III.—The Progress of Geological Investigation in Nova Scotia.—By R. W. Ells, Ll.D., F. R. S. C., *of the Geological Survey of Canada.*

(Read 13th January, 1902.)

Probably in no part of the Dominion of Canada is there a more interesting field for geological research than is found in Nova Scotia and in the sister province of New Brunswick. The formations range from the top of the Triassic to the lowest known rocks, presumably the fundamental gneiss, and there is a large development of the strata peculiar to the Carboniferous, Devonian and Cambrian systems, in all of which important geological and economic problems are presented.

It has been found impossible to classify and arrange the different rock formations of the maritime provinces in accordance with the scheme of nomenclature laid down more than half a century ago by the Geological Survey of the state of New York, and subsequently adopted by Sir W. E. Logan for the province of Ontario and Quebec. In consequence of this difficulty, the necessity has arisen of placing large groups of strata in divisions which have been designated by local names, and this feature has been the cause of some confusion to many persons who are not familiar with the localities and the points of structure peculiar to each.

Too often, also, there has been an attempt made to parallel the rock formations there found with those which they are supposed to represent in England on the one hand, and in distant portions of the United States on the other, ignoring the possibility that the succession of life forms on the globe in early years may not have moved forward simultaneously over the whole surface, but that their distribution may have followed some law of evolution or development which has not yet been sufficiently considered. Geological problems in connection with certain

formations in the maritime provinces have thus occasionally presented features difficult to reconcile with those which are found in supposed similar formations elsewhere, when the attempt at interpretation has been made purely from the standpoint of the contained fossils by those who were not familiar with the local conditions of structure or the nature of the rock formations which are there presented.

In the present paper no attempt will be made to discuss the different views which have been put forth from time to time regarding the horizons of the several rock groups in Nova Scotia. To do justice to this aspect of the subject would extend the limits of the paper to great length. It is proposed, therefore, to give merely a brief statement of some of the work which has been done in this field, with a short notice of the men who have been largely instrumental in elucidating the principal points of structure throughout the province.

Much of this early work in the field was carried out by two Nova Scotians, viz., Dr. Abraham Gesner, a name well-known in the central portion of the province, and by Sir William Dawson, a native of Pictou. Both of these men, under many difficulties, partly inseparable from that early date, devoted much of the time taken from their otherwise arduous duties to the study of the somewhat complicated geological problems there presented.

The task which these two distinguished men, who may well be styled the pioneers in geological science in the eastern provinces, thus voluntarily assumed in the first half of the last century was no easy one. Even in England, the actual work of a geological survey had scarcely been commenced. The nomenclature of the science was in its infancy, and the many helps towards deciphering the writings in the great book of the rock formations, which are now available to the students of geological structure, were altogether, or almost entirely, lacking.

When these men began their work the country was comparatively but little opened up for settlement. Roads were few and far between when once the main lines of communication

were left behind, so that the facilities for detailed careful examination and comparison were rarely found. That so large an amount of really valuable information was obtained in those early days is matter for gratulation and clearly proves that these early students of the earth's crust were not only careful observers but were imbued with the true scientific spirit.

Probably the earliest description, from the scientific standpoint, of the rocks found in Nova Scotia, is contained in a somewhat lengthy paper, contributed to the American Journal of Science by Messrs. Jackson and Alger, two leading American geologists, in 1828-29. This paper was illustrated by a sketch map of a portion of the province, which is probably the first attempt at a geological map issued in Canada.

Without going into details as to the points of structure which are there described, it may be said that this paper contains much interesting information relative to the trap formations of the Bay of Fundy, and to their contained minerals. The gypsum deposits, found along the south side of the Basin of Minas, also received a fair amount of attention, and there is a good description of the iron ores which occur in portions of the South Mountain range at different points.

At that early date the long list of names now employed to distinguish the many formations to which the various rocks which form the earth's crust are now assigned was not formulated. The use of the term Primitive for certain granite masses was common, and these were supposed to represent the oldest group of rocks. The term Transition was also employed to designate certain altered sediments which are in contact with the granites at different points; but such names as Silurian, Devonian, Carboniferous and Triassic were not yet invented.

The terms trap, sandstone and slate are, in this early paper, in general use, but details of geological structure are almost entirely wanting. The article, however, is interesting from its very full description of the trap formation found in the North Mountain range, and to some extent valuable from the description therein contained relative to the mode of occurrence

and distribution of some of the leading economic minerals. In this connection the iron ores of the South Mountain range which are seen at Nictaux and Bear River are regarded as probably continuous throughout the entire mountain range, passing to the rear of the village of Horton, and possibly continuing further east to connect with theiron deposits found in Pictou county.

Considerable information is also given as to the coal and copper deposits in Cumberland, Colchester and Pictou counties, in the latter of which the coal mines, now of so much importance, were then just being opened.

Probably the most important of the early writings on the subject of Nova Scotian geology are from the pen of Dr. Abraham Gesner. The first of his publications to appear has the date 1836, and is entitled, " Remarks on the Geology and Mineralogy of Nova Scotia." The volume contains the results of his observations throughout the province during several preceding years, and is the first attempt made to place the geological formations there found in regular order. Gesner arranged the several rock groups into districts, and placed the granites, which he found so persistent along the Atlantic coast, in the Primary district, regarding these as his oldest division. A second belt which he outlined throughout a great part of the central area of the province, and which consisted largely of slates, he styled the Slate district, and regarded them as more recent in age than the granite.

These were succeeded northward by a great series of reddish sandstones, shales, and some slaty beds, which now include formations from the Silurian to the Trias, both inclusive, which he termed the Red Sandstone district. This division embraced also what is now known as the Coal formation, while to the great ridge of volcanic rocks, including basalts, diabase and amygdaloids, which are found chiefly in the North Mountain range, he gave the name of the Trap district.

This classification, it will be observed, was based largely on physical and lithological characters and upon the predominant rock masses in each.

This volume of Gesner's was accompanied by a small map of the province on which the limits of the several divisions were outlined as then understood.

Of Dr. Gesner, it may be truly said that he was a remarkable man for his times. The collection and preparation of the great mass of facts contained in his first book must have involved a large amount of hardship in the field and in his study, and in the preface he states that "amidst the arduous duties of a laborious profession, and under the annoyance of perpetual interruption, most of the following pages have been written; or during the silent hours of midnight, when the labours but not the fatigues of the day had departed."

Gesner's subsequent publications relative to the subject of Nova Scotia geology may be briefly mentioned. In 1843 an important paper was read before the Geological Society of London, Eng., which was accompanied by a geological map of a large portion of the province, and this shews a marked advance as compared with those which had previously appeared; and a similar paper was published in the London Mining Journal in 1845.

A second volume styled "The Industrial Resources of Nova Scotia" appeared in 1849. This contained two chapters devoted to the geology and mineral resources of the province. In this volume it will be readily noticed that a great advance has been made in geological science since the date of the first book in 1836. The several formations have been fairly well arranged in accordance with modern ideas of nomenclature, though the work was necessarily done on the broad scale. The rocks were arranged under seven heads, as follows :—

1st. The granites or hypogene rocks of the south coast, including the syenites and traps. 2nd. The stratified non-fossiliferous rocks of the interior, now known as the gold-bearing and other associated slates, which he called Cambrian, in which classification they still remain. 3rd. The fossiliferous clay slates, with greywackes, which he styled

Silurian, the term being still held as applicable to a large part of these sediments. 4th. The overlying series to the base of the Carboniferous, regarded as of the age of the old Red sandstone or Devonian. 5th. The Carboniferous proper or Coal formation. 6th. The New Red sandstone and the intrusive or igneous rocks associated, now regarded as probably of Triassic age; and 7th, the overlying drift or boulder formation.

The arrangement of so many groups of rock formations throughout the province in such a manner as to be fairly well sustained by more recent and detailed investigation, conclusively establishes the fact that in Dr. Gesner the province possessed a geologist of no mean order, having a wonderful grasp of the difficult problems everywhere presented in connection with the rock structure in the eastern provinces, and indicating a marvellous capacity for scientific investigation.

During the years from 1838 to 1843, Gesner, at the request of the government of New Brunswick, made a comparatively close study of the rock formations found in that province. The results of his work appeared in five separate reports of great interest, the terms employed to designate the several rock groups corresponding closely with those which he employed in his work in Nova Scotia. He also published a volume on the general resources of New Brunswick which appeared in 1847, in which several chapters were devoted to the geological features there observed, so that it will be readily seen the life work of Dr. Gesner was of great importance and value to both the eastern provinces.

As a sample of his style of writing, the following, taken from his description of the Cornwallis valley, as contained in his first volume, 1836, may be given:—

"Before the visitor descends from the South Mountains near Kentville, let him take a view of the extensive valley before him. On the north side rise those mountains of basaltic columns, which, with proud elevation, line the coast of the Bay of Fundy, protecting the beautiful and fertile Township of Cornwallis, and all the settlements situated at their base from the bleak north-

wester, so well-known, and so little admired in Nova Scotia. Let him turn his eyes towards the western horizon, and as far as vision extends, the red sandstone supports the soil of the almost level country before him, while rocks of different classes are thrown up like walls on each of its sides, affording shelter from southern and northern gales; and lastly, let a glance be taken at the bustling little village beneath his feet, and he will admire not only the grand and beautiful spectacle before him, but also the infant town below, prepared to afford him those refreshments his stroll will have rendered necessary. In the neighbourhood of Kentville, the new red sandstone is in contact with the old red sandstone, the members of the mountain limestone and coal groups being deficient. The great bed of iron, represented as occupying a place throughout the whole South Mountain range, has not yet been discovered south of that village; but from the occurrence of detached pieces of the ore, iron pyrites, and the carbonate of iron at Beech Hill, no doubt can be entertained of its uninterrupted existence, even farther eastward than that place."

An important feature in the history of Nova Scotian geology was the visit of Sir Charles Lyell who, in 1842, made a geological excursion through portions of the province. In this work he was aided by Dr. Gesner and also by Sir William Dawson, the latter at that time a young man of about twenty-three years of age. The results of this visit of Sir Charles Lyell are given in his book, "Travels in North America," published in 1845. He paid much attention to the group of rocks which had been classified in large part by Gesner under the head of the red sandstone division. and as a consequence of his examination these were separated into three portions styled respectively, the upper carboniferous, the productive coal measures, and the lower carboniferous or gypsiferous formation. The last named was placed in its true position beneath the coal measures, while the soft red sandstones, so conspicuous around the shores of Minas Basin, were regarded as an upper division and regarded as probably belonging to the Trias. The visit of Sir Charles Lyell was therefore important as serving to determine more clearly the true horizons of this important series of rocks.

Among the workers in the eastern portion of the province who have aided materially in elucidating points of structure may be mentioned the name of Mr. R. Brown. From his intimate connection with some of the leading coal mines of Sydney, Mr. Brown enjoyed great facilities for studying the rocks of the Carboniferous formations in that area, and he has contributed much valuable information regarding the arrangement and distribution of these rocks for that portion of the province. Some of the results thus obtained have appeared in the Journal of the Geological Society of London, the first article being apparently printed in 1853, as well as in more recent publications.

The association of Sir William Dawson with Sir Charles Lyell in 1842, greatly stimulated the love of the former for scientific investigation, and for many years thereafter much of his spare time was devoted to the study of the rocks in his native province. From his position as Superintendent of Education, which appointment he held for some years previous to his removal to Montreal as principal of McGill University, he was enabled to visit many localities where interesting problems of structure were presented.

Sir William was an early contributor to the scientific journals, since we find a communication from his pen in the Journal of the Geological Society for 1842 on some geological phenomena which he had observed in Prince Edward Island. Many of his papers, more especially in the early years of his work, were read before the Geological Society, of which body he soon was appointed a fellow. Up to the date of his death, which occurred near the close of 1899, his pen was rarely idle, the list of his published writings reaching a total of nearly four hundred, in which are included many books of much interest, some of which dealt exclusively with scientific matters, while others had a wider scope.

The first of these volumes relating to the geology of the maritime provinces was his " Acadian Geology," the first edition of which appeared in 1855. A second edition, much enlarged, was published in 1868, and this was added to by a supplement

in 1878 and another in 1891, in which the latest information on the subject was supposed to be incorporated.

The "Acadian Geology" has for many years been regarded as a standard work in the field of scientific research, though, as more detailed investigations have been carried out, several statements regarding the structure of certain formations have of necessity undergone revision. A large portion of Sir William's life work was spent in the study of fossil plants, in which line of investigation he was justly regarded as an eminent authority. These studies embraced the fossil remains found in the Devonian and Silurian of Gaspé and New Brunswick, and in the Carboniferous rocks of all the maritime provinces, as well as the fossil plants found in the newer formations of the Pacific slope. Like Gesner, Sir William Dawson may rightly be considered as one of Nova Scotia's most distinguished sons in the line of scientific investigation.

Among other zealous workers in the geological field in Nova Scotia must be mentioned the name of the Rev. Dr. Honeyman. Formerly a minister of the Presbyterian church and settled in Antigonish, his fondness for geological study early led him to a close investigation of the complicated rock formations which are found in the eastern part of the province. Afterwards, being transferred to Halifax, he became the curator of the Provincial Museum. Here his field of work became somewhat enlarged, and his researches extended over many parts of the province. The results of his field work appeared in a number of interesting and valuable papers, many of which were published in the Transactions of the Nova Scotian Institute of Science, though others were read before the scientific societies both of England and the United States.

The first of these contributions by Dr. Honeyman on the geology of Nova Scotia was apparently presented before the Literary and Scientific Society of that province in 1859, and from that date to the time of his death in 1889, articles from his pen appeared at frequent intervals. Though the chief field of his labours for many years was the classic ground of Arisaig, where

probably his best work was accomplished, his eyes were open to the natural phenomena which are everywhere presented to him who cares to read the story of the earth.

A full list of his publications has apparently never been published, and the collecting of these in proper order is a duty yet devolving upon some one of those with whom he was intimately associated in the scientific work which has been and is still being carried on in the Acadian provinces.

Prior to the admission of the eastern provinces into the Canadian confederation the work of the Geological Survey did not extend east of Quebec.

Almost the earliest work, however, of the first director, Sir William Logan, was the examination and measurement, in 1843, of the celebrated Joggins section on the western coast of Cumberland county, embracing a total measured thickness of 14,570 feet of Carboniferous strata, in which were included a large part of the Lower Carboniferous formation, the Millstone-grit, the Productive Coal-Measures, and the Upper Carboniferous in part. The work so ably done at that early date has since been revised by several other workers in the field, notably by Sir William Dawson, the results of whose examinations, stated in much detail, will be found in the second edition of the Acadian Geology, 1868. The section as originally published has ever remained as the standard basis of classification for the rocks of the Carboniferous system in the maritime provinces.

With the advent of Confederation in 1867, the work of the Geological Survey was extended to New Brunswick and Nova Scotia. In 1868 Sir William Logan and Mr. Edward Hartley began a detailed examination of the coal fields in Pictou county which was carried on till the death of the latter at the close of 1870. The results of these examinations in the Pictou coal-field were of the greatest importance, and the coal basin was mapped with great accuracy.

In consequence of the importance which the gold-fields of Nova Scotia had assumed, Dr. Selwyn who had been appointed director of the Geological Survey in 1869, made a somewhat

detailed examination of that district in 1870, and published a valuable report on the subject in the annual volume of the Department for 1870-71. In this report the gold-bearing rocks of the province were fully described and compared with those found in the province of Quebec, and also with those of the gold-fields of Australia in which district he had already worked for some years as Director of the Geological Survey of that colony. In 1871 Dr. Selwyn also made a study of the iron-ore deposits of the Londonderry district, the results of which were stated in the Report of the Department for 1872-73.

In 1870 work was commenced in the Springhill coal basin by Mr. Scott Barlow, and carried on continuously by him till the close of 1878. In addition to mapping the Springhill areas, Mr. Barlow's work extended over a large portion of the county of Cumberland, the results appearing in several important reports to the Geological Survey Department. In 1873 Mr. Walter McOuat began a series of surveys in parts of the same field, but more particularly in the area to the north-east of that assigned to Mr. Barlow, which were carried on till his death at an early age in 1875. The results of his explorations also appear in several valuable reports addressed to the same Department.

In 1872 Mr. Charles Robb, after several seasons spent in New Brunswick, began a systematic exploration of the Cape Breton coal-fields. In this work he was associated with Mr. Hugh Fletcher, who, on the retirement of Mr. Robb in 1875, assumed control of and completed the mapping of the coal-basin. The explorations were thereupon extended and the whole of the island carefully surveyed and mapped in great detail.

Upon the completion of this work, Mr. Fletcher's field of operations was transferred to the main land, and the same detailed series of surveys which had been inaugurated in Cape Breton were there continued. In this way much of the northern and eastern portions of the province have been carefully mapped and the geological details indicated with great minuteness, including the counties of Guysboro, Antigonish, Colchester and Cumberland, and large portions of Hants and Kings. The minuteness

of detail shewn in such of these map-sheets as have been published, attest the scientific training of their author and the extreme care which has been taken in their preparation. Much attention has been devoted to the accurate mapping of the important coal-basins of Pictou and Cumberland counties, and to the determination of the economic value of other deposits of economic minerals which are found in the area.

The mapping of the great belt of rocks along the Atlantic coast, including the slates, quartzites and granites, which in the early days of Gesner were styled Primitive and Transition, and in which the gold mines of the province are principally located, has been carried out along similar lines by Mr. E. R. Faribault, also of the Geological Survey staff. In addition to the general maps, shewing the distribution of the several rock formations of that district, a valuable series of map-sheets shewing the detailed structure of the principal gold areas has been prepared. Some of these have been already published, while others are in course of preparation and are of inestimable value to the mining community of the province. The complicated series of rocks which were broadly outlined half a century ago by Gesner and Dawson have thus been worked out in the greatest detail, and the several geological divisions indicated in the clearest manner.

Among those who have done more or less work in the province, it may be said that the writer of this article, in 1884, in connection with his work in south-eastern New Brunswick, spent some weeks in tracing out the formations in the area between the Bay of Fundy and Northumberland Straits in the preparation of the map of Cumberland county.

In 1891 and 1892, Mr. R. Chalmers made a series of careful examinations in connection with the surface deposits of Cumberland county, with particular reference to the glaciation of that district; and in the years from 1890 to 1896, Dr. L. W. Bailey, of the University of New Brunswick, carried on a somewhat extended examination of the southern and western portions of the province, including the counties of Digby, Yarmouth, Queens and Annapolis. A detailed report of the work thus done,

accompanied by a map of the area, was prepared and published in the annual volume of the Geological Survey for 1896, in which the leading geological formations were outlined and many important facts relating to the structure and mineral resources were given. The detailed mapping of portions of this district is still in progress, in order that the map-sheets of that portion of the province may conform with those already published of the northern and eastern divisions.

Valuable papers have also appeared from time to time from the pen of Mr. H. S. Poole, for many years connected with important mining operations in the Pictou coal-fields, which afforded him excellent opportunities for the study of the rocks of the Carboniferous system, and also from Dr. E. Gilpin, of the Department of Mines, Halifax, who has ably dealt with certain points of structure presented by the rocks of that district, and also with many questions relating to the occurrence of economic minerals at many points throughout the province.

In connection with Acadia College, Professor Haycock has recently published two valuable papers, dealing largely with the question of local geology, which are of much interest. In the area about Wolfville and along the Gaspereau Valley, as well as in connection with the rocks of the North Mountain range, there is a most interesting field for investigation which has been as yet scarcely touched. It is to be hoped that this area will now receive that attention from local geologists which it well deserves.

In a paper of this kind it is, of course, very evident that many points of great interest must be omitted. The merest outlines of the subject have of necessity been stated, and there are other names which have been associated to a greater or less extent with the work of investigation, to which but slight reference can be made. Among those who have thus contributed papers relating to the geological structure and mineral resources of the province at a comparatively early date, may be mentioned by Mr. J. Campbell of Halifax, whose reports on the gold-fields, in 1863 are of much interest, and Dr. H. Y. Hind of Windsor,

who, from 1869 to 1872, published several articles on the same subject. Papers of more or less importance relating to the gold of Nova Scotia, have also been printed by Mr. C. Fred Hartt in 1864 and by Mr. H. F. Perley in 1865, both in the Canadian Naturalist of Montreal, and by Professors Marsh in 1851 and Silliman in the American Journal of Science.

Among contributors to the literature pertaining to the coal-fields of the province, in addition to those already referred to, may be mentioned Mr. H. Poole who contributed two papers, one in the Journal of the Geological Society of London, 1853, the other in the Canadian Naturalist in 1860, and Professor J. P. Lesley, whose elaborate article on the structure of the Cape Breton areas was published in the American Journal of Science for 1863.

From the pen of the late Dr. H. How of Windsor, several valuable articles appeared between 1857 and 1866, principally in the Transactions of the N. S. Institute of Natural Science. These, for the most part, described the occurrence of valuable and sometimes rare minerals, found at different places in the province. Various publications, more particularly relating to the occurrence and determination of fossils from various localities have also appeared from time to time, both in the official reports of the Geological Survey and in various scientific journals, and represent the work of Messrs E Billings, T. C. Weston, D. Honeyman, H. Poole, H. M. Ami and others. These can only be thus briefly alluded to, since the aim of this paper has been to give broadly some slight sketch of the leading workers in this field, and a brief statement of the results of their labours. The details of the subject may well be left to others, who through a more intimate acquaintance with the progress of geological science in the province, both as regards men and localities, are better fitted than the writer for the task of elaboration.