majority of the people have their minds filled with material considerations alone. They or their parents have begun life, if not literally seeking their bread, still having as the main purpose the improvement of the material circumstances of their lives, and so it happens that they are deaf to any but what they deem practical arguments. The politicians reflect the people and it is therefore much more difficult than would at first seem natural to obtain a hearing for any expenditure of money which will only indirectly benefit the people. But while this is inevitable in the early days of a country struggling with poverty, it is disgraceful in any country to continue to neglect the higher considerations of national life when there is no longer the excuse of national poverty.

I should like this evening to consider with you what national and provincial surveys should accomplish, and what national and provincial museums should contain, and whether there is any longer a shadow of excuse for Canada persisting, as it has for so long a time, in neglecting these duties.

And first it may be well to review some of the work done in the past by which we have become better acquainted with our country. I shall refer almost entirely to work done by those who were in the public service, whether of Great Britain, the old Provinces, or the Hudson's Bay Company and other fur-trading companies, with only passing remarks on others whose work had no official origin.

In 1814, Admiral Bayfield, his duties in connection with the war being over, began a survey of the Great Lakes, which after the labour of many years resulted in the series of charts covering the entire St. Lawrence system of lakes and rivers and parts of our Atlantic sea-coast, on which charts so much of our navigation still depends. He also found time about 1830 to publish in the first volume of the journal of the Literary and Historical Society of Quebec, papers on the geology of Lake Superior and on coral animals in the Gulf of St. Lawrence. Major-General, then Lieutenant Baddeley, and Sir Richard, then Captain Bonnycastle, both of the Royal Engineers, appear also to have been students of geology, and both contributed papers to the early volumes of the same journal, the services of the former being used, according to Sir William Logan, in a public capacity. He was the first to write regarding the lower Silurian limestones about Lake St. John and Murray Bay, and some of our early knowledge of the Labrador Coast and the Magdalen Islands, is due to him.

About the time when Bayfield was surveying the Great Lakes, Prof. A. Lockwood, who was styled "Professor of Hydrography and Assistant Surveyor-General of the Province of Nova Scotia and Cape Breton," was surveying the coast and harbours of that province, the result of his labours being published in 1818.*

We are not so much concerned with mere topography, but it is interesting to note that Major Samuel Holland, Surveyor-General of British North America, who, as early as 1768, was working out the latitude and longitude of Cape Breton, was the uncle of Lieutenant-Colonel Joseph Bouchette, who was also Surveyor-General and did considerable work regarding the Maine boundary in connection with the Boundary Commission under the Treaty of Ghent, and whose topographical and statistical volumes on the various eastern provinces are so well known.† From our

* Brief Description of Nova Scotia. A. Lockwood, London, 1818.

† 1 "The British Dominions in North America," etc. J. Bouchette, 2 vols., London, 1832.
2 "A Topographical Dictionary of Lower Canada." J. Bouchette, London, 1832.

point of view the services to science in Canada of Dr. John J. Bigsby, who had been commissioned in 1819 to report on the geology of Upper Canada, and became in 1822 Secretary to the Boundary Commission already mentioned, are more interesting. While Colonel Bouchette travelled about the more settled provinces, investigating seigniory boundaries, statistical conditions, and matters mainly incident to the settlement of the country, Dr. Bigsby pushed his way into the wilder parts. He appears to have examined with more or less detail the geology of Lakes Huron, Superior, Simcoe and Nipissing, and the main river systems in connection therewith. The twenty-seven papers written after his return to England and contributed to scientific journals, as shown by the Royal Society Catalogue of Scientific Papers, down to 1873, treat almost entirely of North American geology. He published in 1852 a popular illustrated book in two volumes about Canada, and it is safe to say that in the northern part of Lake Huron he laid the foundation of the knowledge which resulted half a century later in his Thesaurus Siluricus.* His "Notes on the Geography and Geology of Lake Huron," London, 1824, appears to be the first geological report of an official character regarding any part of Canada.

Before dealing with a later period in Eastern Canada we must turn to that great western territory which only came under our control after the Confederation of 1867. Year by year we are becoming acquainted with it, but for a hundred years before the members of our Geological Survey began to thread its wilds it had appealed to the imagination of a few by its very remoteness from civilization, and the volumes published by the most famous of its explorers are therefore fairly well known in literature.

In 1769 the Hudson's Bay Company issued a letter of instructions to Samuel Hearne ordering him to undertake an "expedition by land towards latitude 70° north, in order to gain a knowledge of the Northern Indians' country," etc. From 1769 to 1772 inclusive, Hearne made several journeys, the main object being the discovery of copper mines and to try once more for the North-West Passage, so long and anxiously sought. Before his day, as since, the Company had been accused of being lacking in enterprise and disposed merely to buy furs and keep the country as much a *terra incognita* as possible, but this idea Hearne in the introduction to the account of his travels, endeavours to refute. The published account† shows that in 1770 after a short journey in 1769, Hearne travelled from Churchill into the not far distant country of the Doobaunt and Kazan rivers and back, thus covering part of the barren-lands country through which J. B. Tyrrell travelled on behalf of the Dominion Geological Survey in 1893–94.‡ On his return Hearne immediately set out again and travelling first westward, thus avoiding the barren-lands country, and then northward, he eventually reached the Coppermine River. He recorded little of geological interest but devotes an entire chapter to the description of the animal and vegetable life observed by him. For various reasons his geographical work is out of its reckoning, but apart from the mapping done by Tyrrell it constitutes all that we know about an enormous area of Canada west of Hudson Bay.

In 1789 the active competitor of the Hudson's Bay Company, the North-West Fur Company, sent Alexander Mackenzie who had been for some years factor at Fort Chippewyan on Lake Athabasca, on a journey of exploration, doubtless suggested by himself. We all know that he followed the Mackenzie River to its mouth and returning set out from Lake Athabasca again in 1792, this time up the Peace River to its source, crossing the height of land and reaching the Pacific Ocean at about the fifty-second parallel. Sir Alexander Mackenzie was neither geographer nor naturalist, indeed he was only a trader, but he was one of the men who subdue empire and enrich their country in the effort to enrich themselves. His observation of natural resources and of the highways possible for commerce was very keen and whether it has a reasonable connection with my subject or not, I cannot forbear quoting some remarkably prophetic words, from the closing pages

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* "Thesaurus Siluricus. The Flora and Fauna of the Silurian Period." John J. Bigsby, London, 1868.

† "Journey from Prince of Wales' Fort in Hudson's Bay to the Northern Ocean," etc. Samuel Hearne, London, 1795.

‡ "Report of the Doobaunt, Kazan and Ferguson Rivers and the North-west coast of Hudson Bay," etc. J Burr Tyrrell. Geol. Surv. Can. Annual Report Vol. IX. 1896. (Published in 1897.)

of the account of his travels.* After a careful discussion of waterways he concludes as follows :

"By opening this intercourse between the Atlantic and Pacific Oceans, and forming regular establishments through the interior, and at both extremes, as well as along the coasts and islands, the entire command of the fur trade of North America might be obtained, from latitude forty-eight north to the pole, except that portion of it which the Russians have in the Pacific. To this may be added the fishing in both seas, and the markets of the four quarters of the globe. Such would be the field for commercial enterprise, and incalculable would be the produce of it, when supported by the operations of that credit and capital which Great Britain so pre-eminently possesses. Then would this country (Great Britain) begin to be remunerated for the expenses it has sustained in discovering and surveying the coast of the Pacific Ocean, which is at present left to American adventurers, who without regularity or capital, or the desire of conciliating future confidence, look altogether to the interests of the moment." He was not dreaming of steam railways reaching Vancouver from Montreal in five days, but merely of making less arduous such a journey by canoe and foot as he practically finished when having reached the Pacific he wrote : "I now mixed up some vermilion in melted grease, and inscribed in large characters, on the south-east face of the rock on which we had slept last night, this brief memorial : 'Alexander Mackenzie, from Canada, by land, the twenty-second of July, one thousand seven hundred and ninety-three.' "

Captain George Vancouver being commissioned by the King on a voyage of discovery particularly to try once more for a passage between the North Pacific and North Atlantic Oceans, spent the years from 1790 to 1795† at sea during which time he surveyed the coast of North-West America. We are, however, more concerned with the work of another explorer who spent his life between the Great Lakes and the Pacific, but who, because of the indifference of his countrymen, is less famous than Vancouver. I refer to David Thompson, Astronomer and Surveyor, as he styled himself, first to the Hudson's Bay Company, then to the North-West Company, and later acting with the International Boundary Commission, who from 1784 to 1850, as the forty volumes of records and maps made with his own hand and now in the Crown Lands Department of the Province of Ontario show, laboured strenuously for science, practically without a fellow-worker. In the published journals of Alexander Henry‡ edited by Elliott Coues, footnotes and other information from the unpublished journals of David Thompson appear, and Mr. Coues also gives us facsimiles of three sections and the title part of the great map he evidently hoped would be published. Elliott Coues says in his preface: "It has long been a matter of regret among those versed in the history and geography of the Greater North-West that this luminous record of the life work of so modest, so meritorious an explorer as Thompson was—of so scientific a surveyor and so great a discoverer—has never seen the light, either under government patronage or by private enterprise." And later in the same preface : "The irony of the event is the world's revenge on David Thompson ; but the world can never be allowed to forget the discoverer of the sources of the Columbia, the first white man who ever voyaged on the upper reaches and main upper tributaries of that mighty river, the pathfinder of more than one way across the continental divide from Saskatchewan and Athabascan to Columbian waters, the greatest geographer of his day in British America, and the maker of what was then by far its greatest map—that 'Map of the North-West Territory of the Province of Canada. From actual surveys during the years 1792 to 1812' as the legend goes."

During the years 1819 to 1822 inclusive, Captain, afterwards Sir John Franklin, acting under a royal commission, was carrying out an "expedition from the shores of Hudson's Bay by land, to explore the northern coast of America, from the mouth of the Coppermine River to the eastward." This, and subsequent arctic expeditions, not only resulted in some important geographical discoveries, but gave to the

* "Voyages from Montreal on the River St. Lawrence, though the Continent of North America to the Frozen and Pacific Oceans." Alexander Mackenzie, London, 1801.

† "A Voyage of Discovery to the Northern Pacific Ocean," etc. Captain George Vancouver, 3 vols and atlas, London, 1798.

‡ "New Light on the Early History of the Greater North-West," etc. Edited by Elliott Coues, 3 vols, New York, 1897.

world the two most important works on the natural history of northern Canada, the Fauna Boreali-Americana of Dr. John Richardson, Franklin's co-explorer, and others, published 1829–1837, and the Flora Boreali-Americana of Sir William Hooker, 1833–1840.

In 1857, Captain John Palliser was commissioned by the Secretary of State to "conduct an expedition for exploring that portion of British North America which lies between the northern branch of the River Saskatchewan and the frontier of the United States, and between the Red River and the Rocky Mountains," with permission to go through the mountains to the Pacific. He had as associates in the expedition Dr. Hector as geologist, Lieutenant Blakiston as astronomer, and Mons. Bourgeau as botanist, who, acting under instructions from Sir Roderick Murchison and Sir William Hooker, were to be the scientific members of the party. Palliser had in 1847 and succeeding years, hunted among the Indians of our North-West and knew the country, so that during 1857, 1858 and 1859, the various routes travelled by Palliser, Blakiston and Hector, together and separately, pretty well covered the country south of the Saskatchewan from Lake Superior to the Rocky Mountains and also through many of the passes and valleys beyond. In the various blue-books* which resulted, much valuable information is put on record, and of Dr. Hector's work, Dr. G. M. Dawson, in his Boundary Commission report hereafter referred to, says: "To him the first really trustworthy general geological map of the interior portion of British North America is due; and he has besides accumulated a great mass of geological observations, the significance of many of which appears as the country is more thoroughly explored."

Captain Palliser thought it worth while to explore this country and to report elaborately upon the future prospects of civilization, but while his recommendations as to necessary steps are generally sound he certainly did not overestimate its possibilities. On the subject of confederation he writes in the report of 1860: "Much has been talked about, but perhaps less really thought of, the union of the British North American Provinces, a scheme which, although in the present age might be thought somewhat speculative, may yet not only be projected but accomplished. But it must be a work of time, and such time as many may become impatient even in contemplating." Regarding telegraphic communication he writes: "It would be ridiculous to expect for many years to come a continuous railway communication throughout this immense distance, but from the fact of over one-fourth of the distance being now complete, and considering the incalculable benefit the United Kingdom and her distant colonies would derive from connection by telegraph, I am encouraged to advocate warmly the carrying out of this enterprise."

In the same year, 1857, when Captain Palliser received instructions from the British Government, the Canadian Government commissioned George Gladman, Director, Henry Youle Hind, Geologist, W. H. E. Napier, Engineer, and S. J. Dawson, Surveyor, to "make a thorough examination of the tract of country between Lake Superior and Red River." This was done in 1857. In 1858 the Government commissioned Messrs. Hind and Dawson to extend their explorations to the country "west of Lake Winnipeg and Red River, and embraced (or nearly so) between the River Saskatchewan and Assinniboine, as far west as 'South Branch House,' on the former river." In addition to the official reports† to the Canadian Government the reports appeared as British blue books and Professor Hind also published in an extended and attractive form the results of his labours in two handsome volumes.‡ Professor Hind, like Captain Palliser and Sir Alexander

* "Papers Relative to Exploration by Captain Palliser of that portion of British North America," etc. British Blue Book, 1859.

"Further Papers," etc., in continuation of above, 1860.

"Journal," etc., in continuation of above, 1863.

"Index and Maps," etc., in continuation of above, 1865.

† "Report on the Exploration of the Country between Lake Superior and the Red River Settlement." Canadian Blue Book, 1857. British Blue Book, 1859.

"Report of the Assinniboine and Saskatchewan Expedition." Canadian Blue Book, 1859. British Blue Book, 1860.

‡ "Narrative of the Canadian Red River Exploring Expedition of 1857 and of the Assinniboine and Saskatchewan Exploring Expedition of 1858." H. Y. Hind, 2 vols., Longmans, London, 1860.

Mackenzie, indulges in prophecy. He writes: "As I stood upon the summit of the bluff looking down upon the glittering lake 300 feet below, and across the boundless plains, no living thing in view, no sound of life anywhere, I thought of the time to come when will be seen passing swiftly along the horizon the white cloud of the locomotive on its way from the Atlantic to the Pacific, and when the valley will resound with the many voices of those who have come from the busy city on the banks of the Red River to see the beautiful lakes of the Qu'Appelle." How natural it all sounds now, but doubtless it fell in 1869 upon as deaf ears as similar forecasts made at the present time by members of our geological survey, or as the fervid words of Mackenzie a hundred years ago.

I have not examined the various British blue books from 1832 to 1876, nearly forty in number, relating to the settlement of the boundary between the United States and Canada, but in addition to the work by Bigsby and Bouchette this is the time to mention two scientific results arising from marking the forty-ninth parallel. John Keast Lord who acted as Naturalist to the British North American Boundary Commission when marking the boundary line from the Pacific coast to the eastern slope of the Rocky Mountains, published two illustrated volumes in 1866 on the natural history of British Columbia.* And in 1874 and 1875, Dr. George M. Dawson, not yet connected with the Geological Survey of Canada, made his reports on the geology and resources of the "region in the vicinity of the forty-ninth parallel from the Lake of the Woods to the Rocky Mountains."†

I have thus far indicated, not with precise accuracy, but perhaps sufficiently, the extent of the exploratory work done in the country now included in Canada, under the auspices of the trading companies and the early governments, and not by established geologicnl and natural history surveys. If we consider the publications by their number they stand as an evidence of the inability or unwillingness of Canadians in the past to grasp the future of their country, and judged by the quantity of matter of a purely scientific nature, they betray an indifference to higher considerations not creditable to their intelligence. We certainly owe a debt of gratitude to the few ardent men who braved the terrors of our unknown lands and gave us this scanty literature.

Before referring to the regular geological survey established in Canada in 1843, I should like to compare the exploratory work done in the United States before the establishment of a regular geological survey, by the Federal Government. It must be borne in mind that during nearly half a century before the Federal Government established a regular survey most of the States had established surveys on their own account just as we shall have occasion to remind you that our survey was originally a Provincial and not a Dominion survey. Not referring, then, to the work done by the various States, but merely to the exploratory work of a similarly irregular character to that done in Canada in early days, I shall read a list of expeditions ordered by the United States Government. It does not pretend to be accurate either as to the number or as to the details given of the various expeditions. It was compiled merely in order to indicate how much more earnestly the people of the United States craved for information about their unsettled areas. The majority of the reports are quartos illustrated with expensive plates and often running into several volumes. The Pacific Railroad reports alone exceed in matter all that we have done. The dates given in the following list sometimes indicate the date of the expedition, sometimes of the publication of the reports :—

1804-6. Captains Lewis and Clark. From the mouth of the Missouri River through to Pacific Ocean.

1805-7.—Lieut. Zebulon M. Pike. Through western territories of North America. To head waters of Mississippi River, through Louisiana Territory and in New Spain.

1819-20.—Major Stephen H. Long, Pittsburg to the Rocky Mountains.

1820—Henry R. Schoolcraft. From Detroit through Great Lakes to source of Mississippi River.

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* "The Naturalist in Vancouver Island and British Columbia." J. K. Lord, 2 vols., Bentley, London, 1868.

† "Report on the Tertiary Lignite Formation," etc. B. N. Boundary Commission, G. M. Dawson, 1874. "Report of Geology and Resources," etc. B.N.B.C., G. M. Dawson, 1875.

1823.—Major Stephen H. Long. To the source of St. Peter's River. Lake Winnepeck, Lake of the Woods, etc.

1834.—G. W. Featherstonhaugh. Elevated country between Missouri and Red River.

1835.—G. W. Featherstonhaugh. Green Bay to Coteau de Prairie or from Missouri to St. Peter's River.

1838-42.—Wilkes, U.S. Exploring Expedition.

1839.—David Dale Owen. Geological Exploration of part of Iowa, Wisconsin and Illinois.

1842-44.—Captain J. C. Fremont, Expedition to the Rocky Mountains, Oregon and North California.

1843.—I. N. Nicollet. Basin of upper Mississippi River.

1846-50.—During these years there were seven or eight reports of minor military expeditions in connection with Texas, New Mexico and the Santa Fe route to California.

1848.—Lieut. J. W. Abert. Geographical examination of New Mexico.

1851 —Prof. L. Agassiz. Examination of Florida Reefs, Keys and Coast.

1852.—David Dale Owen. Iowa, Wisconsin and Minnesota.

1852.—Captain R. B. Marcy. Red River of Louisiana.

1853.—Captain Howard Stansbury. Valley of the Great Salt Lake of Utah.

1853-54.—Exploration and survey to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean. 12 volumes. Published from 1855 to 1860.

1854.—Captain L. Sitgreaves. The Zuni and Colorado Rivers.

1854.—Captain R. B. Marcy. The Brazos and Big Wichita Rivers.

1855.—David Dale Owen. Minnesota, Iowa and Wisconsin.

1855-57.—Lieut. G. K. Warren. Explorations in Nebraska and Dakota.

1857.—Lieut.-Col. W. H. Emory. United States and Mexican Boundary Survey.

1857-58.—Lieut. Joseph C. Ives. The Colorado River of the West.

1859.—Captain J. H. Simpson. Great Basin of Utah.

1859.—Captain J. N. Macomb. Santa Fe to Grand and Green Rivers.

1859-60.—Captain W. F. Raynolds. Yellowstone and Missouri Rivers.

1871-75.—Lieut. George M. Wheeler. Exploration and Survey west of 100th Meridian. There are over thirty publications as the result of this survey.

1871-77.—Clarence King. Geological Exploration of 40th Parallel. Published in six annual reports of progress, followed by six volumes of scientific contributions by his co-workers.

Although the Federal Government of the United States down to 1867 had not established a regular geological survey and conducted the exploration of the territories by semi-military expeditions generally under control of the engineering department of the army, several of the State governments established surveys before 1835, and Sir William Logan in 1844 refers to "the liberal view of their own interests, which, during the last ten years, has induced not less than twenty of the State Legislatures of the American Union to institute investigations into the mineral resources of their respective territories," etc. I, at one time, intended to prepare a list of the various State surveys now covering almost every State, which have been conducted during the last sixty-seven years, or thereabout, indicating when each survey began and the extent of the publications, but I have found this impossible in the short time at my disposal and I must content myself with such comparisons as will show how liberal and intelligent almost all other governments in North America have been relatively to our own.

Let us now turn to the establishment of our own regular survey.* In 1842, following the example of about twenty of the States of the American Union, the old Province of Canada instructed Sir William Logan to undertake a geological survey of the Province, work in connection with which began in 1843, Sir William having one assistant, Mr. Alexander Murray. For the ensuing ten years these two devoted men worked in the field, and after a few years Dr. T. Sterry Hunt became their able co-worker in the laboratory as chemist and mineralogist to the survey, for all practical purposes the first officer of that character, although not literally the first. No matter how devoted, two men could not do much judged by quantity, and the ten annual reports from 1843 to 1853 with two separate pamphlets on the mining regions of Lake Superior and the north shore of Lake Huron, make altogether less than 1,250 pages of small octavo, about as much matter as one annual report of the survey now. Two maps of a mine accompany one of the pamphlets, and here and there there is a badly executed illustration, but of fossils there are neither descriptions nor illustrations. It is true that in 1851 and 1852, Sir William Logan contributed important papers on the "Foot-prints in the Potsdam Sandstones of Canada" to the quarterly journal of the Geological Society in London, which were most adequately illustrated by the Society, but in these papers he thanks a member of the Geological Survey of Great Britain for naming the fossils he has occasion to refer to. If I could lay before you these twelve slender pamphlets and the still more slender reports of Dr. Gesner made in the Maritime Provinces, hereafter referred to, and put beside them the reports made by the various public surveys in the United States down to 1853, you would realize more forcibly than I can express in words how completely the Canadians failed to take that "liberal view of their own interests" which characterized the people of the United States. But somewhat better days were in store for the survey. Mr. James Richardson had been added to the workers in the field, and in 1856 Mr. E. Billings entered the survey as palæontologist. In 1857, Prof. Robert Bell, still a member of the staff, also joined the survey. The survey was now fairly equipped and its publications gave evidence of the larger scope of its operations. The report for 1853-56, published in one volume, was accompanied by the first series of maps, illustrating reports on the geology and topography of the Muskoka, Petewawa, Bonnechere, Madawaska, Maganetawan, French, Sturgeon, and Wahnapitae Rivers and Lake Nipissing and its tributaries, also of the Island of Anticosti, altogether about 25 maps. In this volume appeared the first report of the palæontologist, the beginning of a series which established Mr. Billings' reputation throughout the scientific world. It is not accompanied by illustrations, which fate also befel some of his later reports. This is not so strange as the fact that to this day some of his species have been allowed to remain unillustrated. It is characteristic of our interest in science that his name is doubtless much better known to-day in Europe than it is in Canada. In 1863 the results of the work of the survey from the beginning appeared in the well-known volume of about 1,000 pages, published without a single plate but with about 500 good wood-engravings and an excellent atlas of maps and sections. This atlas contained the first geological map of "Canada and the Adjacent Regions," printed in colours, 125 miles to an inch, and it was followed in 1866 by the large map on the scale of twenty-five miles to an inch, coloured by hand. I wish that every Canadian might read the prefatory note accompanying this atlas, and learn what goes to the making of a reasonably accurate map of a new territory. The ordinary report of progress for the years 1863-66 containing papers by two new contributors, Mr. A. Michel and Mr. Thomas Macfarlane, was the last made to the old Province of Canada. In addition to these reports of progress, seven pamphlets appeared and six important contributions to palæontology. Four of these latter, called respectively Decades 1, 2, 3 and 4,

* "The first effort made toward the establishment of a geological survey in Canada, appears in a petition addressed to the House of Assembly of Upper Canada in 1832, by Dr. Rae. Nothing, however, came of this or of several other attempts of the same kind, till in the first united Parliament of Upper and Lower Canada in 1841, the Natural History Society of Montreal and the Historical Society of Quebec joined in urging the matter upon the government, with the result that the modest sum of £1,500 sterling was granted for the purpose of beginning such a survey." Presidential Address, R. S. C., 1894. G. M. Dawson.

appeared in 1858-59 and 1865. The contributors were Mr. Billings of the Canadian Survey, Mr. Salter of the Survey of Great Britain, and Prof. James Hall, the State Geologist of New York. They were slender octavo volumes containing altogether only 370 pages of text, but with a liberal supply of excellently engraved plates. Three of the Decades are monographs on the subject dealt with, and the four volumes are classics in North American Geology and absolutely essential to students of North American invertebrate palæontology. In 1865 the first volume, 426 pp., of a series entitled "Palæozoic Fossils" appeared, the species described being entirely by Billings. Many of the descriptions are unaccompanied by illustrations and those afforded are wood-cuts. In 1866 the pamphlet, 93 pp., entitled "Catalogues of the Silurian Fossils of the Island of Anticosti," was published. It also consists of descriptions of species, sometimes illustrated, sometimes not. This closes the work done by the survey of the old Province of Canada, the operations of which extended only to portions of what are now Quebec and Ontario. As Sir William Logan said, much of the period was occupied in obtaining topographical knowledge sufficient to enable the first geological map to be made, and indeed this is the main result of his labours.* When we look at the very small qnantity of matter in the reports produced during this period of twenty-four years we must deeply regret the indifference of a people who could leave unsupported, save by two or three enthusiasts, a man with such endowments as the Director of the Survey, Sir William Logan, our honoured president in the first year of this Institute. We shall see later what this ignorance and indifference have cost us.

But narrow as was the scope of the work in old Canada it was worse in the Maritime Provinces. As early as 1838, Dr. Abraham Gesner began a geological survey of New Brunswick, which was carried on in some fashion until 1844, when it came to an end, the result being the reports detailed in the footnote below.† There was also, apparently, a report in 1843, 88 pp., not, however, styled the fifth report. Dr. Gesner had already published a volume on Nova Scotia‡ as a private venture in which he was assisted by the province, and the work in New Brunswick resulted in another contribution which reached the public in a similar manner. He was employed in 1846 by the government of Prince Edward Island to report on the geology of that province, which apparently resulted in a short report in 1847, and in 1849 he published a volume on the "Industrial Resources of Nova Scotia," but whether aided by the provincial government or not, I am unable to say. He published other papers regarding gold, iron, coal, and especially petroleum, but evidently to a languid public. In the volume on New Brunswick, published in 1847, and noted below,‖ Dr. Gesner says: "Of the British North American Colonies, New Brunswick was the first to undertake an examination of her mineral resources. Since the commencement of that survey, similar ones have been instituted in Newfoundland and Canada. Prince Edward's Island has also followed the example. Nova Scotia would have engaged in such a work long ago, were not her mines and minerals sealed up by a close monopoly, which withholds from the inhabitants any participation in the mineral wealth of the country."

There were a few apparently official but irregular reports published in New Brunswick which should not be overlooked. In 1850, J. F. W. Johnston made a report on the "Agricultural Capabilities of the Province," etc., which includes geological notes by Mr. Robb. In 1864, L. W. Bailey made a report on Mines and Minerals. In 1865, Messrs. Bailey, Matthew and Hartt, made a geological report on Southern New Brunswick.

We have already mentioned Professor Henry Youle Hind in connection with the Red River and Saskatchewan expeditions. When appointed to this important

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* "In 1854 . . when before the . . select committee of the Legislature . . appointed to investigate the working of the survey. . . Logan was asked what the principal difficulties he had met with were; he replied: 'Independently of those unavoidably incident to travelling in canoes up shallow rivers, or on foot through the forest, are those arising from the want of a good topographical map of the country. Accurate topography is the basis of accurate geology.'" Presidential Address, R. S. C., 1894. G. M. Dawson.

† "First, Second, Third and Fourth Reports on the Geological Survey of the Province of New Brunswick." Gesner. St. John. 1st, 1839, 82 pp.; 2nd, 1840, 72 pp.; 3rd, 1841, 88 pp.; 4th, 1842, 101 pp.

‡ "Remarks on the Geology and Mineralogy of Nova Scotia; with a new map of Nova Scotia, Cape Breton, Prince Edward Island, and part of New Brunswick." Gesner. Halifax and London, 1836.

‖ "New Brunswick with Notes for Emigrants." Gesner. London, 1847.

work he was the Professor of Geology of Trinity University here, and he had for many years edited the journal of this Institute. After completing the publication of the official reports and maps and the other publications which resulted from his expeditions he, in 1861, visited Labrador, the results of his exploration reaching the public in a work published as a private venture* similar in style to the London editions of the Red River and Saskatchewan Expeditions. In 1864 he was authorized to begin a new survey of New Brunswick the only result of which reached the public in the following year.†

We do not find that Nova Scotia ever attempted a geological survey. Reports generally in the shape of legislative documents on her coal and gold mines have been made by J. W. Dawson, Joseph Howe, Henry How, Henry Poole, J. Campbell, David Honeyman, Henry Youle Hind and John Rutherford, but the work in general geology has been done by men who published the results of their investigations at their own expense. In addition to the labours of Dr. Gesner in Nova Scotia we find that in 1832, Charles T. Jackson, afterwards State Geologist of Maine and Rhode Island, assisted by F. Alger, made a report on Nova Scotia‡ and Dr., now Sir J. William Dawson, in addition to a handbook in 1848, which went into at least six editions, published in 1855 the well known Acadian Geology|| of which there have been three editions, the third in 1878.

In 1873 Henry Alleyne Nicholson, then Professor of Natural History of the University of Toronto, aided by a small grant from the Government of Ontario, made collections of fossils in the Province, and in 1874 and 1875 published reports on the "Palæontology of Ontario," with several plates and other illustrations. These reports, perhaps the most valuable publications of the Government of the Province, are now so scarce as to be out of the reach of most students interested in geology, although indispensable until something more comprehensive appears. Unfortunately the descriptions and illustrations of many of the more difficult forms collected by Professor Nicholson do not appear in these reports but are published in expensive journals and other scientific works in England and Scotland, of which very few copies are to be found—in some cases literally only two or three—in all Canada. Since the excitement in mining has influenced the public, some of the provinces have established Mining Bureaus, and while these are a very inadequate substitute for regular geological and natural history surveys we owe a debt of gratitude to those who have induced unwilling governments to do even this much. The most important series of publications of this nature are those of the Ontario Bureau of Mines, which was created by legislation in 1891 and the publications of which have now reached the eighth volume. Under the guidance of its director, our worthy member Mr. Archibald Blue, it will no doubt grow year by year, limited in scope only by the liberality of the Government of Ontario. Ministers of the Crown in this province need not blind themselves to the fact, however, that since 1867, that is for thirty-two years, such material aud intellectual interests in this province as would be represented by a proper survey and public museum, and which, down to Confederation, were being so excellently looked after by Sir William Logan, have been persistently neglected. The next publication regarding mines in importance is that of British Columbia. The Bureau of Mines of that province was established by legislation in 1895 and published its first bulletin in June, 1896. The annual reports for 1896 and 1897, published in 1897 and 1898, respectively, are very creditable productions, quite superior as to printing and illustrations to those of Ontario.

Now if we gather together the pre-Confederation work of Canada, New Brunswick and other provinces, and the publications by provinces since Confederation, including the Mining Bureaus, and compare the entire result with any one of say five or six of the leading States in the United States, the result must make us both astonished and ashamed. But if we add all the work done by the Dominion Survey

* "Explorations in the Interior of the Labrador Peninsula," etc. H. Y. Hind. 2 vols, London, 1863.

† "Preliminary Report on the Geology of New Brunswick." Hind. Fredericton, 1865.

‡ "Mineralogy and Geology of the Province of Nova Scotia." C. T. Jackson and F. Alger. Cambridge, Mass., 1832.

|| "Acadian Geology; an Account of the Geological Structure and Mineral Resources of Nova Scotia," etc. J. W. Dawson. Edinburgh and London, 1855.

since 1867 to the provincial work, one state, New York, exceeds the whole in quantity of matter. Pray notice that I am not discussing in any manner the respective value of the work itself. I am very anxious to impress the legislatures of the Canadian provinces as to their shortcomings, and in order to do so I shall, at the risk of wearying you, press the point still further. If one were to look over a collection of reports on geology and palæontology of the various states he could at once count between 75 and 100 quarto volumes illustrated with fine maps and literally many hundreds of plates describing many thousands of fossils and other things of course besides fossils. And then turning to octavo volumes, similar to our own, I should be afraid to say how many hundred volumes he could count, but the total result would satisfy you that I am warranted in saying that we stand disgraced until we bestir ourselves and show that we possess ordinary intelligence regarding such matters. I shall not further hurt our pride as Canadians by comparing our position with that of many South American republics whose limited civilization we are wont to deplore.

We now come to the work done by the Geological and Natural History Survey of the Dominion. Although the series of publications from 1843 to date is unbroken I have separated them in order to consider the work done by the Dominion Government apart from that of the old Province of Canada. The change which was caused by Confederation was of very great importance, although it does not seem to have impressed itself on the Canadian people. Just before Confederation we had in operation a survey of what now constitutes portions of Ontario and Quebec, which would have year by year become more minute in its character until we reached such results as those obtained in many of the States where each county is reported upon so fully that the nature of its water courses, the character of its soil, the area of its forests, the value of its minerals, building stones, clays for brick-making, etc., etc., are published in such shape as to be available to anyone interested in such matters. But instead of this very desirable consummation of the early labours of Sir William Logan his work was largely arrested by Confederation, and there was thrust upon the Survey a problem similar in character to that undertaken by him in 1843, but incomparably greater in extent, namely, the survey of an area larger than that of the United States, if we exclude Alaska. I refer to the problem as similar in kind to that undertaken in 1843, because it was destined for many years to be mainly topographical and only subordinately geological. As late as 1880 the present director of the Survey, in demonstrating the inaccuracy of our maps of the northern and western parts of the Dominion wrote as follows :* "It is very commonly supposed, even in Canada, but to a greater extent elsewhere, that all parts of the Dominion are now so well known that exploration, in the true sense of the term, may be considered as a thing of the past. This depends largely upon the fact that the maps of the country generally examined are upon a very small scale, and that upon such maps no vast areas yet remain upon which rivers, lakes, mountains, or other features are not depicted. If, however, we take the trouble to enquire more closely into this, and consult, perhaps, one of the geographers whose name may appear on the face of the map which we have examined, asking such awkward questions as may occur to us on the sources of information for this region or that, we may probably by him be referred to another and older map, and so on till we find in the end that the whole topographical fabric of large parts of all these maps rests upon information of the vaguest kind.

"Of most of the large areas marked upon the map here shown, this is absolutely true, and the interests of knowledge, with respect to these, would be better subserved if such areas were left entirely blank, or, at least, if all the geographical features drawn upon them appeared in broken lines in such a way as to show that none of them are certain. In other regions, the main geographical outlines, such as the courses of the larger rivers, are indicated approximately, with such accuracy as may be possible from accounts or itineraries derived from travellers or from officers of the Hudson Bay Company ; or from the descriptions or rough sketches of Indians or other persons by whom the region has been traversed, but who have been unprovided with instruments of any kind, and whose knowledge of the country has been incidentally obtained."

* "On Some of the Larger Unexplored Regions of Canada." G. M. Dawson. Ottawa Naturalist. Vol. IV. 1890.

Apart from the areas of Asia and Africa not yet examined, and possibly of Brazil, the work before the Geological Survey of Canada is the greatest in extent in the world. The topographical work alone is enough to break the heart of any director supported only by the meagre grants of our Government, and if we consider the geological work, confined as it must be at first to the broadest generalizations, it is fairly certain that we shall not in another century reach the position where our people will have before them the information regarding Canada which is possessed to-day by the people of the United States regarding their country.

Our Dominion Survey, since Confederation, has published its annual reports of progress, and these have grown in size until they are among the most important annual contributions to our knowledge of geology, but they are still only reports of progress containing information largely topographical, accompanied by notes on the geological and natural history features. These reports have been accompanied by a liberal supply of maps, the majority of which are topographical and form material for the complete map of the Dominion which we may hope to see in half a century or so. In addition to the report of the director these annual reports of progress contain in separate papers the results of the labours of the various exploring parties and the reports of the section of chemistry and mineralogy and the section of mineral statistics and mines. The work of the palæontological section is published separately. These have appeared under several titles in a manner which makes it difficult to at once appreciate just how much work has been done. There are at least five distinct series, most of which are still in progress. There are the "Palæozoic Fossils" of which the first volume preceded Confederation. The first part of the second volume, containing work by Billings, appeared in 1874 and remains unfinished. Of the third volume three parts have appeared—1884, 1895 and 1897. Then we have the "Mesozoic Fossils" of which three parts of the first volume have been published—1876, 1879 and 1884. There is a series entitled "Contributions to Canadian Palæontology" of which the first volume was published in five parts and is complete—1885, 1889, 1891, 1892 and 1898. The present able palæontologist, Mr. J. F. Whiteaves, Assistant Director of the Survey, succeeded Mr. Billings and these volumes contain his work alone. The first part of the second volume of "Contributions to Canadian Palæontology," which appeared in 1895, is devoted to Canadian Fossil Insects and is by the eminent authority on that subject, Dr. S. H. Scudder, of Cambridge, Mass. The first part of the third volume, published in 1891, is the only quarto publication. It is by the late E. D. Cope and is a valuable but all too small contribution to our knowledge of the fossil vertebrates of the North-West. We have also a series called "Contributions to Canadian Micro-Palæontology," of which have been published four slender parts of a first volume by as many authors, none of whom are members of the Survey, bnt all experts in the particular subject. In addition to these series Sir William Dawson contributed two monographs on fossil plants, published in 1871, 1873 and 1882. This sounds like a great deal of matter but when put together there are less than 1,500 pages and about 185 plates, equal in quantity to two, or at the most three, average reports in the United States. This is what we have produced in thirty years from a country most notably rich in fossils, and during a period when hundreds of volumes on palæontology have appeared in the United States. In botany there have been six extensive catalogues of Canadian plants and several additional pamphlets mainly the work of the indefatigible botanist of the Survey, Mr. J. Macoun. I do not remember a single illustration, although in the United States Pacific Railway reports already referred to, there are hundreds of engraved plates illustrating western plants. There are a few other publications of the Survey and many contributions by members of the Survey to the volumes of the Royal Society of Canada and to other journals, but they only serve to emphasize the impossibility of making bricks without straw. I am very happy to hear that in addition to the contributions of Mr. Whiteaves we are to have important contributions in the shape of a revision of the Palæozoic Corals of Canada by Mr. L. M. Lambe of the Survey and I hope we may soon see the results of Dr. H. M. Ami's work in print and plates. It is also gratifying to hear that Dr. G. F. Matthew, of St. John, N.B., one of the most eminent authorities in Cambrian geology and whose contributions to the Royal Society of Canada form the most important additions to our knowledge of this branch of palæontology, is to do work in certain fields for the Survey as he did some years ago. If we could but feel that as the field workers bring in material it would be studied at an early date by the palæontologists of the Survey, so far as it might come in the line of their studies, and that the rest of the material would be submitted to other palæontologists, who are experts in the particular subjects, a new day would dawn for us, but without money this is impossible. I have not alluded to the particular explorations of those who worked in the field under the directorship of Dr. Selwyn and of his successor, Dr. Dawson, and of their fellow-workers in the laboratory and study. It would be impossible to mention the names of all or to make a selection, but we can well afford to thank the few who are left in the field, Messrs. McConnell, Bell, Ells, Fletcher, Low, Macoun, and others, for their devotion.

In 1867, the year in which the Dominion Government took charge of our survey, the United States inaugurated the first regular survey under the Department of the Interior. It was called the "Geological and Geographical Survey of the Territories," and was under the charge of Dr. F. V. Hayden, until it was superseded in 1880 by what is called the "United States Geological Survey." A comparison of the publications of these two surveys alone with those of Canada during the same period, would be unfair to the United States, because we thus overlook the publications of the Smithsonian Institution, the United States National Museum, and other departments at Washington, but the result is overwhelming enough. We must also bear steadily in mind the fact that while these publications were being produced, twenty-five or thirty States were also actively at work, while the Provinces of Canada were doing practically nothing. During Hayden's Survey, 1867-1879, annual reports were issued somewhat similar to ours in size and character, but there were also five volumes of bulletins, containing upwards of 150 papers, thirteen miscellaneous, and fifteen unclassified publications, about seventy-five maps, and thirteen final reports or monographs. The monographs were splendid quartos, liberally supplied with plates and other illustrations, and illustrating and describing vertebrate and invertebrate fossils, including fossil insects, also fossil flora, and existing forms of rodents, acridians, rhizopods, etc., all from the far West. The present survey has published nineteen annual reports. The last report will include, apparently, six parts, and some of the parts cover two volumes. I wish it were possible to explain here the scope of this one annual report. Of bulletins about 150 had been published down to 1897, and of papers on water supply and irrigation, ten. Of monographs, of the same character as those under Hayden's Survey, thirty-four. Of maps, statistical papers, etc., there has been also a liberal supply.

The operations of our Survey for the year ending June 30th, 1897, cost \$117,000. For the nearest year in the United States the cost was \$1,034,000. Our usual basis of comparison is population, and measured thus we spend the most, but clearly, that is not the measure for this particular item of national expense. The real basis of comparison between the United States and Canada of expenditure for survey and topographic purposes, should be the respective areas of unexplored or insufficiently explored territory. Judged thus, Canada should be spending much more than the United States, and we must not forget that in comparing the \$117,000 spent by Canada with the \$1,034,000 spent by the Federal Government of the United States, we leave out the large expenditure by the various States carrying on surveys on their own account. I am quite sure that on mere topographic work we should spend more than the United States, but I am aware that we think at all events that we cannot afford to spend so much, and I would not spoil a good cause by asking for what will certainly not be granted. But looking at matters in the hard light of politics, and gauging the possibilities in Canada by other countries not more able to spend, I am quite sure that at least \$250,000 annually should be appropriated for our geological and natural history survey. And in addition to this, the Provinces should each spend at least \$10,000 annually and carry on their work in concert with the Dominion Survey, so that in all respects there would be united effort and no unnecessary duplication of work. Perhaps some of the Maritime Provinces would think \$10,000 too high, and a smaller sum might suffice, but for Quebec, Ontario and British Columbia with their vast areas, the sum suggested is very small. That the people would find the expenditure a good investment in dollars and cents I am certain, quite as good an investment as our expenditure on canals and railroads. I approve of state aid to railroads and canals in a new country, because transportation is one of our greatest problems, but the first duty, the very first duty of an intelligent country, is to know what it has or may have to transport.

In conclusion I should like to say a few words as to what we might reasonably expect in the way of Dominion and Provincial surveys. We should have the Dominion and Provincial surveys working out the topography in a far more minute manner and on a greatly larger scale than at present. We should never again send out a topographic party, a boundary party or a land surveyor laying out a base line, without being accompanied by trained geologists and naturalists. The history of our own Northern Ontario is an example of what we have failed to accomplish in this respect. We should not only publish annually such broad truths of geology and natural history as are gathered during these rapid topographic surveys, but we should be engaged in our provincial surveys on reports dealing with the features of each county separately, and in our Dominion Survey in working out special problems of geologic or other scientific interest. For instance, in the United States there are many complete monographs dealing with the iron ores of different localities, or the coal, or natural gas, or the forestry conditions, or other problems of great commercial importance. Have we no curiosity about our great areas of iron ore, our really wonderful coal fields, and our other minerals? Should we not appreciate intelligent monographs on the treatment of refractory ores, on modern mining machinery, on brick-making, salt-wells, gas-wells, and the many other things so intelligently presented to the people by the State in more favoured countries? Of course we should. Let our Governments but try.

And as to Public Museums. The Dominion Government at Ottawa and each province, at its city of chief importance, should have a museum belonging to and supported by the people. These museums should contain exhibits of the metallic and non-metallic minerals of the country, both those of economic and of merely scientific value, the forest trees, with the bark preserved, in say six feet sections, cut also and partly polished, and each specimen accompanied by a small map showing its habitat; the fresh water and sea fishes, mounted after the modern methods; the fur-bearing animals, the game birds, and the birds of our forests, fields and sea-coast, many of them mounted so as to tell a child their habits at a glance; the reptiles, crustaceans, insects, plants, indeed as complete a record of the fauna and flora of the country as possible; the rocks of stratigraphic importance and all the varieties of fossils which can be gathered in this country; the archæological and ethnological evidences of the races we have supplanted in Canada, and much more that does not occur to me at the moment. I should not like to suggest a limit of expenditure on such museums. The necessity of a new building at Ottawa is admitted. The crime of leaving exposed to fire, in a wretched building never intended to protect anything of value, the precious results of over fifty years of collecting, has been pointed out in a recent official report. But the Government seem deaf to such claims. I can only repeat that we are rich enough to bear the cost with ease, but we are not intelligent enough to see our own interest in spending the money.

I have been careful to indicate that so far as this is an account of what has been done in geology and natural history in Canada, it is mainly a record of work done officially, that is for the governing bodies and not by individuals unassisted by public money. But it must not be supposed that I am unmindful of the fund of information which has reached the public through the journals of the scientific societies of Canada, some of which have been labouring for over half a century in this field of higher education. Nor must I fail to acknowledge that such societies are, as a rule, aided by public grants of money. It would have been a great pleasure to have mentioned many of the writers and investigators who have contributed gratuitously in the past to this fund of knowledge, but I can do no more than to record here our gratitude to some of the living geologists—to Sir J. William Dawson, Dr. G. F. Matthew, Prof. L. W. Bailey, Dr. J. W. Spencer, Dr. F. D. Adams, Prof. A. P. Coleman, Mgr. J. C. K. Laflamme, and all others who still labour in the good cause, although not members of our Survey. I am aware that I should add the names of many botanists, ornithologists, entomologists and other workers in natural history, but I fear my knowledge of these subjects is too limited to enable me to give credit where it is due.

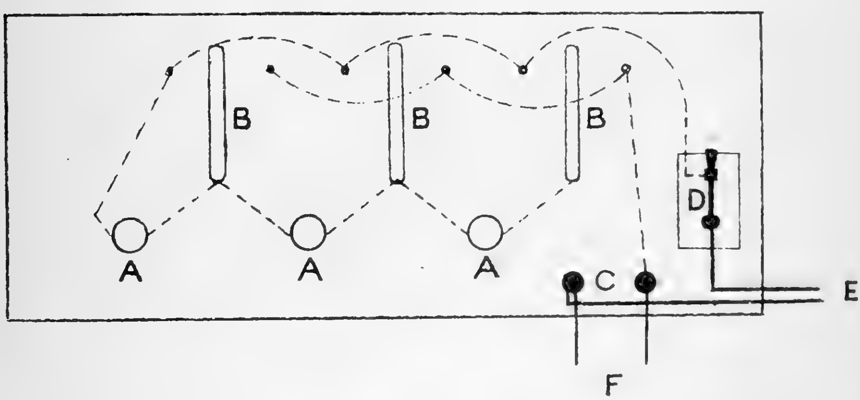
I am sure I must have wearied you with such a lengthy address. I have but one excuse—my firm belief that the future of Canada depends to a degree not generally recognized, upon our liberality in spending money to exploit our country.

A Convenient Resistance for Electrolytic Analysis. By J. Watson Bain, B.A. Sc.

(Read 10th February, 1900.

CHEMISTS, who employ electrolytic methods, are often annoyed by difficulties in obtaining a suitable current. Primary batteries are most unsatisfactory in many ways, requiring constant attention, and being subject to considerable variation in their current. Storage cells are very much more convenient, but the necessity of charging is a drawback, and detracts somewhat from their value.

By means of a suitable resistance, the direct current of the ordinary incandescent circuit may be used with great comfort; the variations which occur



are so slight as to be negligible, there are no cells to be kept in order, and the current is always ready for use. A convenient resistance for this purpose has been employed in the chemical laboratory of the School of Practical Science for more than a year, and a brief description of the apparatus, may be of value to those, who have not had time to experiment for themselves.

The arrangement is represented in the accompanying diagram in which *AAA* represent three sixteen-candle power incandescent lamps, with their sockets; *D* is a single throw switch; at *C* are two binding posts, to which are connected the wires *F* leading to electrodes in the solution under analysis;

BBB are strips of brass, pivoted at the lower end, each of which can make contact with two of the studs, represented by heavy dots in the diagram; *E* are feed wires from the incandescent circuit; and the dotted lines represent the invisible connections.

These various parts may be conveniently mounted on a board eighteen by eight inches.

By combining the lamps in different ways, currents varying from 0.2 to 2 amperes may be obtained, a range which is ample for the usual electrolytical work.

NOTES ON SKULLS TAKEN FROM A PRE-HISTORIC FORT IN KENT COUNTY. BY MR. ARCHIBALD BLUE.

(Read 21st April, 1900.)

THE Indian Fort on lot 59 north of Talbot Road, in the Township of Orford, is situated at the springs which are the source of Clear Creek, two-and-a-half miles from the shore of Lake Erie and a mile from the decayed hamlet of Clearville. Until twenty years ago the Fort stood in the midst of a dense forest of beech and maple, white oak and black walnut, and there were trees of large size growing on the walls and within the enclosure. The site was known to the early settlers, but none among them were archæologically inclined, and the ground was not disturbed by them. It used to be said, however, and I think it is true, that one of my old schoolmasters, Galbraith the Phrenologist, was a frequent visitor there, and that he dug up some skulls to help in his studies. It was while he was employed as teacher in our school, in the years 1848-49-50, that he applied his spare hours to acquiring a knowledge of Phrenology, and from our school he went out on his long career of lecturer on the subject in this Province and elsewhere.

But the first serious attempt to explore the Fort was made eleven years ago by Mr. David Boyle, our archæologist, who succeeded in getting six skulls which are now in the Museum of the Education Department. Mr. Boyle made measurements of the Fort, and a sketch and description of it together with an account of his exploration was printed in the Proceedings of this Institute for 1888-89.* In Mr. Boyle's opinion the graves exhumed by him did not probably belong to the people who built the walls, but to subsequent possessors of the ground who had lost all knowledge of its former occupancy.† He suspects, indeed, that there were three successive occupations by different tribes separated by wide periods of time. The skulls secured by him were discovered in an ossuary on the highest plane within the walls, and had been interred with the limb bones only.

These Notes lend confirmation to Mr. Boyle's views, and being mainly a transcription of the entry in my notebook made upon the ground I can vouch for their accuracy.

It was on the 14th of August, 1889, about a month after the explorations made by Mr. Boyle, that I first saw the Fort, although I had known of it from childhood. I was accompanied by Dr. P. H. Bryce of this city and my brother, the late John Blue, jr., of Orford. The trees had been cut down and the timber removed at that time, but most of the stumps were yet fresh and showed that a number of the trees were of large size. In all other respects the site was practically unchanged. The walls or embankments of the Fort were in an excellent state of preservation, and oblong or nearly oval in form. As originally constructed they appear to have followed upon the north, west and south sides the edge of the bank of the creek and one of its small tributaries, and there are cross-walls from north to south which divide the enclosure into three unequal areas, two of which occupy benches of the creek, while the third is on the tableland of the country. Where intact, the walls are about ten feet wide at the base, three to four feet high, and about five hundred yards in the outer circumference. At the north-east angle there is a breach in the wall about twenty-five feet long, which may have been an opening to the midden-heap, and at the north-west angle is a low bit of wall about seventy-five feet long. There is a third opening midway in the

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* Annual Report of the Can. Inst., Session 1888-9, pp. 15-18.

† Notes on Primitive Man in Ontario, 1895, p. 20.

west wall, which no doubt was the water-gate of the Fort, as some of the springs which feed the creek are not more than thirty feet distant from it. The north wall like the west one extends parallel with the ravine, but is at a higher level and overlooks a steeper slope. As already stated, the enclosure occupies three distinct levels, separated by cross walls, the lowest one on the first bench of small extent, and the upper ones which rise by successive steps embrace about 7,000 square yards each.

Numerous openings had recently been made on the upper level and also upon the enclosing walls, at almost every one of which we found ashes, bones and pieces of pottery. Along the northern side of the second bench we were attracted by a small but distinct depression, about six feet in width and lying 5° west of north. As it seemed to be a likely spot for exploration we made an opening along the middle of it, at a point twenty-five feet from the base of the north wall. At a depth of eighteen inches the spade struck and broke what proved to be a thigh bone, and the limb was carefully uncovered down to the foot. We then opened towards the head, measuring about six feet from the heel, and struck upon a skull in such a position as led us to suppose it must be part of the same skeleton as that of the thigh and leg bones already uncovered. Extending the work from the head downward we found the position to be such as would suggest that the pelvis had been bent from the general line of the body ; but further digging showed that we were upon a second skeleton, lying upon the east side of the first. Having removed the earth from a space seven feet long by four wide, the true situation was apparent. The bodies had been laid side by side on a north and south line, but with the heads inclining towards each other at an angle of about 15°.

The bones had the usual yellowish brown color peculiar to extremely old bones, and were so fragile as to crumble almost at a touch. The sutures however indicated that the age of the persons at the time of death would not exceed 40 years.

The skeleton lying upon the right or westerly side was obviously that of a male person, as it measured five feet nine inches in length and was relatively narrow across the pelvis region. It was equally obvious that the other was a female, the length of which was five feet five inches with a relatively broad pelvis. The head of the male was thrown forward, with the lower jaw fallen down upon the vertebræ of the neck, the cause of which was discovered in the root of a walnut tree which had entered at the right ear, and, passing through to the left side, pushed the sub-maxillary bone out of position. The skull may be described as rather brachycephalic, but with retreating frontal bones, broad occiput and dome-shaped vertex. It was completely filled with a fine black mould, upon removal of which the parts separated and fell to pieces. A curious find in the base of the skull was the under-jaw of a chipmunk. There were twelve teeth in the lower jaw of this skull, well preserved, but the two left incisors were blackened and worn down about one-twelfth of an inch below the level of the other teeth. The two bicuspid teeth on each side were missing, but the molars were sound. The bones of the vertebræ and all the lower parts of the body were in position. Those of the feet were lying outwards. The bones of the left side were throughout more fragile than those of the right, except in the skull, which was injured by the root that had penetrated it. The arms lay alongside the body, extending two-thirds of the way down the thigh bones, but with the fingers of the right hand underlying the thigh.

The female skeleton was in a better state of preservation than the male, except as they were injured by the root, which, extending under the skull and spinal column, had destroyed the occipital bone and portions of the spine. The head was very nearly within the brachycephalic limit, with high and rather broad frontal bone, wide occiput and large eye sockets. The teeth were in good condition, and only three were missing—two bicuspids in the lower and one in the upper jaw. The front lower teeth were slightly worn.

There is no doubt from the color and condition of these skeletons that they had lain a long time in the earth ; but additional evidence of time is afforded by the root which had disturbed them. This root, which was two-and-a-half inches in diameter, belonged to a walnut tree which grew within the walls of the Fort, at a distance of fifteen feet to the north-west of the bodies. From the appearance of the stump, the tree had been cut down for at least a quarter of a century. The diameter across the cut was forty-six inches, and I counted four hundred and eighty concentric circles of growth, exclusive of two inches of decayed wood on the circumference. Assuming each circle to represent a year, the beginnings of that tree must be carried back to the dawn of the fifteenth century, or nearly a hundred years before Columbus discovered America, and the probability is that during the first period of occupation no trees stood within the walls of the Fort.

The skulls exhumed by Mr. Boyle were found in the highest plane of the enclosure, where evidently they had been re-interred. All of them are remarkably fresh and well preserved, as compared with those taken up by Dr. Bryce and myself; but one is minus a portion of the left temporal bone, so that an exact measure of its breadth cannot be secured. Measurements of the two lots for calculating the cephalic indices have been made for me by Mr. Boyle, and they are interesting in so far as they appear to prove that the older and newer skulls represent two distinct races of people who at different times occupied the same locality. The skulls collected by Mr. Boyle are given according to their catalogue numbers and with brief descriptive notes.

No. 12,480.—$6\frac{3}{4}$ by $5\frac{3}{8}$ inch. Nicely formed skull of a woman. Reddish brown in color, as if caused by suffusion of blood. No Wormian bones. Age, 35 to 40 years. Cranial index, $79\frac{3}{5}$.

No. 12,494.—$7\frac{1}{2}$ by $5\frac{1}{8}$ inch. Pronounced supra-orbital development. A strongly formed skull, with sutures prominent. Age, about 50 years. Cranial index, $68\frac{1}{3}$.

No. 12,499.—$7\frac{1}{4}$ by $5\frac{1}{2}$ inch. Occipital bone largely developed, with very prominent process. Large Wormian bone at the fontannels of the parietal and frontal bones and along the occipital suture. Age, 60 to 65 years. Cranial index, 76.

No. 12,500.—$7\frac{3}{8}$ by $5\frac{1}{4}$ inches. Extraordinary development of supra-orbital ridges. Sutures ossified. Age, probably 80 years. Cranial index 71.

No. 12,501.—$7\frac{1}{8}$ by $5\frac{5}{16}$ inch. Skull of very fine texture. Slightly unsymmetrical in occipital bone. A few Wormian bones around the occipital. Age, 40 to 45 years. Cranial index, $74\frac{1}{2}$.

The two old and uncatalogued skulls give the following measurements :—

Male.—7 by $5\frac{1}{2}$ inch. Cranial index, $78\frac{4}{7}$.

Female.—$6\frac{3}{4}$ by $5\frac{1}{4}$ inch. Cranial index, $77\frac{7}{9}$.

The cephalic index is used to represent the percentage of breadth to length in the living head, and is assumed by Ripley and others to be two to three per cent. more than the cranial index or proportion according to skull measurement. When the percentage rises above 80, according to Ripley, the head is brachycephalic; when it falls below 75, it is dolichocephalic; and when the index is between 75 and 80 it is mesocephalic,—or short, long and medium formed heads respectively. Applying this rule to the skulls of the Clear Creek Fort, it is found that the two old skulls are on the border line of the brachycephalic class. Only one of the later skulls belongs to that class, two are markedly dolichocephalic, and two are mesocephalic.

There are not a sufficient number of skulls for computing an average index. As far as numbers go, however, they indicate that two widely different races are represented, and so completely are they cut off from us that even the more modern of them has hardly left an event, a record, a fact, or a tradition out of which to weave a page of human history.

THE PRESIDENT'S ADDRESS. BY JAMES BAIN, JR., ESQ.

(Read 18th November, 1900.)

IN declaring open the fifty-second session of the Canadian Institute, my first duty is to thank you for the honour you have conferred by electing me to fill a chair which has for half a century, been occupied by a succession of eminent men, the very recollection of whose names fill me with a sense of my own unworthiness. The recent semi-centennial celebration forcibly reminds us that the old generation has almost passed away and that a new generation has entered into its place, let us hope, with the same simple, earnest, unselfish desire to advance the cause of scientific research in this city and province, and to enrich ourselves with a deeper insight into the secret processes of nature. In addressing you on this occasion, it seems natural that I should consider the Institute and the work which is being carried on in it, from the standpoint of my own profession, and its library, therefore, occupies a leading position in my remarks this evening.

Private libraries, when accumulated by thoughtful men are almost always the reflex of the owner's mental pursuits, whether he gathered his books as his working tools, or indulged in what is generally called literature, for the refreshing of his mind and indulgence of his love for the beautiful. Associations of persons engaged in search for common objects or desiring a common end, must, if they accumulate books, follow the same course as private individuals, and their library becomes the reflex of their wants. The collection is more or less heterogeneous according to the number of those who have influenced the purchasing. In this way, libraries such as our own have grown up, and while special libraries for scientific use have often been collected in a brief space of time, and with a strict adherence to the definite purpose for which they were intended, most collections made by young and energetic societies have grown, as I have described. When the Natural History Museum was removed from the British Museum to South Kensington, it was resolved, to buy new working libraries for each department, rather than deplete the collection in Bloomsbury. A large sum of money was granted for this purpose to the Botanical Department, and perseverance and energy extended over a few years, created a library of books on this branch of Science, which has few equals. It is seldom however, that libraries are thus formed. During the early years of this Institute, it was the intention of the members to obtain either by purchase or donation, those books on science, history, travel or biography, which, month by month as they were published, commended themselves to the council, as being of more than ephemeral value. In looking over the remains of the early purchases, it is interesting to trace the individual tastes of the members of council of those years. The removal of the Institute twice, the change in the manner of life, carrying the homes of the members further from the centre of the city, and most important of all, want of funds, tended to diminish interest in the Society's collection of modern scientific literature. A library of current books, whether scientific or not, depends for its active existence upon a steady influx of new books, and when this ceases, the library rapidly loses its position and usefulness.

During this period however, a continuous stream of transactions, collections, proceedings, archives and other publications of learned and scientific societies poured in, so that when the present building was being completed, the council realized for the first time, that they had the nucleus of a library which might become extremely valuable from its wealth of scientific material. For some years the council devoted a considerable portion of its limited income to binding the accumulations, but finding that they were not able to overtake the arrears and keep up to the yearly additions, they asked the government of the Province to aid them in what they felt was a provincial work. This assistance was generously and readily given for two years. A surplus in the hands of the committee for the reception of the British Association in 1897, was also handed over to the Institute, for the purpose of increasing the number and completing such sets as it was desirable either to buy or perfect. This work is now being carried on by your library committee, a number of sets have been completed during the past year, and an accurate list has been made of the balance, to obtain which persistent efforts will be made. Most of the miscellaneous books have been exchanged or sold, and all the available space devoted to the publications of Societies. The library of the Institute is therefore strictly specialized as a Science library, not limited to any one branch of Science. It contains to-day about 7,000 bound volumes, containing the annual or biennial publications of 588 societies. These societies are scattered over the civilized world, wherever men are thinking and working on scientific lines. The mere list of countries is suggestive, as I go over them in alphabetical order: Algeria, Argentine Republic, Austria-Hungary, Belgium, Brazil, British Guiana, Canada, Chili, China, Cape Colony, Costa Rica, Cochin-China, Denmark, Equador, Egypt, England, France, Germany, Greece, Holland, India, Ireland, Italy, Japan, Java, Mexico, New South Wales, New Zealand, Norway, Peru, Portugal, Queensland, Roumania, Russia, Scotland, Spain, Straits Settlement, Sweden, South Australia, Switzerland, Tasmania, Tunis, Turkey, United States, Uraguay, Victoria, West Indies, forty-seven in all. Some of the countries have so recently entered the field of Science, that it is difficult to realize the change which has taken place in a hundred years. That Algeria or Cochin-China, or Java, or Costa Rica should be there, is one of the features of the 19th century, which marks it off from all preceding eras. Down nearly to the middle of the 18th century, Latin was the common language of Science in Europe, and the use of a common tongue did much to extend scientific knowledge, at a time when the number of students in each country was limited. But now the vulgar tongue prevails within certain limits, for we find that though these five hundred and eighty-eight sets represent forty-seven countries, they only require fourteen languages. English has 281, French 100, German 89, Italian 42, Spanish 34, Norwegian 9, Swedish 8, Dutch 8, Russian 5, Hungarian 4, Danish 3, Portugese 2, Latin 2, Modern Greek 1. As might be expected their subject matter is extremely varied. A large number of societies like our own, include within their publications, original papers on any subject of scientific research. The number of sets pubished by these general societies is two hundred and eighteen, and the remaining three hundred and seventy are divided thus:—Chemistry 5, Botany 14, Geology 29, Archæology 25, Engineering 39, Philosophy 25, Geography 40, Philology 7, Entomology 6, Astronomy 11, Biology 6, Physics and Mathematics 12, Zoology 4, History 28, Meteorology 13, Ethnology and Anthropology 38, Agriculture 9, Medicine 8, Statistics 10, Law 8, Mineralogy 1, Microscopy 7, University Papers 21.

The yearly increase is about two hundred and fifty volumes. The number of papers or treatises in each volume may be estimated at an average of ten, which fairly represents 70,000 separate books.

Let us now compare our situation with that which prevails in older countries. In all these it may safely be said that they point to the number and quality of their libraries, and the use that is made of them as one of the evidences of their culture and intelligence. The nation without such marks of learning, is lower in rank in the scale of civilized peoples, and one of the distinguishing marks of its rise, is the number of libraries which are established. Outstanding above all others in English speaking countries, is that of the British Museum with its 2,000,000 printed books and manuscripts, and 200,000 pamphlets, with its readers from all parts of the world, and its yearly increase by purchase, donation and copyright of 27,000 volumes, and 67,000 serials and parts of books. In English books it is the richest in the world, and in the literature of France, Italy, Russia, Germany and Austria it is only second, if indeed second to the National Libraries of these countries. Its collection of American books is equal to anything on this side of the Atlantic, and its Oriental literature is not rivalled by any of the great cities of the East. The United Kingdom also possesses in addition over three hundred libraries, ranging from five thousand to half a million volumes. The largest library in the world is that at Paris, which contains about two and a quarter million of books and 160,000 manuscripts, and France possesses in addition five hundred public libraries, containing four and three-quarter million of books. Germany has no less than ninety-seven large libraries, averaging 100,000 volumes each, the Royal Library at Munich, having something over 900,000 volumes, and the Royal library at Berlin over 700,000. We are not accustomed to think of libraries in connection with Austria-Hungary, but it stands first among all the countries of Europe for numbers, having no less than five hundred and seventy-seven public libraries, containing about 6,000,000 volumes, a number which is equal to about twenty-six books per head for the entire population. Russia, so comparatively recent in its civilization, has one library very nearly as large as the British Museum, and seven over 100,000 volumes. Even the smaller countries, like Switzerland and Denmark, have respectively eighteen libraries, ranging from 40,000 to 100,000 volumes, and four libraries containing 725,000 volumes. I might continue the list of countries, which all tell the same story, but will only mention one other,—the little Island of Iceland, poor in men and means, but exhibiting to us its love of learning, has one scientific library of 30,000 volumes in addition to several libraries of general literature. I have purposely refrained from mentioning the American libraries, because so many of them are familiar to us, and because most of us are astonished at the wealth which has been expended upon them, the rapidity of their growth and the energy with which they are conducted. But it may well be said that these are general libraries, which by the assistance of the State, or by private generosity are enabled to make immense collections for the benefit of readers of all classes. As general libraries they strive to cover the whole field of human knowledge, and do so more or less superficially. Even in the case of the British Museum, we were recently told by a very high authority, that "it did not contain more than one-half, or at least three-fifths, of the books in English which have been printed." It is not too much to say that the best library of the English speaking people, is more or less, of a makeshift. Mr. Bullen, the late keeper of the printed books in that library recognized this, when he testified before the Society of Arts, "that on few or no subjects to be investigated, could the British Museum afford the scholar half the necessary books." Let us now turn to the consideration of societies like our own and see what they have done to supply the demands of their readers. In Great Britain the Royal Society has 75,000 volumes, the Royal Institution has 50,000, the Royal Irish Academy 80,000, the Newcastle Literary Philosophical Institute 60,000, and many others with corresponding numbers of books in their libraries. But these while confining them to Science generally, evidently do not meet the wants of students in special subjects, for we find a Geological Society's library of 17,500 volumes and another of 30,000, a Geographical of 25,000, a Statistical of 27,000, and an Electrical Engineers of 100,000 volumes, and so on through every branch of the Arts and Sciences. Now think of these and then of our collection of two hundred and ninety volumes in Geology, or in Geography of four hundred, or Statistics of one hundred volumes.

The fact is, that when a student enters upon a special branch of study, he finds so little to help either in our own library or in other libraries in this city, that he is compelled to look elsewhere for the literature of his subject. Let him be engaged upon, say, botanical research, he would find that our apparently large collection contains perhaps one hundred and fifty volumes devoted to this subject, and so with every other branch of Science. The closer the student specializes, the more difficult it is for him to arrive at what is known, as a basis upon which to carry on his researches. It is evident that our library, however complacently we may admire it, is as yet, but in its infancy. We must not cease to enlarge and develop it, every opportunity must be taken to increase the number and preserve the high character of its books. The council has done wisely in fixing the limits within which it ought to grow. Other institutions in this city have their own place to fill, and should be stimulated by our example, to increase their usefulness within their own limits. We must do more to meet the wants of our own students, gaining from them such a knowledge of our shortcomings, as will aid us in building up our collection on special subjects. The student who knows his subject is the best friend of the library, and the council would act wisely in purchasing freely, to meet his requirement, even if for a year or two, the library may become one-sided. Others follow in time on different subjects and should be treated in the same way, so that the period is not far distant, when it would become a scientific library of high standing. It is well to remember that a library is not of value according to the number of its books, but because of their character and the facility with which their contents may be known. The Encyclopedia represents the demand for systematically arranged knowledge. The information contained in it may be found in more extensive form, in more interesting shape and in close connection with its context, in a few hundred books, but the ordinary reader has no time to make the necessary search, or lacks the necessary knowledge to guide him, and therefore turns to a quarter where it is found under its proper letter of the alphabet. It is therefore better to have a library of 5,000 volumes fairly covering two or three subjects and provided with the proper apparatus for gaining a knowledge of its contents, than 20,000 which are scattered over all subjects, without such a guide. The one will attract special students from all directions, who will find within reach, their subject fairly treated, while the other will become the happy hunting ground of the dillitante, or the careless, edifying none. To make our own library worthy of the Institute, it is essential therefore, that it should increase in fixed directions, that subjects should be chosen which can be worked up, and that proceeding thus, department after department might be made so complete, as to make it of immense value to the whole Province. One of the requirements which I have pointed out as an essential in a good library, is an easy and accurate means of obtaining a knowledge of what it contains. In our case this is rendered even more necessary, as the treatises we have and hope to obtain, are contained in volumes which bear as their title the name of the society by whom they were issued. In some cases the contents are very miscellaneous ranging over many subjects. Some institutions publish at long intervals, ranging from ten to fifty years, properly arranged catalogues or indices, covering the volumes published during the interval, but the index may be only for the early volumes, while the information sought is to be found in the more recent. The expense of preparing a catalogue, month by month. as the different fasciculi arrive, is so great, that no society with limited sources of income could undertake it. Fortunately for small libraries and scientific enquiries, this difficulty is now being overcome, and what one society could not hope to do, the many in combination are about to do. About ten years ago, a conference under the auspices of the Royal Society, was held in London, to consider the possibility of a co-operative catalogue of scientific papers. The conference contained representatives from almost all civilized countries, and was favourable to the undertaking. Much time and infinite pains have been taken to arrive at a basis upon which to proceed with the work, and at the meeting held in London in June last, the conditions as amended and reconsidered, were finally adopted unanimously. The objects and nature of the catalogue are thus defined :—

1. That it is desirable to complete and publish by means of some international organization, a complete catalogue of scientific literature arranged according both to subject-matter and to author's names.

2. That in preparing such a catalogue, regard shall, in the first instance, be had to the requirements of scientific investigators, to the end that these may, by means of the catalogue, find out most easily what has been published concerning any particular subject of inquiry.

3. That in indexing according to subject-matter, regard shall be had, not only to the title (of a book or paper), but also to the nature of its contents.

4. That the catalogue shall comprise all published original contributions to the branches of science hereinafter mentioned, whether appearing in periodicals, or in the publications of societies, or as independent pamphlets, memoirs or books.

5. That a contribution to science for the purposes of the catalogue, be considered to mean, a contribution to the mathematical, physical or natural sciences, such as, for example, mathematics, astronomy, physics, chemistry.

mineralogy, geology, botany, mathematical and physical geography, zoology, anatomy, physiology, general and experimental pathology, experimental psychology, and anthropology, to the exclusion of what are sometimes called the applied sciences.

The convention conferred power upon an International Council to carry out the details of the work on the lines laid down, during each ten years' interval of the meeting of the convention. The central Bureau for the actual work, is located in London, and Regional Bureaus "have been established in all countries, who will be responsible for the preparation of the slips requisite for indexing all the scientific literature of the region, whatever may be the language in which that literature may appear." The Regional Bureau also sends one member each to the International Council. The catalogue is to be issued for the present, in book form only, at least one annual volume for each science, the first group to be published in July 1901, and continued regularly at quarterly intervals. Each annual volume will contain an author's and subject catalogue, and the first literature to be included in the catalogue, is that of January, 1901. This enormous undertaking, which has been carried out under the inspiration of the Royal Society, will prove of infinite value to scientific labourers, and to the library it not only means perfection of cataloguing of the books it possesses, but an absolute guide to what it has not and what it requires.

At the first conference held in London, in 1890, invitations to send delegates, were extended to all countries. Canada was represented on that occasion by Lord Strathcona, who freely expressed the good wishes of the Canadian Government. At the last conference, it was resolved to ask all the countries represented at any of the conferences, to assume a certain amount of financial responsibility. A sum was to be agreed upon as the approximate yearly cost of each year's volumes, until some years of experience permitted more accurate calculations. Each country was asked to guarantee a fixed number of sets for five years. The United States for example were apportioned forty-five sets and have already subscribed fifty-eight. Canada as yet has done nothing, and is now asked to bear her share. Our national honour demands that she should not hold back from this work of the community of nations. I trust that this Institute will not be backward in its efforts to induce the Government of Canada, to do, what is being done by other colonies of the Empire, and by Denmark, and the smaller countries of Europe, and that, at least a sufficient number of copies shall be subscribed for, to supply the eight or nine Universities of the Dominion.

A successful library on the lines I have indicated, would create such a standard as would naturally influence the other libraries of the Province. The demand for a Provincial Central Library, commensurate with the importance of its interests would follow in due course. The Economic Arts would demand the same attention, the Fine Arts in the various forms of painting, sculpture and decorative art, would present their claim, and the Province of Ontario would awaken to a sense of its poverty in all that tends to develop a sense of the beautiful, of its inability to compete with foreign nations in those industrial pursuits, which demand the employment of artistic taste, and in those higher qualifications, without which, no nation has risen to eminence. Such a Central Library, working in connection with the smaller specialized libraries, would become a centre of light for the Province. Its books with some exceptions, should be placed at the service of every student wlthin its limits, so that a graduate from any of our Universities might be enabled to continue his studies wherever his home is fixed, and the self-taught scholar, however humble his surroundings, brought within reach of the master-minds of the century. Is it among the impossibilities of the future, that the post-office department could be induced to grant a one cent per pound rate for books going and coming from the library to a resident in the Province?

I have from this platform urged the claims of those who are far removed from the centres of education; whose little reading matter is poor and tawdry, except what is obtained from the weekly newspaper, and I wish in conclusion, to say a few words on their behalf. The population of the older portion of this Province is largely agricultural; the new Ontario promises to be a land of miners. This means that homes are isolated and self-dependent. Our winters forbid the carrying on of farm operations during three months of the year, and the farmer is necessarily driven into his home for much of this time. Would it not be profitable to teach him in his hours of leisure? We have insisted that the children should be educated, and have at great expense planted schools in every portion of the land. Have we no responsibility beyond that? Does education cease with learning the three "R's" or does it not then begin? If so, are we to employ teachers to follow to their homes the young people and there carry on the work we have begun? and what better teachers can we give them than good books? Let them be interesting, well chosen, and they will be read. Once establish the reading habit, even in one member of the household, and you work a revolution in the daily thoughts and daily practice of every member.

Little money is required to start a movement for supplying this want, but much careful organization. Solitary examples of those who see the want and are making efforts to meet it, are already to be found in different parts of the Province, and whether it be to provide printed matter to awaken interest in, or stir the imagination of the members of a lumber or mining camp, or to give to the boys and girls in the solitary log house, some faint idea of the wonders of the world beyond the surrounding circle of woods, all praise should be given for their efforts, however humble. And their example should stimulate us who enjoy so much, to use our influence and experience to systematically carrying out the work they have attempted.

It is probably a dream, which ought to have no place in a building set apart for pure science, but I could look forward to a time when the student in the city or country, would be able to put his hands speedily on the records of the experience of other students, whether of time past or present, on every branch of human knowledge; when every village or town in the Province would look to their public library as their greatest treasure; when in every collection of homes, there would be found those who regularly gathered together for consecutive and careful study of great thinkers, obtaining all the necessary literature required for his elucidation, from some central library, and when every household throughout the length and breadth of the province, would look forward with pleasure to the day which brought the weekly or monthly package of books from the great library. Then indeed, would the Northland be more famous for its learning than for the extent of its domain.

In addressing you upon the shortcomings and deficiencies of our library, I have been led to speak of the wants of our country in the same direction. My predecessor in this chair, upon a similar occasion, forcibly presented the claims of public museums, as scientific aids and popular educators. He recognized, as I have done, the influence which this Institute wields both corporately and individually, and I have no doubt felt as I do, that that influence will be exerted to awaken the citizens of the Province and of the Dominion, to the value of these libraries and museums, and that the result will be, to add to the number of public benefits which the members of the Canadian Institute have been privileged to confer upon their fellow citizens.

Recent Views Respecting the Constitution of the Sun. By Arthur Harvey, Esq., F.R.S.C.

(Read 30th November, 1901.)

At the base of a mountain the view is usually limited and obscured, but the horizon widens and the prospect gains in clearness on the upward climb. Still, when the Alp is scaled, peaks beyond peaks become visible. So in science, and especially in astronomy, some new fact or theory is daily added to the general store, but it is only thereby made evident that there is far more beyond our ken than within it, and we are compelled to think of the last words of Laplace:—" Ce que nous savons est peu de choses ; ce que nous ignorons c'est immense ! "

The sun is the orb of which, in comparison with its importance, we know least, and its various phenomena are almost all, as yet, mere riddles. What was thought fifty years ago to be assured knowledge has not held firm, while even modern views as to his constitution are uncertain and indefinite, notwithstanding the array of new facts of which we have become the masters through the aid of the huge telescopes, the perfected spectroscopes and the photographic instruments lately brought into use.

Changed views as to the sun have been forced upon us by the alteration of our ideas about the earth, in which, too, there has been a revolution within a life time.

No longer are we told that the height of our air is forty miles. Auroræ can now with reasonable certainty be numbered among atmospheric phenomena and I have proved one remarkable auroral arch to have been over 150 miles above the ground.* We now know that falling stars light up by friction in the air, and in tracing the path of a remarkable bolide seen in Toronto, I learned that it became luminous at the height of 80 or 100 miles.† The trail of that meteor became snake-like before it vanished, the sinuosities having a breadth of half the apparent diameter of the moon. If these were caused by air-waves, such as Mr. Napier Denison has told us of,‡ these waves had a breadth of at the least 2,000 feet. Laplace, a hundred years ago, said the atmosphere was bounded by a lenticular shaped surface of revolution whose volume is about 155 times that of the solid earth and should reach out to a distance of about 26,000 miles at the equator and 17,000 at the poles. Professor Woodward, lately President of the Mathematical Society of America, appears to agree with him.§ New gases have been discovered in the air, and its constitution is even thought to change as we ascend in it. Carbon dioxide decreases, hydrogen increases and it is thought by some that on the aerial outskirts there is hydrogen alone or with the smallest admixture of the

* Transactions Astronomical Society of Toronto, 1893, p. 78.

† Transactions Astronomical Society of Toronto, 1898, p. 118.

‡ Transactions Canadian Institute, February 6th, 1897.

§ Science, January 12th, 1900.

oxygen and nitrogen which so largely predominate on the surface.* We now know that the higher the clouds are the faster they move and *Ciel et Terre* says that the motion of cirrhus clouds is on the average 60 feet a second in latitudes like our own and 45 feet within the tropics, while there are thus currents in the upper air to the violence of which nothing indicates the limits. The word violence I understand implies chiefly velocity and amplitude, for in highly rarefied air, the force of such currents must not be likened to what we should experience if there were at our level a constant gale of from 30 to 45 miles an hour. From mountains and balloons those who frequent high altitudes have often seen below them the upper surface of a layer of clouds, the existence of which surface depends upon a delicate adjustment of heat and gravity. They have described how huge billows will rise from the placid and shining cloud-layer and sometimes subside as quickly as they arose. *Ballons sondes* and high-flying kites have carried instruments which show that there are frequent horizontal strata in our atmosphere, and that the low barometer in one is seldom vertical to the low in another, so that the lowest reading at a height of ten thousand feet may be hundreds of miles distant from the lowest reading at the surface. And the characteristics of these layers are very different. Thus; the outer one, which we never shall reach, must shade off in temperature to the cold of space, dust and moisture never reach it and its inferior surface is the upper limit to the lightest possible cloud. Then comes the air of which the lower limit determines the snow-line on our mountains. Lastly we may place the shell in which we live, within which alone lightning flashes and rains fall, and there is enough moisture to interpose a blessed screen against the terrible cold of a very few miles above. We will not consider the terrestrial hydrosphere and lithosphere because there can be nothing analogous to them in the solar orb, to which we will now turn.

The first scientific conception I can find as to the physical nature of the sun is that of Anaxagoras, who is reported to have said it was a red-hot stone, as large as the Peloponnesus. A hundred years ago it was defined as a glowing solid mass, stationary in the heavens. Even Sir John Herschell in the early edition of his astronomy which I used when a school boy said "it is hardly possible to avoid associating our conceptions of an object of definite globular shape and of such enormous dimensions with some corresponding attribute of massiveness and material solidity." A theory that it was liquid fire prevailed for a time. But it seems to be regarded now as composed of incandescent gas, and I too believe that the sun is a great globe of such vapours or gases, of which the visible outer envelope is as tenuous as the smoke of a cigar.

No sooner had Galileo turned his *perspicillum* on the sun than he perceived its frequent spots, and it was his treatise *Delle macchie solari* which was the ostensible cause of his disfavour with the papacy. Milton, who as a youth visited him, has a half punning allusion to them :—

. . . . "A spot like which, perhaps,
Astronomer in the sun's lucent orb
Through his glazed optic tube yet never saw."

Their nature was mysterious then, and the question as to their cause and nature is not yet surely answered. One plausible theory, which still holds a certain sway, is Wilson's, who thought they were depressions in the luminous solar envelope, through which the dark interior body of the sun became visible. But out of hundreds of drawings, made with the utmost care and minutely examined, less than one in three gives any countenance whatever to this view. Were it true there should be a regular shading off from the circumference of spots to their centre, whereas there are only two well marked distinctions, viz., the black looking umbra near the middle and the more lightly shaded penumbra irregularly surrounding it. The way spots are usually drawn in astronomical journals has become conventionalized; radiations from the centre towards the circumference or *vice versa* are rarely to be seen. Moreover, this hypothesis assumes the interior layers to be less luminous than the exterior, which, as they cannot well be cooler, is improbable. Another theory was that the spots are scum or slag, floating on the surface of molten matter, but if the visible surface be

* M. G. Heinrichs, Comptes Rendus de l' Academie, August 20th, 1900.

not liquid, it must be abandoned. I have seen a large dark spot which seemed to show on the western limb as an indentation, but the effect might be produced by a dark mass covering a considerable surface or by the obscuration of that surface otherwise, and I incline to the belief that some emission from the interior spreads over the surface of the photosphere in the form of vapour, some matter which impedes the transmission of radiations giving light and perhaps heat as their effects, but does not so impede or absorb the radiations which carry electrical charges.

Whatever may be the cause of spots, they were seized upon as affording means for determining the time of solar rotation, and Sir John Herschell, in his Astronomy, edition 1842, thus summed up this branch of the subject :—

"Our telescopes show us dark spots upon its (the sun's) surface, which slowly change their places and forms, and by attending to whose situation at different times astronomers have ascertained that the sun revolves about an axis, inclined at a constant angle, of 82° 40′ to the plane of the ecliptic, performing one rotation in a period of 25 days, and in the same direction with the diurnal rotation of the earth."

Some further elements of supposed precision having been introduced by Mr. Carrington, the Greenwich Observatory adopted and keeps to a rotation period of 25.38 days, sidereal.

I found, however, as a very casual observer may easily do, that this period did not suit the spots I examined, with a view to discover if there were not permanently active regions on the sun, answering to volcanic districts upon the earth. The changes in spots seemed anything but slow, they drifted in irregular ways, both in latitude and longitude, and when after disappearance they again emerged at about the same region, the time was not sufficiently exact for identification. So, as the attitude of a student towards all science should be one of scepticism, following the advice of St. Paul to the Thessalonians, *πάντα δὲ δοκιμάζετε*, judge for yourselves about all things, I began to see if I could not ascertain the exact period of solar rotation for myself, by less difficult and more certain means than the observation of spots. I sought for and thought I had found it in the periodicity of outbreaks of terrestrial magnetism. My theory was that the internal convection-currents bringing intensely heated matter from the sun's interior towards his surface would cause solar disturbance which in some way would be radiated in pencils, like beams from search lights, from the sun to the earth, that such convection-currents would follow established lines, and that whenever the particular solar locality was turned towards the earth, there might be a magnetic effect here, and surely would be, if at the time that solar volcanic vent were active. I found from the whole series of Toronto observations, which began in 1844, that one magnetic storm repeated, intermittently, but continuously enough for a preliminary identification, in 27.24575 days synodical or 25.35447 days sidereal.*

Two new announcements bearing on the subject were made about that time. One was that cathode rays, which exist in abundance in solar radiations, carried with them charges of negative electricity. Mr. H. Deslandres communicated to the French Academy in 1898 his discovery to that effect, and shortly afterwards it was added that Lenard and Becquerel rays, emitted by radio-active substances, have the same property. This solved the perplexing question, how could electricity be radiated across space, in which there is no permanent conducting medium. The other was that the spectroscopists, who have now perfected their instruments so that they can tell the rate at which a luminous body is moving towards or away from them, announced their agreement with the astronomers who had been doubting the uniform rotation of solar spots. The sun being two and a half millions of miles around, and rotating in 25 days, the velocity of its rotatory movement at the equator is a mile and a quarter per second. Thus a point at the equator is approaching us at that rate when it comes into view, and receding as it vanishes. The rates of approach and recession vary with the distance from the equator of the locality under observation, but are quite sufficient even near the poles to noticeably shift the dark lines of the solar spectrum nearer to the blue end in the one case and to the red in the other. The

* Transactions, Astronomical Society of Toronto, 1897.

most painstaking observations are perhaps those of Crew and of Duner, which have been worked out by three different formulæ and give as results :—

Rotation period at the equator................days 25.53 ; 25.71 ; 25.50
Rotation period near the poles................days 37.66 ; 49.45 ; 45.98

Bringing such periods to the measure of velocity we have the materials for a table in which φ. is the latitude, *v.* the velocity, while *v.* sec. φ. is the velocity at the equator corresponding to that observed at the various latitudes.

φ.	v. *per* Second in Miles.	v. Sec. φ.; Miles.
0°.4	1.23	1.23
15	1.15	1.19
30	0.98	1.13
45	0.74	1.04
60	0.46	0.92
74.8	0.21	0.81

It is evident that if the sun rotated as a solid, all the values of *v.* sec. φ. should work out the same, that is, to 1.23 miles per second. But the table shows that the region in latitude 74° 8′ rotates one-third less swiftly than it would on that supposition. Something analogous is found in connection with Jupiter's rotation, for his cloud-belts differ in their rate of movement, though not nearly in the same proportion.

The consequences of this discovery have not all been reasoned out, and, as Crew does not completely agree with Duner, further observations are necessary, but the view that the gases at the visible surface of the sun are extremely tenuous is much strengthened. A rotation of a solid sun in sections is unthinkable ; there can be nothing approaching to solidity where there are such varying rotatory rates. Yet at a depth not far below the surface there must be density enough to make the great gas-ball more coherent, and as the density increases the substance must tend more and more to act as a viscous if not as a solid body. The sun therefore appears to rotate more slowly in depth than at the surface. Again, since the more rapid the rate of rotation the greater the centrifugal force, the convection-currents from within the sun must be directed towards his equatorial belt, they must acquire additional force in proportion as they are so deflected, which is not an improbable reason for the excess of solar energy manifested near his equator.

To treat of the Corona which envelops the sun, and has up to the present time only been seen during total eclipses, would be foreign to the purpose of this paper. It may, however, be remarked that attempts have been made to determine whether it rotates too, and at what rate. I have only heard of one successful observation, made by Deslandres in 1900, who thought it rotated faster than the sun, so far at least as its west side was concerned.

Already, however, we can picture to ourselves the sun as a star surrounded by a nebula of which the greatest extension is about its equator and revolves with something like planetary velocity. It does indeed seem that the materials of which the solar system is composed have not yet been completely absorbed into the sun and his planets, but that a remanet still girdles him and is seen in the Corona and especially in the zodiacal light.

What is it then that causes so sharp a distinction between the visible disc of the sun and the nebula outside it? Seen through powerful telescopes it is as definite as it appears to the unaided vision. it does not shade off by degrees like comets' tails or nebular wisps. I have thought that the cold of space prescribed the limit, that there is a line beyond which solar vapours cannot incandesce, like that which limits the height of clouds upon the earth, alluded to at the outset. Therefore, as I do not learn that any variability has been observed in the sun's diameter, I have not been an enthusiastic supporter of those who think the sun's condition gives hot or cold seasons to the earth. If from any cause the sun did emit more heat one year than another, the first effect, it seems, would be the expansion of his own visible disc. Nor does the answer given by Schmidt, of Stuttgart, make this objection less weighty, whose work of 1891 has been recalled and further explained by Otto Knopf, of Jena, in 1893. They do not think that the light reaches us from the solar surface ; in a word, they deny that there is a definite surface to the sun. They say his light originates within a globe of superheated gases and that, owing to the refractive index of these gases being reduced through diminished density as the external strata are reached, the rays from within the sphere necessarily appear to be limited by a circle. They think the spots are not upon what looks to be a photospheric surface, but below it, and even suggest that they may be optical phenomena due to disturbances of the refracting properties of the superior layers. Their theory of the spectrum is necessarily unusual too. The solar spectrum was long supposed, following Kirchoff, to originate on the photosphere, which he considered liquid, and covered by an atmosphere which by absorption caused the well-known dark lines. Schmidt and Knopf think the violet and blue rays originate in a smaller concentric shell than the red rays, under greater pressure, and that having to pass through a denser medium throws them farther along the spectrum. The visible circumference of the sun being unreal, the absorption lines may have their origin at a considerable depth within the solar atmosphere, which they think is so rare in the shells outside the incandescent strata as to have very little absorptive effect.

That the sun does emit more heat at certain periods than at others, varying according to the extent of spots upon his surface, seems to be the opinion of the day, though our own Canadian records do not indicate the slightest periodicity, excepting in so far as rain-fall is concerned (where there is a certain periodicity which may be due to heat elsewhere). But there is no doubt there is a somewhat ill-defined term of more or less spottiness, called the sun-spot period. If we cannot as yet certainly connect it with radiations of additional heat or of light, we can certainly trace its concordance with the varying intensities of the earth-currents of electrical force. In my paper for our semi-centennial memorial volume,* I brought down to that date my own studies on the subject, and to avoid repetition, I refer thereto, especially as that was the first publication of my discovery that the solar disturbances which cause sun-spots and our magnetic storms and auroræ also cause simultaneous excitation in the tails of comets and in the condition of other planets. There has been no doubt since the publication of Professor Loomis' papers in the American Journal of Science, many years ago, that the curve of magnetic excitement followed very closely that of sun-spottiness, and the curves which prove their similarity have been brought down to the present date by Mr. W. Ellis, F.R.A.S., attached to the Greenwich observatory. Shortly after the date of my paper just referred to I made a curve from the differences between the observed brightness of Encke's comet at its many apparitions and the brightness it should have attained if distance from the earth and sun had been the only factors to be considered. That investigation, published in a Presidential address to the Toronto Astronomical Society, showed that the excitation of that comet has always corresponded in a most remarkable way to the magnetic excitation of the earth, and therefore to the condition of the sun.†

We have, however, been passing through a period of minimum solar excitation, and I have on that account been giving less attention to phenomena expected at active periods than to those which can be studied within walls and ceilings, and I have nothing new to say on that subject.‡ I find, however, that I have not yet communicated to the Institute my demonstration that antarctic auroræ are synchronous with auroræ boreales. This I was able to prove from the observations of that painstaking and thorough meteorologist Henryk Arctowski, now of Liege, who was with Commander de Gerlache on the *Belgica* during her antarctic sojourn. His table of auroræ seen in *Belgica* Straits, far to the south of Cape Horn, answers precisely to the table made from Canadian and Washington

* Transactions, Canadian Institute, 1898, 1899. p. 345.

† Transactions, Astronomical Society of Toronto, 1898.

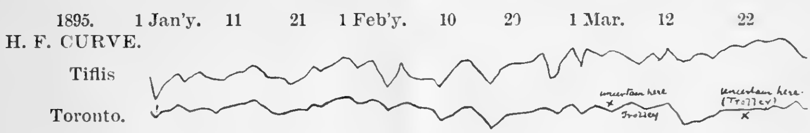
‡ Since the reading of this paper, the author has found reasons for believing that the zodiacal light also brightens during magnetic disturbances.

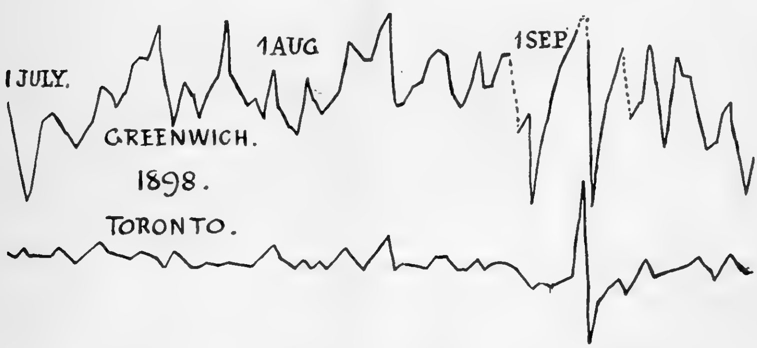
observations. Mr. Arctowski, in an address to the Royal Geographical Society, published in its *Journal*, called on northern meteorologists to see if there were any correspondences between these Auroræ, Australes and Boreales, and it is, I think, extraordinary that the *Journal*, with which we exchange, should have lain on our table for a month before I saw it, and that even then I should have been the first to answer the appeal. But as our President remarked, there is a sort of justice about this affair, for it was to trace out magnetic similarities and differences in the two hemispheres that the Toronto observatory was established, sixty years ago, and it is to its admirable continuous work and the courtesy of its director that this concordance of Arctic and Antarctic auroræ has now been determined by a Toronto amateur. I need scarcely add that magnetic disturbances have also synchronised with Arctowski's most brilliant auroræ. That synchronism as regards our northern lights is treated of on page 352 of the memorial volume above quoted from. We have thus additional proof of the cosmical bearing of auroral phenomena and can mentally see the spectacle of earth, receiving electrical discharges by means of cathode rays thrown off during solar disturbances, and lighted up around both poles with the lovely coruscations accompanying the distribution of this electrical surplus.

Is it permissible to enliven the course of a scientific discussion with the spice of romance? In the papers by Arctowski I noticed one dated at Liege, where a daughter of mine was studying at the Conservatory of Music. I wrote, enquiring if Liege were Mr. Arctowski's permanent residence, and received an answer that she had the pleasure of knowing him, and she was going that evening to Madame Arctowski's house. Did I know he had been lately married, and how it came about? Supposing I did not, she would tell me the story. When the ship was in the ice pack, the four chiefs of departments were in their little dark cabin, with just light enough to see by, and they were amusing themselves by turning over for the twentieth time the pages of year-old magazines. Subject for discussion—which was the best looking girl of all whose portraits were figured there? Each made his choice and gave his reasons, and Arctowski, cutting out the picture of an American then in Paris, put it in his pocketbook and vowed that if he lived to get back to Europe, he would find that fair woman out and marry her. And so he did. May the pair enjoy to the full the wedded bliss which had so strange an origin!

Mr. Arctowski's letters were insistent on a further point. Were the characteristics of the auroræ seen here at given dates similar to those which he observed at corresponding dates in the southern hemisphere? He thought Toronto was more homologous than any other station as to position with respect to the northern magnetic pole to that which the *Belgica* had occupied with respect to the southern. Observations of the auroræ here were unfortunately not in sufficient detail to give an answer to the question, but I was able to obtain fifteen or sixteen reports from the United States Weather Bureau which were of service in establishing a presumption that it must be negative. At the date of an aurora which Arctowski would describe as waving curtains of yellow light, the aurora here would as often as not be seen as almost stationary auroral clouds. More puzzling still, the aurora was not seen in equal brilliancy, of corresponding colour, or of similar rapidity of motion in the different stations here from which it was reported. In two of the instances given by Mr. Arctowski, there was a clear sky in our latitude from the Atlantic to the Pacific. But the local distribution of the auroræ observed was singular—in one case they were reported all over the north-eastern States and our Maritime Provinces but were not seen west of Toronto until the region was reached which in both the United States and Canada adjoins the Rocky Mountains. In the other case the display was not seen east of Toronto or far west of Minneapolis. I wrote a paper on this subject for the Royal Society of Canada, as complete and as brief as possible, but that Society is very dilatory with its publications and appears to care more for literature than science. The fact is probable that atmospheric conditions, other than clouds, interfere with the visibility of auroræ, and hence the erroneous opinion that because magnetic storms are not everywhere accompanied by auroræ, the connection is not fully established. It is, however, possible that longitude has something to do with the location of auroræ, and that Arctowski's "homologous" positions will have to be reckoned with. It may be that a broad tongue of electrical influence shoots from the north towards the equator, and that another issues from the south to meet it at the rendezvous. A study of the few auroral observations made by Borschgrevink when he was in the Antarctic on the "Southern Cross," which have been tardily issued, favours this inference. His station was on the other side of the globe; we had here the magnetic depression to accompany, but not in all cases the auroræ, which may have illuminated the northern Pacific ocean more brightly than this western region.

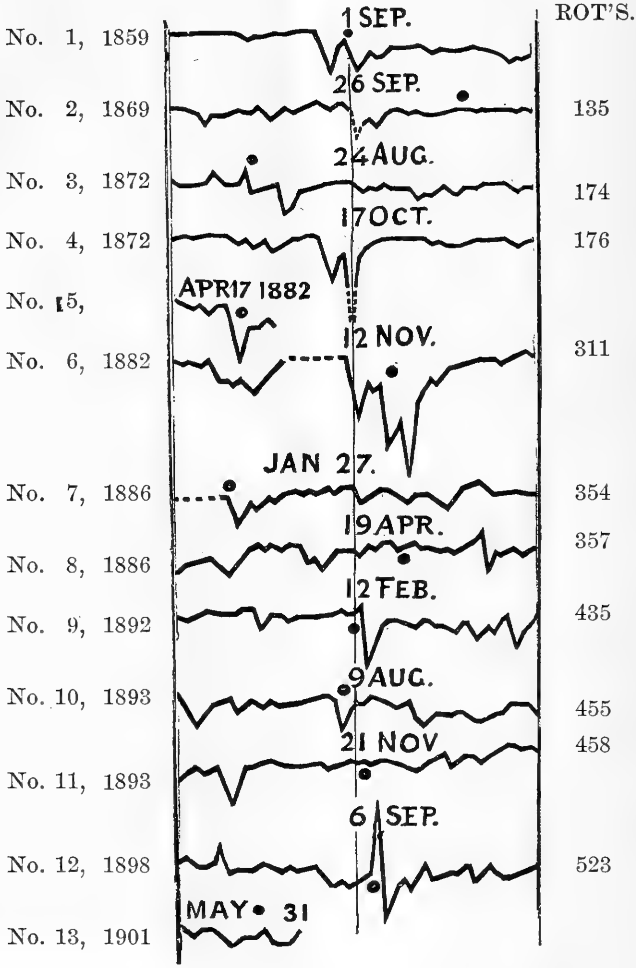
I have searched available records for further proof of the statement respecting the connection between sun spots and magnetic storms made at pages 351 *et seq* of our Memorial Volume, and present a diagram which shows the magnetic disturbances associated with the most noteworthy sun spots of recent years. I begin with the magnetic disturbance of the end of August and beginning of September, 1859, because it is somewhat celebrated in astronomical history, and has given rise to a fabulous legend. Most popular works on the subject of sun-spots report that while Messrs. Carrington and Hodgson were examining the sun they saw a spot appear and there was a simultaneous disturbance of the magnets. The original statement of Mr. R. Hodgson, F.R.A.S. was made to the British Association as follows:—"While observing a group of sun-spots on September 1st, 1859, I was suddenly surprised at the appearance of a very brilliant star of light, much brighter than the sun's surface, most dazzling to the unprotected eye, illuminating with its light the upper edges of the adjacent spots . . . It lasted five minutes and disappeared instantaneously. From a photograph taken of them at Kew the previous day the size (length) of the entire group appears to have been about 2′ 8″, or say 60,000 miles. The magnetic instruments at Kew and at Greenwich were simultaneously disturbed at the same instant to a considerable extent." I assume that the sun spot group was central at that date, and the magnetic curve is taken from the Bombay register as we do not possess the 1859 Greenwich records. The whole world, however, feels these magnetic disturbances with wonderful simultaneity. Here are two examples of the curves





CURVES OF HOR. MAGNETIC FORCE. DAILY MEANS.

for three months' daily mean readings of horizontal magnetic force; one pair Toronto and Tiflis, the other Toronto and Greenwich. Allowing for differences in scale, you will see that the ups and downs exactly correspond. Even the principal tremors are to be seen on the photographic curves now made at quite distant places, such as Paris and Perpignan, Berlin and Vienna, Manila and Zi-ka-wei, and so exactly to the instant that the difference in longitude can be checked by this strange wireless telegraphy. The beginnings of magnetic storms are often noted by a jerk in the regularity of the trace, and this appears to be observable at every station. Returning from this aside, I will ask you to examine the magnetic tracing for the year 1859. You will see that Carrington and Hodgson's disturbance was fairly severe on April 21st, May 19th and June 16th, strong on July 11th, slight on August 8th, and very severe on September 2nd. These various dates are separated by about the interval of a solar rotation, and I have arranged the other curves so that the same solar meridian which faced the earth on that September 1st, also faced it at the dates placed underneath it in all, adopting my own rate of solar rotation. It differs from the one adopted at Greenwich by 3/100



of a day only, but in the forty years covered by these curves that equals twelve days or nearly half a solar rotation. With the uncertainty above referred to as prevailing in reference to this exact period I need scarcely say that we should not yet be too positive of correctness. The concordances apparently established by my diagram and table may be accidental. The diagram is made to show that great spots are associated with magnetic storms, and each of the curves gives some noteworthy proof of this fact; their being placed under each other has an independent bearing upon the other fact as well. I have taken all the great spots of which I have found an account in the volumes accessible to me.

In an old "London Almanack" I find there was about central on October 13th, 1869, a huge spot, 672,000,000 of miles in area. I therefore had to plot the magnetic curve, No. 2, and it seems to show that the disturbance repeats after 135 rotations, but the spot has no relation to this storm; it may, however, be the outcome of the solar disturbance which caused the depression of September 14th, a rotation before. The next curve, No. 3, is plotted to show at August 25th, 1872, the beginning of a storm which culminates on October 17th—176 rotations. It also shows the association of a spot and a disturbance in the beginning of August, both of which are on another disturbed meridian which shows magnetic effects in all the subsequent tracings and has spots associated with it in Nos. 5, 7 and 13. The two curves Nos. 5 and 6 are given because of a paper in the "monthly notices" of the Royal Astronomical Society "On the great sun-spots of 1882, April, also November 12th–15th." The day of centrality in April is not given, but on the 17th there was a magnetic storm so violent that it could not be completely registered. It can be traced back to September 12th and October 9th of the previous year. The November sun-spot is in the middle of a long and pronounced disturbance of the needles, the beginning of which is 311 rotations subsequent to the storm of September 1st, 1859. In the "monthly notices" there is a paper "on a remarkable sun-spot of 1886, April 24th." This is an instructive occurrence because there was no remarkable disturbance of the magnets along with it (see curve No. 8), but there was a disturbance on January 8th and 9th, with an accompanying spot; there was another on March 31st, which apparently gave rise to the spot which appeared the month after. In these curves, especially in No. 7, the commotion with which it began may be seen to continue. Curve No. 9 shows the depression figured in detail by the late Professor Carpmael in the frontispiece of the Transactions of the Astronomical Society for 1892, which produced the celebrated rose-auroræ of February 13th, and what the Royal Astronomical Society's notices say was an exceedingly large composite spot, the largest up to that time ever recorded. I observed this spot with care and submitted a series of drawings of it to our Astronomical Society. The spot had appeared during the previous rotation, January 8–12, and the magnetic disturbance, which can be traced back to September 25th, 1891, continued as regularly as could be expected, considering the immense solar area involved, well into 1893. You may see that it kept on causing spots, shown in curves Nos. 10 and 11. The Toronto Astronomical Society records in 1898, September 2nd–15th, a spot 65,000 miles long and 75,000 miles broad, belonging to a disturbed area 150,000 miles across, and curve No. 12 shows the great magnetic depression which immediately followed it. Lastly I give the location of the spot of May of the year 1901, which is rather celebrated, though not a very large one. The Abbè Moreux, of Bourges, first saw it on May 20th, when it was so active that he thought the solar spot-minimum had suddenly passed away. His vivid description of its rapid changes of form and division into two main parts startled the world, who expected a scorching summer in consequence, a fear which I attempted to allay by showing its small comparative importance and the absence of great magnetic disturbances connected with it. Its activity may, however, yet be important to science, as it was just on the edge of the sun at the time of a total eclipse, and we may hear of moderate coronal disturbances near the latitude it occupied.

Physicists and astronomers are indeed now beginning to admit, with apparent and unaccountable reluctance, the intimate connection between the two effects of a common cause, sun-spots and magnetic storms. Mr. Wm. Ellis, F.R.S., says: "the general effect observable is that in our latitude there may be at one time a large solar spot with great magnetic disturbance . . . at another time a considerable solar spot may appear without accompaniment of unusual magnetic movement; and again, magnetic disturbances may occnr without any noteworthy spot." The "general effect" is not quite fairly stated, even by this most cautious and painstaking official; there seldom if ever is a great spot without a magnetic storm with which it can be connected, usually while it is visible, occasionally a rotation before. Mr. Ellis does not seem to have quite freed himself from the old idea that spots cause storms, or fully to recognize either the cosmical nature of magnetic phenomena or their effect all over the earth, else why does he allude to "our latitude?" The converse, as he puts it, that there are magnetic storms not accompanied by spots, proves little—the cause of the storm may have been in a solar region where spots do not appear, or, for reasons we cannot think of, may not have given rise to spot phenomena.

Several astronomers still cling to the idea that to prove the connection a spot must be absolutely central at the time of a magnetic storm. The diagram just explained shows that the spot often lags a day or two behind its related storm. It also indicates that there are three active meridians on the sun. I am not yet prepared to speak of the latitude of active spot regions, but I have checked the prominences for several years, and while they too are apparently more numerous on three meridians, they are strangely distributed in belts, like those of Jupiter and Saturn, while there seem to be extensive regions of comparative quietude. I find that Professor Wolfer, of Zurich, has been doing similar work, and his results, which I have seen in the *Memorie* of the Society of Italian Spectroscopists, are apparently the same as my own.* As I have worked out each year separately, the question of the exact rate of rotation is not seriously involved. I do not at present attach a high value to this work, but it is interesting as showing changes in the latitude of prominence belts. Some years this activity extends to near the poles, and we have a belt of prominences in latitude 80°. The next year it may be five degrees or even more nearer to the equator. Sometimes prominences are numerous in the northern solar hemisphere, and again the southern hemisphere may exhibit more activity. Prominences often occur in the neighborhood of spots, but frequently where none are visible, and the range of prominences is much greater than that of spots, for they have been seen at the very pole. I have not been able to discover that they affect the needle in any way, though they are more frequent and larger when sun-spots are many and magnetic disturbance great.

I must not conclude without a notice of the labours of Dan Carlos Honore, director of the International Solar Institute of Montevideo. Like myself he found it needful to arrive at a true period of solar rotation but he pursued the meteorological method. Professor Frank H. Bigelow, of Washington, D.C., had already shown similarities between magnetic curves and North American temperature waves, and by making a time allowance for the movement of pulses of heat and cold from the Rocky Mountains towards the Atlantic Coast, he brought them into tolerable harmony. Mr. Honore does not attack this concordance; he takes as a guide the normal temperature of each day, attributing the surplus or defect of heat to radiations from the sun. The days of surplus heat are shown in his figures on one side of a circle and the days of excess of cold on the other, he then finds a marked periodicity, and declares the synodical solar rotation to be 27,241,326 days. I understand he thinks the solar shell from which we get the most effective heat rotates in that time, and if the shell which causes electrical manifestations rotates a little more slowly, according to my reckoning, there is nothing contradictory in that difference. Mr. Honore has so much confidence in his theory that some parts of the sun are hypothermic, and cause an excess of heat when turned towards the earth, that he has prepared tables of solar rotation covering hundreds of years. On dividing the year into two, and superimposing the curves, he found an inequality, and concluded that there is an interior sun, with an axis slightly inclined to that of the photosphere, and a rotation slower by 0.00867 of a day, which leaves 363.33 days for the heliothermic year and 27.25 days exactly for the synodical rotation of the interior sun. With these data Mr. Honore thinks he can define the latitude as well as the longitude of the solar regions on this interior sun which send us heat, and even by those whose radiations he believes cause earthquakes. He has sent me diagrams of solar thermic centres, calculated by his tables, also other diagrams which localise the solar seismic centre, which he thinks controls the Mexican volcanic field in a seismic circle of 15 heliothermic years, or 200 synodical rotations of the interior sun. With this cycle he identifies every one of the long list of Mexican earthquakes published by the Antonio Alzate Society. I have the calculations, not yet carefully examined.

I think the sun's condition does influence the earth in the matter of cold and hot days, but the number and area of sun spots has but a slight connection with

* Vol. XXIX, dispensa 7a.

that particular irregularity. In Toronto there is evidently no settled relation between annual temperatures and sun-spot frequency. Many times sought for, any correspondence whatever has eluded the researches of others besides myself. But this is the worst of places in which to look for periodicities in weather, the areas of low barometric pressure coming from the Rocky Mountain districts may go a hundred miles north or south of us, and thus introduce a disturbing element which baffles investigation. Even a slant of wind off the lakes may cool the shores, or its absence heat them, and thus disturb the temperature of any given day. It is in Tropical regions and in places where storms of wind and rain with thunder and lightning are rare, that we may probably discover a periodicity corresponding with that of solar rotation, and perhaps even find a temperature curve agreeing with the sun spot cycle ; but such changes must be very slight, on the general average, and it is the height of absurdity to hold the sun responsible for a great excess of heat or cold lasting for a whole season. The excess or defect of mean temperature at Toronto above or below the average is seldom a degree, and has never been known to be four ; very hot seasons here are probably balanced by cool ones in other parts.* We are therefore working on very small margins. This is natural, since the sun and the earth are not in their youth. Lord Kelvin has reduced his estimate of the time the earth has lasted since the first crust covered its surface from a hundred million years to forty, but though I side with the geologists who think a hundred millions are too few, yet in this connection I can be content with the smaller number as an estimate. For, before its crust formed, there were long aeons during which the earth was an agglomeration of mere vapours. Nor is Terra the first born, but, with Venus, is a daughter of the sun's old age, while Mercury is his Benjamin. Mars, Japiter, Saturn, Uranus, Neptune, and probably another, are his elder sons. The sun then has had time to become fairly steady. Being a ball of gas, convection-currents are probably doing their work quietly ; the solar disturbances cannot be of the nature of a terrestrial eruption in which the violence seems to be determined by the resistance to interior forces of an exterior crust. The spots float up from the places which these convection-currents disturb, and as stated at the beginning of this paper they are probably nothing more than large quantities of vapours much attenuated on reaching the surface, possibly absorbent of light vibrations, certainly so constituted as to interfere with them. But though these produce the primary effects of solar disturbance but slight secondary effects here, there is something irresistibly attractive in observing them and endeavoring to account for their origin and nature.

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* The average in Toronto since 1840 has been 44°. In 1875, the average was 40°.07, and in 1889 it was 47°.02.

Sun-Spots and Weather Cycles. By A. Elvins.

(Read 15th February, 1902.)

We all feel interested in the *weather*, our personal comfort and the prosperity of our country depend very much on it. Some seasons are *early*, some *late*; some *wet*, some *dry*; our *farms* and *gardens* are productive or the reverse, as the weather is favourable or unfavourable; the opening or closing of navigation, whether it is early or late, depends on the weather, and this is important to our sailors, and to trade and commerce generally. If we could foretell the *general character* of a coming season we could act, so far as possible, to meet coming conditions.

Nations have seen the importance of knowing the climate of the different parts of the earth's surface and have erected and maintained observatories where observations are made and preserved. From these records the *mean* meteorological conditions existing at such localities are known.

But the *extremes*, rather than the mean conditions, are what is needful to be known. Every one knows that we sometimes get a *wet* spring, and on other years a dry one. Our pastures are some years green in summer, at others dry and parched. In 1843 and again in 1878 we had above *43* inches of rain at Toronto, and less than *18* in 1874 and 1887. *What can be the cause of these changes?*

We know that our summer results from the northern hemisphere of the earth being then turned sunward, and our winter from the same hemisphere being turned from the sun, and we naturally turn to the sun and try to find an answer to our question *from it*.

Ever since the invention of the telescope the sun has been an object of great interest to astronomical observers; sometimes it is a spotless globe of light, and at others, one or more spots are seen on its surface. They break out unexpectedly, exist for a short time, occasionally two or three months, and gradually disappear. Some of those spots are of great magnitude. I have seen some more than 100,000 miles in length, or rather the group has been that long. In and around these spots the sun's surface seems very much disturbed, and with the aid of the spectroscope great uprushes of gases can be seen rising to an enormous height; and we are led to ask if those great solar outbursts, sun-spots, etc., are not the cause of our weather changes.

I shall have to return to those sun-spots, but here I shall diverge a little to refer to another fact. When a magnet is suspended so as to move freely on a pivot as in surveying instruments, and properly protected from local disturbances, it points in a definite northerly direction and is as a rule stationary. But it is not always without motion; sometimes it vibrates from side to side of the main line, and this continues for a time, and then disappears. This is known as a magnetic storm.

Such magnetic storms are found to be more frequent when the sun is much spotted than at other times, and it has been thought that these *storms* are *caused* by the disturbance on the sun, which disturbs the ether of space, and the magnetism of the solar system; that is, that magnetic storms are the result of the outbreak of sun-spots, or as Mr. Harvey thinks, of the disturbance to which the spots themselves are due.

There is also another phenomenon which must not be overlooked, that is, auroral displays. We at Toronto have had good opportunities of studying these, for we have been well situated for their observation during the past century, and the displays have been frequent and very grand. Like the disturbance of the magnetic needle, the auroral displays are more frequent and brilliant when the sun is most spotted, and when we plot the number of occurrences in a curve for many years we find the sun-spot curve, the curve of magnetic disturbance, and the auroral curve, to be so nearly alike that one curve differs very little indeed from the other.

It seems almost certain that the disturbed condition of the sun must produce magnetic and auroral disturbances, or that some common cause produces *all three.*

Careful observations have established the fact that there is a periodicity, somewhat irregular it is true, but still a periodicity, from one maximum of those phenomena to the next following, the period being eleven years and a little over, and the curves of all three phenomena are so nearly alike that the coincidence is unmistakable.

These coincidences require to be examined with eare, and we should find which is the cause of the different phenomena, or if some cosmic condition may, or may not, produce all of them.

Are there any facts which show if the magnetic storm is caused by the outbreak of spots, or whether they are both the effect of some common cause?

There are two important facts which seem to me to help us to answer this question.

(1) Many *magnetic storms* have occurred when no spots have existed on the sun.

(2) Large spots have broken out and run their course, and no magnetic storm has been observed.

It seems from these two facts that the many synchronisms which undoubtedly exist, must be chance coincidences, and not that the sun-spot caused the *magnetic storm.*

Let us now look at the *auroræ* which are also numerous at the time of sun-spot maximum. *First:* We frequently get magnetic storms when fine auroræ are visible, and we sometimes get magnetic storms when no aurora is visible here, but we *never* get a fine aurora without a magnetic storm coincident with it.

This seems to show that the *aurora may cause the magnetic storm*, but that the *magnetic storm cannot* cause the aurora.

And even the magnetic storm which sometimes exists when no aurora is visible here, may be the result of the descent of auroral matter somewhere near. Mr. Stupart speaks of a distinct auroral display observed by him when returning from the North-West, and though we had no aurora here, the chronograph showed a disturbance of the needle at the same time.

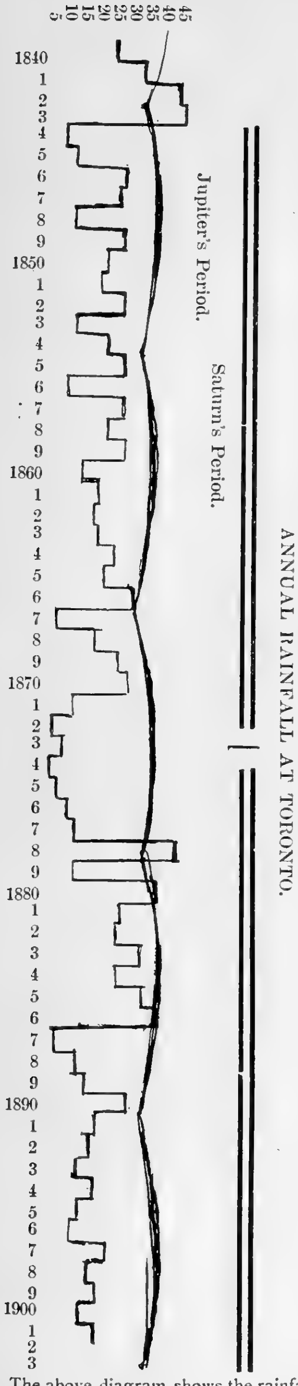
For the cause which produces the three phenomena we must look into the space in which the solar system exists, and the space through which it moves. Is it possible to find what the disturbing cause is?

I do not think that we can say with certainty; but there are reasons which lead me to think the disturbing element is to be found in the cosmic or meteoric matter existing in space, and which must be revolving in orbits around the sun, and possibly in a far less degree around the planets also.

Proctor in his "Other Worlds," Chapter ix., proves clearly enough that the solar system, especially near its centre, is crowded with meteors of all sizes, from almost invisible particles to masses of many tons weight. (Page 191., 4th edition) he says: "we recognize how erroneous that opinion is which an eminent astronomer recently expressed, who asserted that the united weight of all the bodies other than the planets in the solar system must be estimated rather by pounds than by tons." His reasons are convincing, and lead justly to the conclusion "that the aggregate weight of the various meteoric systems circulating around the sun must be estimated by billions of tons rather than by ordinary units."

Can we not go a step further? I have long thought that the atoms of the chemical elements may and do exist in space; if so, such would be as obedient to the laws of motion as larger masses are. In fact, all aggregations of *physical particles* (which in my papers on "Moving Matter" I have called *atoms*) will be subject to the same laws as large masses or worlds.

And perhaps we need not stop here. I have long thought that the chemical atoms are themselves aggregations of smaller particles, and these again of particles smaller still—the ultimate particles, or primitive atoms—those being the units of which all masses are built up; and that the chemical atoms are formed in space and should be regarded as of celestial, rather than of terrestrial origin.



All such cosmic matter within the sphere of the sun's influence will be gathered into the solar system. Let us try to follow their course when they pass toward the sun.

Masses coming into the system move rapidly around the sun and as a rule pass off into space; they may sometimes collide with other masses moving in opposite directions, and as this would destroy their projectile force and shatter the masses, some of the fragments will in such cases fall on the sun. The planets as well as the sun will receive cosmical matter, and I think the meteoric showers which fall on the earth are but a small fraction of the matter which is constantly being added to its mass. The ultimate particles existing in space must be aggregating and forming chemical atoms; these enter our atmosphere and form part of it.

I have frequently observed the beautiful auroræ with which we in Canada are so often favoured, and I could not repress the conviction that some attenuated form of matter was descending through the atmosphere from a radiating point above us, when the arches passed roughly from east to west, with waves of light near the zenith passing westward, and especially when a corona has formed at the zenith. Streamers radiating from that point reminded me so very forcibly of the meteoric shower of 1868 that I could not doubt but those radiating beams of light were the result of matter of some kind falling on the earth, as the star showers are known to be.

This view of the aurora finds support from the fact that bright meteors have been seen to fall passing parallel to the direction of auroral streamers, and the fact that the magnets in the Observatory of Itataya were violently disturbed during the fall of a meteorite which fell or rather passed very near it. (See note, page 119.)

We thus find a reason why magnetic storms, auroræ, and sun-spots are most numerous at the same time, namely, that a larger quantity of cosmic matter is in the central part of the solar system than at other times, which falling on the earth produces auroræ. The auroræ cause the magnetic storms, and large masses fall into the sun, producing sun-spots.

It is now time for us to ask if this affects the weather? To answer this question we must ask why more cosmic matter exists near the earth sometimes than at others.

If no planets existed moving around the sun in the same plane, our weather would be less varied. It is the action of the outer planets on the incoming cosmic matter which condenses it in some parts, causing it to move in streams at

The above diagram shows the rainfall in each year since 1840. The arcs of a circle represent the periods of Jupiter of which there are five. It will be noticed that each period ends with a heavier rainfall than the average, and this is followed by a dry year. If this is a law we should have a *wet* year in 1902 and a dry one in 1903. But as the more distant planets Saturn, Uranus, and Neptune will be disturbing factors a year plus or minus may be possible.

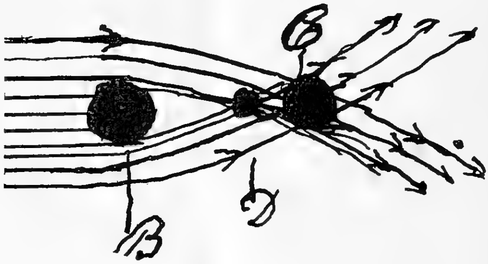
The late investigations of J. J. Thompson and of Arrhenius, on fractional portions of the chemical atom, seem to me to be in harmony with the views expressed in this paper.

some points, and scattering it in others, which projects incoming matter in paths sometimes wide off the orbits they would have followed but for planetary action.

The sun has a sphere of attraction beyond which its influence is practically nil; but the dimensions must be enormous. From the remotest parts of this sphere cosmic matter moves sunward, very slowly at first, but increasing its rate of motion as it draws nearer and nearer to the solar system. The distance from our system will be so vast that off in space the lines of their motion must be practically parallel.

And here it should be understood, that no matter whether my speculations as to the origin of the chemical elements are correct or incorrect, the fact remains that cosmic matter, solid and gaseous, really exists in space, and moves in orbits around the sun, and so far as the weather is concerned it does not matter how they originated.

Matter coming from beyond the orbit of Neptune, will, when moving in the medial plane of the planetary orbits pass near the orbits of Neptune, Uranus, Saturn, Jupiter and Mars before it reaches the *Earth*, and will have its path changed more or less by any and every planet which it may pass near to; and as those atoms and masses are passing sunward in vast numbers, and at greater or less distances from the planet, their paths will intersect and cross each other at a distance, as shown in the figure.



It is not possible to represent sizes and distances correctly in a figure, but it is easy to see if cosmic particles came into the system in the direction of the parallel lines and passed on each side of the planet B, they would cross and fall on an inner planet at C in greater numbers than at other points. If we suppose B to represent Jupiter and C the Earth, the earth would receive more meteoric matter when it was passing through this focus than before it reached it, or after it had passed through it. All the outer planets would act in the same manner on incoming matter, and this matter comes from all directions. Some will move *direct* and others *retrograde;* large numbers moving in opposite directions will collide, destroy each others' motion of translation, and fall on the planet within whose sphere of influence they may be at that time.

The great mass of the planets Jupiter and Saturn will probably cause them to be the disturbers of incoming matter, and we may consider them to be so situated as to act most powerfully to produce changes. They will shift their position in relation to each other constantly, and as Jupiter's period is 12 years and Saturn's 30, they will not be in the same position in relation to each other, and their position in the zodiac, for two revolutions of Saturn and five of Jupiter or 60 years, $12 \times 5 = 60$. So we have two cycles, one produced by Jupiter of 12 years, the other by Saturn of 30; and a cycle of 60 when both will act together. These may be causes of weather. Can we trace or find such cycles in our meteorological record?

Here is the rainfall record at the Toronto Observatory.

Sixty years ago Saturn and Jupiter occupied nearly the same position which they do this year (1902); we had a sun spot minimum in 1843 and a great rainfall, 43.55, and our average is only about 26.

Starting from 1843 as our zero year, we find a 12 year cycle fairly marked by rainfall, and this cycle ends in 1903. 60 + 1843 = 1903 which (if the theory is correct) should give us a plus from the Jupiter cycle. And again, two revolutions of Saturn starting at the same time also, end in 1903; so from this theory we should get 43 inches of rain next year. But all the other planets must have an influence of like kind; and to follow all the changes is beyond my power, and I give it up; but I still think that it will be done by some future meteorologists, and I wish our Mr. Stupart and other workers ultimate success.

NOTE TO PAGE 117.—This was observed by Dr. Massena at Itataya, Brazil, Aug. 7th, 1868. See Sci. Am., Oct. 28th, 1868.

THE PLEIADES IN LEGENDS, GREEK DRAMA AND ORIENTATION. BY J. C. HAMILTON, M.A., LL.B.

(Read 5th April, 1902.)

Mr. Hamilton showed that the Seven Stars, by their gentle rays, impressed their image on the scroll of humanity in all ages. They were the clock stars of old astronomers, the guides of the mariner in his voyaging, and the husbandman in his seasons. The cluster was a familiar object in early British days. "Ye Old Seven Stars" is an inn in Manchester, whose license dates back to the reign of Edward III., in 1356, and the time of Chaucer. Guy Fawkes was here a visitor. Clubs of literary and social character took their names from the Pleiades.

The Seven Wise Men of Greece included Solon and Thales, the astronomer. Ptolemy Philadelphus had a Pleiad of Tragic Poets. Charlemagne formed a similar literary party, himself being one. Henry III. of France had his Great Pleiade, and Louis XIII. followed the example. In New England, there was a Pleiad of Yale poets, including Timothy Dwight and other ante-revolutionary men of learning. All poets have found them fit subjects for their muse. In "Locksley Hall," their rising is beautifully described. Wordsworth speaks of them, in his poem "Peter Bell:"

"The Pleiads that appear to kiss
Each other in the vast abyss,
With joy, I sail among them."

The cluster was affectionately regarded in Germany, Servia and Spain.

In the famous adventures of Don Quixote, that knight and Sancho Panza were made to pass the place where the "Little Nanny Goats," as they were called, were kept, and Sancho describes them inimitably. Thus the Spanish peasantry style these far-away, twinkling orbs.

Allusion was made to the customs in India, in reference to the measure of time and observing of feasts in honour of these stars. So, also, in China, where they are the Seven Sisters of Industry.

American legends as to them were discussed at length. They were also prominent in the religious ritual of the Aztecs and their successors in Mexico. In Peru, they were the gods of rain, and the year was counted, not by the sun but by them. The legends were very marked among the Blackfeet, Hydahs, Crees, Ojibways and Cherokees, of which interesting examples were given. While these are generally rudely drawn tales, inherited often from Asiastic ancestry, they have features in common; the persons represented are always seven, of whom one is lost or otherwise disappears.

The Blackfeet have a zodiac of 29 constellations.

Mr. Hamilton then discussed the beautiful references to these stars in the Agamemnon of Æschylus, and the Iphigenia and other dramas of Euripides.

In the building of temples and other public structures, reference was, by the Egyptians, Greeks and other ancient people, made to a particular star at its rising or setting. Such star was used as a clock, its light being made to fall into the temple an hour before sunrise, that time being fixed for the morning sacrifice. Among temples oriented to Alcyone, chief star of the Pleiades, were that of Minerva, at Athens, 1530 B.C.; the temple built in 1150 B.C., on the site afterwards occupied by the Parthenon; that of Bacchus, at Athens, and several others. The Jews avoided this custom as heathenish. The Temple of Solomon and the Tabernacle were so designed as to cause the worshippers to face west.

Ezekiel VIII., 16, refers, with abhorrence, to a place where worshippers faced the east and worshipped the sun. This was 500 years B.C.

The description of the Great Pyramid, as given by the late Professor Piazzi Smith in his book, "Our Inheritance in the Great Pyramid," edition of 1880, was referred to, who declares that the Pleiades were there, as also in old Mexican temples, specially honoured; but it was shown that later writers, such as Gerald Massey, dispute much of this theory.

Mr. Massey, so, also, comes into conflict with the theories expressed by Ernest de Bunsen and R. G. Haliburton, and limits the cult of the Pleiades very much to Greece and Rome and the races sprung from them.

The late work of Sir N. Lockyer and Dr. Penrose, F.R.S., in orienting Stonehenge on Salisbury Plain was lastly discussed.

They show that there was here a great Temple of Apollo, after the Grecian or Egyptian model, oriented to the Sun, and declare that it was erected about 1680 B.C., or 500 years before the fall of Troy, by people who were not ignorant of astronomy, and whose priests knew more of the arts than they are generally credited with.

Stonehenge was assumed to be the place referred to in Diodorus Siculus II., 47, as a sacred enclosure dedicated to the Sun-God, and by Caesar, de Bello Gal. VI., where he stated that its Druid priests taught of the movements of the stars, the size of the world, the nature of things and the power of the immortal gods.

Mr. Hamilton referred to certain legends connecting Stonehenge with the Pleiades.

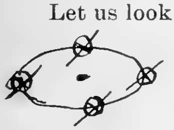
The Cause of the Accumulation of Magnetic Storms when the Earth is Near the Equinoxes. By Andrew Elvins.

(*Read 7th February, 1903.*)

In a paper read before this Institute about a year ago on sun-spots and the phenomena which seem to be connected with them, I expressed the idea that sun-spots, auroræ, and magnetic storms are caused by matter forming in space, and passing sunward in orbits more or less elliptical, which, when they cross the earth's orbit, produce auroræ and magnetic storms, pass on sunward, and by planetary perturbations and collisions fall in part on the sun and produce solar-disturbances. Supposing the theory then advanced to be correct, I wish to show how it is the fact that magnetic disturbances are *more numerous* at times when the earth is near the equinoxes than at other times.

The fact that disturbances are more numerous when the earth is at the equinoctial points, than at other parts of its orbit, shows it to be in some way connected with the earth's annual revolution.

Let us look for a moment at this motion. The sun is at the centre of the path in which the earth moves. We call the plane in which the earth moves the plane of the ecliptic. Whilst the earth is making its annual revolution, it is also rotating on its axis, and this axis is not at right angles to the plane of the ecliptic but about 24° from it.



If the poles were at right angles to the plane of the earth's path, each of the poles would be equally exposed to matter coming sunward from without in each month in the year (and as the planets move near this plane, and reach outward into space, *their action* on incoming cosmic matter will cause the larger part of it to move in this plane also ; cosmic matter will be more abundant near the ecliptic than elsewhere) ; the earth in passing through it will have one pole more exposed to this matter during one half of its orbit, and the other pole most exposed during the other half. But at the equinoxes both poles will be equally exposed, and at any given point, except, perhaps, near the equator, the plus of cosmic matter which produces magnetic disturbances will fall on the outside hemisphere of the earth when *it is near the equinoxes*.

On this theory cosmic matter passing by the earth going sunward is the cause of *auroras* and *magnetic disturbances* : the plus of such matter caused by the action of Jupiter and Saturn, on incoming cosmic matter, is encountered by the earth when it passes us going sunward, and this is the cause of the long 11-year period. The moon's revolution, combined with the earth's motion, is the cause of the 25-day period, and the inclination of the earth's axis is the cause of the *plus of disturbances at the equinoxes.*

THE PLEIADES AS THE HESPERIDES, ISLE OF THE BLEST, OR PLACE OF FUTURE BLISS. BY J. CLELAND HAMILTON, M.A., LL.B.

(Read 14th November, 1903.)

MR. HAMILTON referred to Dr. Wallace's theory, that the solar system is the centre of the universe, as controverting both scientific and classical notions, and not yet at least generally held. He then took up in detail legends of many nations which pointed to the stars of the Pleiad group as the resting place of their ancestors' spirits and their own heaven. Such were the Arabs, the Berbers of North Africa, and Dyaks of Borneo. The British Druids had an ancient mythology drawn from the same source as that of the Greeks, had gods of characters similar to Pluto, Mercury and Zeus, and, in strange metaphoric poems, referred to the Pleiades. Their midnight ceremonies in the autumn, at the time of our Hallowe'en, commemorated the season when the Seven Stars were highest in the visible firmament.

The lecturer discussed legends of the Adipones, the Hurons, Iroquois, Blackfeet and other native American races, which made their heaven where the sun sets. Hiawatha's departure to the west in his birch canoe was compared to that of King Arthur in the Druid legend, the basis of Tennyson's "Mort d'Arthur." "The White Stone Canoe," an Ojibway legend translated into Hiawathan metre, by the late Sir James D. Edgar, represents the young brave Abeka, seeking his lost love, Wabose, in the redman's spirit land, where he finds her on a beautiful happy island, and here is repeated the Greek legend of the "Isle of the Blest" with a Promethean moral. Such beliefs were found also among the Hydahs, Eskimos, Chippewayans, Salish, Chiwaks, and, throughout the continent, to California. The curious myths of the Polynesians were referred to, and examples given of many strange coincidences with the legends of Egypt and Phoenicia, and paralleling those as to Atlas, Hercules, Pluto and other deities of Greece. They had, too, an "Isle of the Blest," but knew only six Pleiades, which they called "Matariki"—"Little Eyes," or "Tau Ono," The Six. They were objects of worship in these islands until the introduction of Christianity in 1857.

The ideas of the Hindus, Chinese and other Eastern people as to the place of the future were reviewed. The different views expressed by Homer, Hesiod, Lucian, Pindar and Plato were discussed. There were depicted beautiful plains without winter, fear or pain, where fruit of every kind abounded and joys never ceased. They were placed in the West, where the sun goes down, in a happy isle, where gentle sea breezes blow. Plato taught that only those enjoyed such bliss who had spent life in holy philosophical pursuits, useful to their fellow-men. He placed this pure abode in "the upper parts of the earth in places not easy to describe." The conception of the Hurons, Iroquois and Algonquins as to this place of bliss, is described by Colonel Garrick Mallory and Dr. A. F. Chamberlain, the archaeologists, and by the historians, Bancroft and Schoolcraft, in very similar expressions. The essayist quoted several beautiful Greek epitaphs in which such ideas are embodied along with hope of future meeting. He then explained the theory which assigned Alcyone, the chief star of the Pleiades, to the position practically of the centre of the universe and the place of future bliss. This great star was often so regarded and called "the central one" and "the leading one." However much appears to sustain such theory in classic story and in legends of uncivilized tribes, it was admitted that such claim is not as yet supported by science.

The lecturer concluded his discourse, stating that these many widespread traditions furnish a mass of evidence in favour of a common origin of mankind and of the existence of a general belief in life hereafter, where those who had here lived worthily would meet their ancestors and friends in a beautiful happy place somewhere, either on an island in a western ocean or in the most favoured of the great orbs, which, to use Shelley's words, form "Heaven's constellated wilderness."

INTERIOR THERAPY: A CASE OF LEAF-CURL. BY ARTHUR HARVEY, ESQ.

(Read 21st November, 1903.)

I HAVE always had trouble with peach-trees owing to their liability to "leaf-curl." I am not aware that it is annoying to larger growers, or on other than clay land. But in Rosedale I have found more than half my trees affected by it. It is destructive to the crop. I suppose it to be a bacterial disease.

As soon as the leaves are an inch or two long, their substance thickens about and around the point attacked, the swelling soon deforms them, a sort of knot is formed, they curl, turn red and yellow in places, and as most of the leaves are thus affected, the branches look as if blasted by some irritant poison. If left to themselves, the diseased leaves will fall off, others will grow further up the shoots, but even they are liable to be affected, though not to the same extent. If picked off, which with small trees I have tried to do completely, the same result follows; the disease is not conquered even by two years of such drastic treatment. Some trees have this "leaf curl" worse than others, some are quite immune.

Last year a fine Elberta in my garden was beginning to blossom, and it suffered so much that I would have cut it down had I not wished to attempt a cure. This spring, as soon as the evil began to show itself, I bored a gimblet hole in one of the branches, at an angle of 45° with the horizontal. Into this I fitted a quill, and kept the quill full of a saturated solution of copperas. The tree absorbed a quillful in about six hours. In a day, I could see that the leaves in the upper part of the branch were affected, and those which wilted in this manner soon died, and no further vegetation took place to supply the want of them. I soon perceived that the copperas had not been diffused to any appreciable extent, for the injury went along one only of the branches springing from that which was under treatment, and only one of the final tufts of leaves was killed. The particular fibres cut by the gimblet had soaked up the solution, which did not extend to others but only to their own continuations. This, I believe, puts an end to all hope of success in the particular direction attempted. A weaker solution, or one of a different kind, would in like manner affect a few fibres only and their ramifications.

In the fall there was a line of spots, exuding gum, along the whole of the affected fibres, not elsewhere, except that below the boring there were also a few, due to the death of the fibre leading upwards from the root, from want of exercise. Not having any connecting tubes, it got choked. The rest of the tree was not affected by the copperas, it suffered as usual from "leaf curl," and I shall cut it down next spring.

I may say that washing the bark with lye or the usual poisons has no palliative effect, in my experience.

AURORAL PHENOMENA, SUN-SPOTS AND MAGNETISM. BY ARTHUR HARVEY.

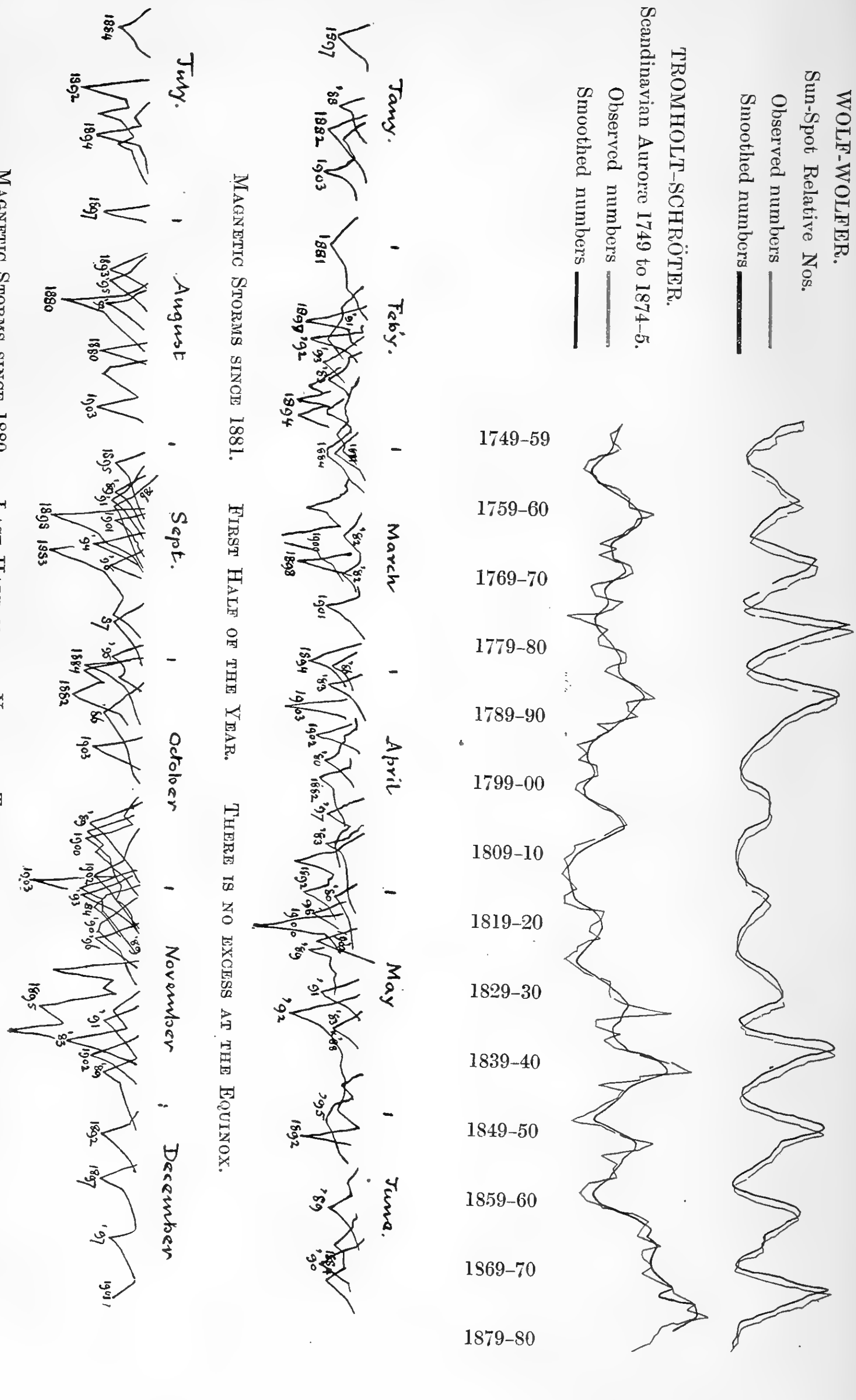
(Read 28th November, 1903.)

MR. ANDREW ELVINS having stated in a recent paper that magnetic storms were more frequent at the equinoxes than at other seasons, I have prepared a diagram to show the times at which such storms have occurred since 1881. Were it not for the encumbrance to distinctness I would have gone back fifty instead of twenty years. There is no greater frequency at the equinox. The points mark the depressions in the curve of magnetic Horizontal Force at Toronto, and indicate not only the dates of magnetic storms but their relative intensity.

Mr. Elvins produced a statement from the Washington *Weather Review* that Tromholt's auroral catalogue showed some excess of auroræ at the equinoxes. I was aware and had myself stated when Mr. Elvins read his paper that there had been a slight excess of magnetic tremors noticed about the equinoxes by the United States observers at Los Angeles—and to see if this were really reflected by a slight excess of auroræ, I made a study of the interesting catalogue of Norwegian auroræ, the life-work of the late Dr. Sophus Tromholt, of Christiania, edited by Prof. I. F. Schroter, of the Observatory there, at the joint cost of the Scientific Association of that city and the Fridtjof Nansen Fund. I found a very slight excess of auroræ observed in March and September, but it was accounted for by quite other reasons than Mr. Elvins supposed, namely, by climatic obstacles to observation in the most northerly regions of the Scandinavian peninsula, where for nearly half the year people do as little outside observation as possible, and during most of the other half, twilight or actual sunlight renders auroræ invisible. It is plain that about the equinoxes the conditions for observation are more favourable, and the wonder is, not that there should be a trifling excess observed, but that the excess should be so very small.

There were, however, other things of interest to be gathered from Tromholt, some of which are to be alluded to in the present paper, which is intended to be a new historical proof that auroræ are especially prevalent during years of solar activity, and that their numbers and brightness correspond accurately therewith : also to illustrate the changed position of observers of such meteoric phenomena in that superstitions regarding them are fading ; and lastly to touch on some instances of the wide extension of remarkable auroral displays.

The earliest allusion to Scandinavian auroræ is that in Tacitus ("Germania," chapter xlv.) : "On the farther side of Swedes-land is another sea, dark and almost motionless, which is thought to girdle and enclose the terrestrial orb, because there the last light of the setting sun endures until its rising again, so brightly that it dims the stars. Moreover it is credibly reported that sounds are heard there and the shapes of gods seen, with radiance around their heads." Pliny puts us on the track of earlier auroræ when he says ("Natural History," Book I., chapter xxvii.): "There is a flame of a bloody appearance, and nothing is more dreaded by mortals, which falls down upon the earth, such as that seen . . . when King Philip was disturbing Greece." Also that "a bright light has been seen issuing from the heavens in the night time, so that there has been a sort of daylight at night, as was the case in the consulship of L. Valerius and Cn. Papirius." The date of L. Valerius was 462 B.C., when the Romans were having a troublesome war with the Æqui, and, says Livy, "the heavens were seen to be on fire with a very great flame," so a three days' penitential ceremony was ordered, during which crowds of men and women thronged the temples, begging the angry gods to stay their hand. Three years later the sky was seen on fire again, there was an earthquake, and a bull was heard to speak. The King Philip trouble was about 200 B.C. (Livy xxi., cap. 12) when again the heavens were aflame, and the priesthood saw their opportunity for interpreting the natural phenomenon in their peculiar way,



MAGNETIC STORMS SINCE 1881. FIRST HALF OF THE YEAR. THERE IS NO EXCESS AT THE EQUINOX.

MAGNETIC STORMS SINCE 1880. LAST HALF OF THE YEAR. THERE IS NO EXCESS AT THE EQUINOX.

as they had done for thousands of years before, and occasionally persist in doing still. But, coming to Tromholt, we read that in A.D. 1550 the "common people" thought the lights were "a reflection from the schools of herrings which assembled about the beginning of autumn, and, by turning hither and thither, and leaping up and down, threw such a light upon the clouds that the heavens flared up." He transcribes several curious accounts, as of "a glowing sword which thrice smote the earth and swiftly rose again," and of "a black cloud in the north-west with a long neck and a head with a Russian hat and plumes." This was met by another with a Mecklenburg hat, and a third with a Royal Crown, and "one could see that the one with the hat had a long pointed beard and a crooked nose." Next there came "a tremendous big bear which opened its mouth wider and wider and spewed fire, steam and smoke high into the sky. . . . What all this is to betoken is all in the hands of the Lord." There is a case where "a long neck grew from a cloud which became like a living camel, and against it came a fearful beast, which was most like a dragon, with a long, crooked tail." When the dragon attacked the camel, this beast opened its jaws, swallowed the greater part of the dragon, and both vanished. This display does not bear the marks of an aurora so clearly as the other accounts, but it shows how supremely fitting it was for Shakespeare to put into the mouth of a Prince of Denmark the familiar words—

Hamlet—Do you see yonder cloud that's almost in shape like a camel?
Polonius—By the way, and 'tis like a camel, indeed.
Hamlet—Methinks it is like a weasel.
Polonius—It is backed like a weasel.
Hamlet—Or like a whale.
Polonius—Very like a whale.

But we need not go to the Baltic or the Mediterranean for accounts of the superstitious fears with which people once looked on the lovely phosphorescence of the auroræ. Here is a pen picture by the Rev. James Harvey, a Northamptonshire rector, whose "Meditations Among the Tombs" were once classical, who was a fair astronomer, and wrote "Contemplations on the Starry Heavens":—

"Sometimes, at this hour, another most remarkable sight amuses the curious and alarms the vulgar. A blaze of lambent meteors is kindled, or some very extraordinary lights are refracted, in the quarters of the north. The streams of radiance, like legions rushing to the engagement, meet and mingle, insomuch that the air seems to be all conflicting fire. Within a while they start from one another; and, like legions in precipitate flight, sweep, each a separate way, through the firmament. Now they are quiescent: anon they are thrown into a quivering motion; presently the whole horizon is illuminated with the glancing flames. Sometimes, with an aspect awfully ludicrous, they represent extravagant and antic vagaries, at other times you would suspect that some invisible hand was playing off the dumb artillery of the skies, and by a strange expedient, giving us the flash without the roar.

"The villagers gaze at the spectacle, first with wonder, then with horror. A gruesome panic seizes the country. Every heart throbs and every face is pale. The crowds that flock together, instead of diminishing, increase the dread. They catch contagion from each other's looks and words; while fear is in every eye and every tongue speaks the language of terror. Some see hideous shapes, armies mixing in fierce encounter, or fields swimming with blood. Some foresee direful events: states overthrown, or mighty monarchs tottering on their thrones. Others, scared with still more frightful apprehensions, think of nothing but the day of doom. 'Sure,' says one, 'the unalterable bow is struck and the end of all things come.' 'See,' says another, 'how the blasted stars look wan! Are not these the signs of the Son of Man coming in the clouds of heaven?' 'Jesus, prepare us,' cries a third, and lifts up his eyes in devotion, 'for the archangel's trump and the great tribunal.'"

Nor is it needful to leave our own country to find such examples: we have them in the letters of the Jesuits from Canada. Father Biard writes from Port Royal, now Annapolis, N.S., January 31st, 1612:—

"The stars had already begun to appear when suddenly, towards the northwest, a part of the heavens became blood red, and the light, spreading little by little, in spear and spindle-shaped beams, shifted until it was over the settlement of the men from St. Malo, tinging the whole river and making it luminous. It lasted about eight minutes, then disappeared, when the same programme was repeated. Our Indians cried out, 'Gara gara, endirquar, gara gara,' that is, we shall have war, such signs denote war. Nevertheless . . . during the day there was nothing but friendliness. But at even everything went contrariwise—confusion, quarrels, rage, uproar between our savages and the people from St. Malo. I do not doubt that a cursed band of furious and sanguinary spirits were fluttering about us all that night, expecting every hour and moment a horrible massacre of the few Christians who were there, but the goodness of God restrained them, the wretches."

A similar meteor in 1616, when also the sky became wonderfully red, was greeted by the Indians with the exclamation, "Gara gara, maredo." War, war, there will be blood. A hundred and twenty years later, in 1736, familiarity had deprived auroral phenomena of their terrors, and Father Aulneau, writing from Fort St. Charles, among the Crees, near the north-west angle of the Lake of the Woods, merely says :—

"I have noticed on several occasions, especially while on Lake Huron, grand displays of the aurora borealis . . . scarcely a night has passed but the northern skies have been all aglow with it."

It is improbable that many of us, who have seen some auroral glories, or at least read about them, would be given over to such abject folly as our forefathers, but to populations who take literally the imagery of the Sacred Book of Revelations and look for the actual, physical happening of the poetical prophecies of its author, who beheld the heaven depart as a scroll when it is rolled together, and heard angels sound on trumpets signals for hail mingled with blood to fall upon the earth, and for a great star to fall from heaven, blazing as it were a lamp, and who saw other spirits pour out vials upon the earth, and the sea, and the streams, and the sun, and the air, when there was a great earthquake, and the cities of the nations fell, and every island fled away and the mountains were not found—to such, I say, the sky, luridly red behind light drifting clouds, may cause mortal fear, and so may the fiery arch with flaming coruscations, slowly moving to and past the zenith. Nothing dissipates such terrors more efficiently than travel and scientific study, which are necessary to the growth of civilization, as foreseen by another prophet, Daniel, who said that "many shall run to and fro and knowledge be increased." The car of Science is as merciless as that of Juggernaut. It leaves as victims behind it not the bleeding corpses of votaries, but the lesser miracles, which it destroys one after another, leaving glorified the one great miracle of all, the wonderful order of nature, the living world, which is dying daily but daily being resurrected in obedience to the law of its being. With the six literal days of creation vanishes also the one single day of judgment, and the sudden end of things, and we shall ere long hear that the one has no more Divine warrant than the other. But while there still exists a lingering faith that heavenly displays are signs and portents, science may be charitable to those who look at them in the spirit of Bernard of Morlaix, who was perhaps dreaming of a northern aurora when he wrote of the *bona patria* in his wave-crested dactyls—

"Est tibi consita laurus, et insita cedrus hyssopo :
Sunt radiantia jaspide mœnia, clara pyropo.
Hinc tibi sardius, inde topazius, hinc amethystus
Est tua fabrica concio cœlica gemmaque Christus."

Every one now knows that the aurora is a manifestation of terrestrial magnetism and that both are intimately related to solar activity. But we can estimate the rapid progress of modern science and the length of its recent travels along the pathway of solar radiations by reflecting that some of us, in this very hall, have heard that as there could be no action at a distance without a medium, no electrical energy could be transmitted from the sun to the other bodies in his system. Nobody denies, to-day, that there is a medium we have agreed to call the ether, whose qualities we are beginning to comprehend, nor is there any further denial of a direct rectilinear radiation of energy from the sun. The proof of this action of the sun upon other bodies was given in our semi-centennial volume of "Transactions," page 345. Another step was taken here and noticed at page 107 of our "Proceedings" for 1901, where the synchronism of auroræ australes and boreales was shown, which entitles auroræ to be classed among cosmical events. The bold theory of Dr. Gilbert, one of Queen Elizabeth's physicians, that the Earth is a great magnet, though scouted by Bacon, as was the Copernican system, too, and though it slumbered from its birth to the times of Faraday, has now taken on a new beauty. We can picture to ourselves the round world receiving its electrons or whatever carries or transmits energy through a material ether from the distant sun, and lighting up at night with coruscations about either pole, as this distribution from the cathodic source occurs.* The comparative figures are given in the annexed table. The Antarctic Auroræ are those observed by Mr. Henry N. Arctowski, in the "Belgica."

* The auroral beams seem to emanate from the edge of an irregular elliptical region, which includes both the strong Canadian magnetic pole and the weaker one in Siberia. Thus, by going north, one gets into parts

1898.	March.			April.			May.			June.			July.			Aug.			Sept.			1898.
	A	C	W	A	C	W	A	C	W	A	C	W	A	C	W	A	C	W	A	C	W	
1	...	...	...	...	2	2	4	2	...	...	...	...	*	...	...	4	...	...	...	1	1	1
2	...	...	...	...	...	2	...	...	1	...	...	...	*	1	1	...	4	1	45	19	50	2
3	...	...	...	4	3	1	20	7	...	...	...	...	*	5	...	...	2	1	...	4	3	3
4	...	...	...	...	...	2	...	6	...	...	...	...	...	...	1	...	1	...	...	1	1	4
5	...	...	...	...	...	...	*	...	...	...	...	...	...	3	1	...	3	...	5	...	1	5
6	...		...	14	4	1	*	...	2	*	9	2	...	9	0	...	1	...	...	2	2	6
7	...	...	...	...	1	1	...	2	1	...	1	3	...	...	...	...	...	...	...	...	1	7
8	...	...	...	...	1	2	...	2	1	...	...	...	4	1	1	*	...	...	4	4	5	8
9	...		...	...	17	1	*	5	3	...	2	...	4	...	3	...	...	...	25	36	52	9
10	*	2	...	17	20	3	...	3	2	5	2	1	4	...	2	...	1	1	25	32	28	10
11	5	6	4	4	16	5	*	5	3	...	...	2	4	...	...	...	...	...	...	...	...	11
12	5	5	2	*	59	32	*	2	...	...	1	2	4	5	...	*	9	7	...	...	...	12
13	...	2	30	4	16	13	...	3	...	26	4	1	21	4	1	...	4	3	...	...	...	13
14	15	109	289	50	25	23	...	...	...	4	4	4	...	...	2	...	1	...	...	...	...	14
15	...	96	252	25	20	7	...	3	3	4	2	1	4	...	...	*	10	...	...	...	...	15
16	*	8	27	...	7	...	4	4	...	...	...	...	...	...	3	4	16	8	...	...	...	16
17	...	1	3	...	8	1	...	...	1	...	...	1	4	2	...	...	17	3	...	...	...	17
18	*	10	6	*	8	1	...	...	1	...	1	...	...	2	2	4	3	3	...	...	...	18
19	22	20	17	*	11	...	...	2	1	*	2	1	...	12	11	12	7	5	...	...	...	19
20	28	11	4	...	6	2	11	2	1	...	...	1	*	18	5	4	...	...	...	...	...	20
21	...	13	4	4	1	...	4	...	...	...	4	1	15	20	10	...	...	...	...	...	...	21
22	*	10	7	9	4	...	4	...	...	19	32	6	11	18	4	...	5	3	...	...	...	22
23	4	...	...	...	2	2	...	...	...	10	8	...	5	2	1	*	...	1	...	...	...	23
24	4	5	3	4	7	...	...	1	1	12	3	...	4	8	...	...	4	1	...	...	...	24
25	11	7	1	19	2	1	...	...	...	...	5	4	...	6	...	*	...	...	...	...	...	25
26	38	10	2	...	2	2	...	2	...	...	...	...	...	1	...	5	11	1	...	...	...	26
27	...	4	1	*	6	2	...	5	1	*	2	1	...	3	1	5	2	1	...	...	...	27
28	4	1	3	4	3	...	*	...	2	...	2	1	...	...	2	...	...	1	...	...	...	28
29	4	14	5	...	1	2	6	17	3	...	4	4	...	...	...	...	...	1	...	...	...	29
30	...	4	1	...	4	1	...	7	3	...	...	...	...	2	1	...	...	2	...	...	...	30
31	5	4	3	...	...	...	...	1	...	...	...	...	...	...	4	...	...	...	...	...	...	31

A—Antarctic Observations. Arctowski.
C—Canadian Weather Service Observations.
W—United States Weather Bureau Records.
*—Cloudy all day and night, usually preventing even glimpses of clear sky.
The Antarctic Observations are weighted according to the features reported; the Canadian in the ratio of number and brightness; the American Weather Bureau gives numbers only.

Tromholt gives Norwegian Observations only, but the editor has wisely added the Swedish records collected by Rubenson. The curve from the first is much less instructive than that made from the two sets of figures combined, and the latter is the one I present for examination. I contrast it with the sun-spot curve made from the figures of Professor A. Wolfer, of Zurich.

The auroral year begins with July 1st of one calendar year and runs to June 30th of the next. The difference with the sun-spot year, which follows the calendar, has been duly allowed for in the diagram.

A sun-spot maximum, in 1761, had just passed when these observations were begun. Including it, twelve maxima and as many minima are indicated, echoed by the same number of auroral maxima and minima. The gradients of the two curves are generally alike, and would probably be more so if we could add contemporaneous records from other regions and so mark the irregularities due to

where auroræ are seen to originate to the southward. The "Century Magazine" for February (1903) has a description of one seen March 16th, 1898, a day on which the skies were continuously clouded for Arctowski, in the Antarctic, and no aurora could be seen. At Point Barrow (lat. 71° 17′ N., long. 146° 40′ W.) Mr. E. A. McIlhenny was "watching a number of Esquimaux playing football. Suddenly they stopped and began to whistle. On being asked why, they pointed to a small bright spot near the south-eastern horizon, and said they were calling the aurora, a marvellous display of which immediately ensued. From the spot in the south-east there shot up a ray of bright rosy light, etc., etc." Mr. F. W. Stokes has an article on the aurora in the same "Century," and he was north of the ellipse in lat. 64° 10′ N., long. 55° W., for he writes that when he was called on deck by exclamations of enthusiasm, "a faint film had arisen at a point low on the south-eastern horizon. Then, silently and swiftly, a curtain of light arose," and Mr. Stokes' vivid sense of colour and form enabled him to perceive that in the north "great nature's palette was set with more varied riches than elsewhere."

cloudy weather, moonlight nights and the different lengths of daylight in summer and winter. But the differences are noticeable too, and afford another proof of the statement I ventured to make last session that the extent of spotted areas on the sun is not an exact measure of solar activity. Counting the same spot over and over again, day after day, as it persists, is in my judgment erroneous, being a duplication and reduplication of the credit entry in the solar ledger, whereas the magnets on the earth rarely show continuing storms for more than a couple of days. The auroral curve corresponds more closely to the magnetic curve than to the one showing the spotted areas on the sun.

Professor Wolfer, on being informed of this view, which implies that the special solar energy concerned in the production of a sun-spot does not last throughout its visibility, but is greatest at the outbursting of the spot and during its active growth, and diminishes with the decay of the spot, replied that he believed the force which caused the spot continued until its extinction, but later letters show less confidence in that theory. The general question of sun-activity is of the greatest interest and importance.

Galileo and Scheiner were the first observers of sun-spots early in the seventeenth century, but it was not until the middle of the nineteenth that Schwabe discovered their recurrent frequency in what is known as their eleven year period. The systematic observation of faculæ comes quite within our own times, as does that of prominences, which, indeed, could only be recorded after one of the most wonderful of the many applications of the spectrescope had enabled us to see them as they come on or pass off the sun's limb or edge. These three forms of solar activity are necessarily related, that is, while the spots are at a maximum, there are more faculæ and prominences, but the precise times do not correspond. So magnetic energy on the earth follows very closely the sun-spot curve, and, as might be expected, auroral frequency does the same. But, as compared with sun-spots, magnetic storms tend to "lag." The principal magnetic disturbance is usually a few hours after the centrality of the spot region from which the excess over the daily issue of radiations issues, sometimes even a day or two. Also, curious to note, these Tromholt auroral curves show a usual "lag" of months between the auroral and the sun-spot manifestations. The figures work out, by my calculation, as follows:—

Maxima.		Minima.	
By Sun-spots.	By Auroræ.	By Sun-spots.	By Auroræ.
1750.3	1749.0	1755.2	1755.5
1761.5	1761.7	1766.5	1766.0
1769.7	1769.7	1775.5	1776.0
1778.4	1779.1	1784.7	1784.0
1788.1	1788.3	1798.3	1799.0
1805.2	1805.7	1810.6	1811.0
1816.4	1817.3	1823.3	1823.5
1829.9	1830.7	1833.9	1834.5
1837.2	1839.0	1843.5	1845.5
1848.1	1849.0	1856.0	1856.0
1860.1	1862.0	1867.2	1867.0
1870.6	1870.6	1878.9	1879.0
Average lag, .55 of a year.		Average lag, .24 of a year.	

The determination of the auroral maxima and minima to the fraction of a year is not so precise as that of sun-spots has become, owing to the lack of observations in both hemispheres and all around the earth. We see no auroræ in the far north in May, June, July and August, and have as yet no reliable means of rectifying the irregularity by observations in the far south.

We see in the Tromholt curve, and it is not unimportant to observe, that the wave between the principal auroral maxima appears to embrace two spot maxima. Thus, the great curves from 1755 to 1776, and from 1776 to 1779, seem each to be one wave of influence having two impulses about eleven years apart. So also the quiet time from 1799 to 1823.5 seems one period, while from 1823.5 to 1845.5 is evidently one wave of twenty years length. While from 1845.5 to 1856 is a shorter vibration, it is manifest that from 1856 to 1879 we have the double period again. I have not yet been able with the data at control to prolong the Schroter tables to the present date, for the auroral data on this side of the Atlantic, which are being fairly well collected now, were in an imperfect state from 1878 for several years. It is, however, fairly clear that the Tromholt tables give but slight countenance to Sir Norman Lockyer's 35-year period between important minima. It appears between 1776 and 1811, and perhaps between 1811 and 1845.5, but the only auroral minimum which could fit in before 1776 was in 1738, which is thirty-eight years before, and the one at this end of the series, following 1845.5, was in 1879, or 33.5 years apart. These divergences are too wide to base a law upon.

The solar prominences are now being sub-classified, I hope. The observations appear to be separating the common form of hydrogen prominence from the metallic prominences. While in our "Transactions" I have recorded my inability to detect magnetic effects consequent upon the former, which are by far the most frequent, I do find a connection with the latter. We are upon the eve of important solar discoveries, and another step in advance towards a knowledge of his constitution and the problem why the Geyser-like intermission of the eruptions upon his surface occurs. It will assuredly not be the sun's passage through matter floating in strata in space, which is an old theory Mr. Elvins has not yet chosen to abandon.

We can see by the Tromholt auroral curve, as well as by the spot curve placed in juxtaposition, what a shamefully irregular body the sun is, and how little dependence can be placed upon his ill-understood whims. Adverting now especially to spots, not only are the periods uneven, varying on the interval before us from 7.3 to 17.1 years between maxima, and from 9 to 13.6 years between minima, but the amounts of spottiness attained during his pulsations of energy vary, too, some maxima being three times as marked as others, that is, the spots cover three times as much solar area. Galileo had no trouble in seeing and drawing sun-spots in 1510-13, but his successors were less fortunate, for, as Miss Agnes E. Clerke tells us, a prolonged solar calm set in about 1643, and only a few solitary spots were seen in 1660, 1671, 1684, 1695 and 1705, which Professor Maunder happily calls "the crests of a sunken spot-curve." As to auroræ, the earliest Norwegian observer says: "When I was a child, about 1550, they were for the first time seen in the southern regions of our country, but since 1570 they have been rising so high that they can even be seen in places to the south-east and south of us, and I think they may now be viewed in other countries, too." It seems, however, rather astonishing to learn that no auroræ were seen in England from 1575 to 1706—a hundred and thirty-one years. From 1790 to 1815 there were very few seen in Norway, and not many for ten years more, after which they again became frequent. The correspondence between the recent solar minimum and the magnetic and auroral minima has not yet been thoroughly examined, but at Toronto the records show, on the magnetic traces, during the rather prolonged and very marked solar minimum, which reached its nadir in 1901.7, an almost continuous straight line. In Christiania, Milan and Prague, the least average variation in declination was in 1902, another "lag" as compared with the spot minimum, and the same feature may be evidenced when the Toronto records are digested. The auroræ observed here in 1901 and in 1902 were equal, but less than in any year since 1878. In this year, 1903, sun-spot activity is markedly revived, also magnetic variations, earth currents and auroræ.

As to the cause of auroral light, the new theory of corpuscles seems to apply—particles shot off from the sun being constrained to move in spiral pulses along the lines of magnetic force as they approach the earth's surface. As they move from the upper regions of the air towards the poles they go through air strata so rarefied that luminosity can be easily excited (as when an electric current passes through a nearly exhausted receiver), but as they approach the earth the density of the air forbids their luminescence. So far the theorists, and perhaps we had better for the present suspend judgment. The rapidity of the motion of electricity would scarcely allow the eye to follow it, as it does in the case of the aurora, even at the ascertained height of auroral displays here, say 100 miles. We should see something resembling the lighting's flash for swiftness. Possibly the radiations which convey electrical charges from sun to usward move more slowly than those we feel as light, which might account for the peculiar "lag" of magnetic effects.

The localization of auroral effects is also very strange. The same aurora is seen differently in different regions. This was made curiously evident in examining the remarkable aurora of September 2nd, 1898, at the request of Mr. Arctowski, who described it as he saw it in Belgica Straits.

"At 7.50 a fine arch, large, exceptionally high. 8.00, a second arch forms within the first, becoming very intense. Color, green. Rapid movement of the rays from right to left. Fluctuations. Ribands. Snake-like undulations, curving back on themselves. Homogeneous light, white or yellowish, mingles with the rest. 9.30, intensity renewed. Above, a great arch, a single band, clearly defined below, shaded off above, with large waves. 10.15, inside the arch, now much disorganized, is a broad, intense band, bow-shaped, recurved, undulating in the upper part. 10.30, double arch, the outside one whiter than the yellowish but higher one inside. The interior arch bent upwards at one end and fringed with rays. 10.40, the auroral sheen is intense. All the details of the aurora are in a way effaced by a spontaneous effervescence of light. The whole segment is luminous. 10.50, fading, rays distinctly green, distributed all over the part of the sky where it has been, seeming to start from a series of different bands."

The weather in North America was fine and clear on that September 2nd, all over the latitudes where auroræ are to be looked for, except in the State of Maine and the adjoining Maritime Provinces. The observations available are 78, and they are thus distributed—

United States—Idaho, 1; North Dakota, 1; South Dakota, 1; Minnesota, 9; Iowa, 9; Wisconsin, 10; Illinois, 7; Michigan, 10; Indiana, 3; Ohio, 1; New York, 4; New Jersey, 1; West Virginia, 1; Maryland, 1.

Canada—North-West Territories, 5; South-West Peninsula of Ontario, 10; Muskoka and Northern, 4.

Thus the visibility of this aurora was localized in and just around the basin of the great lakes, with a secondary focus of excitation in the far west, on both sides of the boundary line.

Localization is to be noticed in the case, too, of the fine aurora of September 9th, 1898, also brilliant in both hemispheres. Arctowski tells of its "dark segments," "homogeneous arcs," "double arcs," and "rays," witnessed in extraordinary beauty in the Antarctic. Here we had 80 observations, the weather being clear all across the auroral belt of America, except in Nebraska and Iowa. There was a little patch of 16 observations in the North-Western States, and another of a dozen around Pembina and Quesnelle, some brilliant. Then there is a connecting belt of 7 sporadic observations between Winnipeg and Montreal, corresponding to those in Minnesota (4), Wisconsin (2), Illinois (1), and Michigan (1). A scattered single report comes from Kansas. And then comes the great outburst further east: Pennsylvania (3), New York (5), Rhode Island (1), Maryland (1), Vermont (2), Connecticut (2), Massachusetts (7), New Hampshire (10), Maine (5). In Quebec and around the Gulf of St. Lawrence (12), Maritime Provinces (6).

This aurora, then, had its chief American focus by the sea, and a secondary one two thousand miles to the west. It was particularly fine on the European side of the Atlantic.*

Eight descriptive accounts of the aurora of September 2nd have been sent to me from Washington. They are strikingly dissimilar, so much so that the discrepancies cannot arise from errors of observation. Thus, at Dubuque, Iowa, it is expressly said that no arch was visible, and none is mentioned from Duluth or Milwaukee, but there was an arch at Grand Haven, Green Bay, the Sault de Ste. Marie and Rochester, N.Y. At Milwaukee the aurora was highly coloured, green, yellow and yellowish green, at times a red tinge, the whole appearing to be covered with a silvery sheen. At Green Bay "the entire heavens would at times be illuminated with a variety of tints." At Duluth there were "well defined curtain folds and streamers beautifully coloured, constantly changing effects." On the other hand, at the Sault de Ste. Marie, while there was a fine arch and streamers reaching to the zenith, there were no colours noticed; at Grand Haven the arch only gave out faint streamers and no colours are mentioned. At Dubuque there was "a pale, diffuse light," no arch; slender, luminous beams of a pale yellow occasionally rose and suddenly disappeared. The account from Minneapolis differs from both the above classes. "About 9 p.m. two broad parallel bands of light were seen extending . . . across the sky. In the north-east the sky seemed somewhat overcast, and on the edges of what appeared to be clouds there were occasionally patches of bright light which came and went with some rapidity. Sometimes a suggestion of a vibratory motion, but the illuminations were all indistinct. Later in the evening the lights were much more brilliant, with curtain-like movements,

* Bulletin of the Astronomical Society of France, October, 1898.

dark segments, flickering motions, etc. It lasted until nearly midnight." This is the description which offers the closest analogy to Mr. Arctowski's aurora, except that at Minneapolis no colouring is mentioned. But such resemblances are evidently fortuitous. On September 9th the aurora seen on the Belgica was not reported from Minneapolis, but of that aurora, the writer has analyzed eight American reports. Their principal feature was the appearance and persistence of detached masses of auroral radiance, while nothing of the kind is mentioned by Mr. Arctowski. These accounts, too, differ widely among themselves. It will be in order, then, to examine the hygrometric conditions of the atmosphere attendant on these various kinds of display, for differences therein at various levels may cause the variations in the auroral effects of the same magnetic influence—the height of the streamers and their colouring.

Arctowski writes as follows :—

"Dans mes remarques, je n'ai insisté quelque peu que sur l'identité probable des distributions géographiques, par rapport au poles magnétiques, du phénomène auroral, et j'ai posé un point d'interrogation au sujet de toutes les autres analogies qui sans doute seront decouvertes dans la suite. Mais voila que M. Harvey vient de nous demontrer une remarquable concordance entre les aurores observees en 1898 au Canada et dans le Nord des Etats Unis et celles que j'ai notées dans l'Antarctique."

He further says :—

"Mr. Arthur Harvey ayant sous la main des documents beaucoup plus importants que ceux dont je dispose, je ne puis que l'inviter d'étudier, au point de vue auquel il est place, les observations que la Commission de la *Belgica* publiera sous peu."

He formulated several questions which we can now answer—

Q.—Was the duration of the auroræ of September 2nd and 9th, 1898, the same in the Northern United States and Canada as at the station of the *Belgica?*

Ans.—At the points where the auroræ were best noticeable, the duration was about the same, but was not alike at all places.

Q.—Were the fluctuations of intensity the same, north and south?

Ans.—They differed among themselves here, in this particular also.

Q.—Do the maxima and minima correspond, to the moment?

Ans.—No, these too differ here.

Q.—Are the heights to which the auroral arch rises the same, at homologous points, *i.e.*, at points equi-distant from the magnetic pole and on the same magnetic meridian?

Ans.—All we can say is that so far as our observations go, the higher the latitude, the higher the arch and its streamers rise. We cannot say which of the places at which we have observers is to be considered most homologous to that of the *Belgica* with respect to the magnetic pole. The positions are as follows :—

N. magnetic pole lat., 70° 30′ N. ; long., 97° W.
S. magnetic pole lat., 73° 39′ S. ; long., 146° 15′ E.
Toronto lat., 43° 39′ N. ; long., 79° 24′ W.
Belgica lat. (September 2nd, 1898), 70° 00 S. ; long., 82° 45′ W.

Thus Toronto is 1,950 miles from the north magnetic pole, and the Belgica nearly 2,300 miles from the south magnetic pole. Toronto is 600 miles east of the agonic line, the Belgica 1,000 miles west of it.

If, then, anything is to be gained by comparing auroræ in homologous positions (which is very doubtful, as the condition of the air as to moisture, and electrical conductivity at various heights is changeable and seems to govern the brilliancy and colouring and even the character of the movements of auroral displays), better points must be chosen than the Belgica's winter station and Toronto City.

Beautiful auroral displays here are, however, things of the past, owing to the electric lighting which now dims their brilliancy and dulls their colours. One must get beyond the range of arc and even incandescent lights to see the grandeur of the mighty illuminations which formerly often seemed to rival, if not to transcend, the glories of the dawn of day, whose name was for the time usurped. The opaline clouds, delicately tinged with exquisite elusive tints of etherial amber, verging on chrome yellow, Niagara green, rose pink or spring lilac—sometimes almost stationary and again waving, tripping, dancing, leaping in rapid measures—the embroidered curtains moved by celestial airs in delicate folds of entrancing grace, shedding or dropping a rain of heavenly light so beautiful that one could but gaze in silence and wonder and admire the great bows which spanned the heavens, having one end, it was felt, on the western mountains, and the other on the Atlantic Ocean—these are for the denizens of a large city, like the dreams of youth to the mature man, fond memories of vanished rapture.

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