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OF

THOMAS STERRY HUNT

1826-1892

BY

FRANK DAWSON ADAMS

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Thomas Sterry Hunt was born in Norwich, Connecticut, on September 5, 1826, and died in New York on February 12, 1892. Forty years have now elapsed since he passed away so that but few men of science of the present generation knew him. He was, however, an outstanding figure in science in the last century and one who made many and important contributions to the knowledge of his time.

His second name Sterry was derived from his mother's side of the family. The Sterrys were a famous family among the Puritans in England in the time of the Commonwealth, several of them were preachers of renown. One of them, Peter Sterry, was Chaplain to Oliver Cromwell, while another, Thomas Sterry, was the author of the well known tract "A Riot among the Bishops, or a Terrible Tempest in the Sea of Canterbury." A branch of the family consisting of three brothers—Roger, Robert and Cyprian Sterry—together with a sister, came to America about 1753 and settled at Providence. Two of Roger's sons, John and Consider, edited and published *The True Republican,* a leading organ of the old Jeffersonian party. Jane Elizabeth, a daughter of Consider Sterry, was married to Peleg Hunt in 1823 and Thomas Sterry Hunt was their child. He often referred to his "Uncle Consider," whose name, following a common usage among the Puritans, was the abbreviation of a more extended designation, in this case a verse of Scripture, his full name being "Consider-the-lilies-of-the-field-how-they-grow Sterry." Sterry Hunt's father died in 1838, leaving his wife in rather straitened circumstances. She was, however, a woman of character and ability and by her own exertions brought up and educated her family—young Hunt had to leave school and go to work for his living at the age of thirteen. His strong predisposition toward science was manifested from the first and he contrived, while working in the shop during the day, to find leisure for study and to carry out chemical experiments.

Hunt's ideal man of science was Michael Faraday and the early career of the two men followed closely similar lines. The Sixth Annual Meeting of the Association of American Geologists and Naturalists, the progenitor of the present American Association for the Advancement of Science, which was held at New Haven in 1845, gave Hunt his first formal introduction to the world of science. He attended the meetings as a correspondent for a New York newspaper but was unanimously elected a member of the Association. Shortly after this Hunt was fortunate enough to make the acquaintance and to enlist the friendship of the elder Silliman, who played the same part for him that Davy did for Faraday. Recognizing his abilities and promise, Silliman secured his admission to the Scientific School of Yale University, where, under the younger Silliman, he entered upon his career as a chemist. During an hour or two each day he assisted Silliman in connection with his lectures, while the rest of his time was devoted to analytical work in the chemical laboratory. Writing to a friend in 1845, he says, "I have seated myself in the laboratory with the flasks by my side so as to work and write at the same time. . . . I have free access to Professor Silliman's cabinet and a key to unlock all the cases. . . . I am boarding in a club of students at $1.25 a week. We have little or no meat. I do not like this very well, but it is cheaper, though I think I will board myself after a while. The room I expected to have has been occupied, as I was uncertain whether I was coming and so I have taken up my lodgings in the loft of the laboratory building itself and am so quite at home with chemical apparatus and preparations all around, 'they are congenial spirits,' as Mr. Silliman remarked when he showed me the room."

During the years 1845, 1846 and 1847, while at Yale, he contributed no less than eighteen articles and notes to *Silliman's Journal,* his first paper being entitled "A Description and Analysis of a New Mineral Species Containing Titanium, with Some Remarks on the Constitution of Tellurium Minerals." His wide acquaintance with chemistry is also shown by the fact that he wrote the portion dealing with organic chemistry, of

Silliman's "First Principles of Chemistry." Professor Silliman in the preface to the first edition of this work writes prophetically of the high position which his young assistant was to attain in his chosen profession: "The author takes pleasure in acknowledging the important aid derived in this portion of his work from his friend and professional assistant, Mr. Thomas Sterry Hunt, whose familiarity with the philosophy and details of chemistry will not fail to make him one of its ablest followers. The labour of compiling the organic chemistry has fallen almost solely upon him."

In 1842, the Geological Survey of Canada was established and in the Spring of the following year Mr. William E. Logan (afterwards Sir William Logan) entered upon his duties as its first Director. So soon as the work of its preliminary organization had been completed, Mr. Logan felt the imperative need of an able chemist and mineralogist on his staff and wrote to Professor Silliman, Jr., asking him if he knew of anyone whom he could recommend for the position. Silliman strongly recommended Hunt as a suitable person and in this he was warmly supported by Professor C. Upham Smith and Professor J. D. Dana.

Hunt accordingly—although then but twenty years of age—came in February, 1847, to Montreal and took up his duties as Chemist and Mineralogist to the Geological Survey of Canada. For the next twenty-five years Sterry Hunt lived and worked in Canada. This was by far the most productive period of his life and his name will consequently always be associated in a very special way with the Dominion of Canada. The first report which he made after his appointment to his new position was submitted to Logan in April, 1848, and dealt with the petrography and mineralogy of the Grenville limestones occurring along the course of the Ottawa River and with certain mineral waters in this and adjacent districts. This was followed by other reports in subsequent years. An immense amount of information concerning the geology and mineral resources of the great virgin field which Canada then presented was rapidly gathered together by the officers of the Geological Survey and Logan decided to collect and correlate this. This was done and the results were presented to the public in the large volume of nearly 1,000 pages issued in 1863 under the title of the "Geology of Canada." That portion of this volume dealing with petrography, mineralogy, the mineral waters and a large portion of the chapters on economic geology, were from the pen of Sterry Hunt.

These early years on the Canadian Survey brought to Hunt a great wealth of information and directed his attention to certain lines of thought and investigation which he developed as the years went on. While he undertook a certain amount of geological field work and made a number of important observations in the field, and while he wrote extensively on geological subjects, he was first and foremost a chemist and he approached all the subjects which he studied from the standpoint of chemistry. His contributions to geology dealt chiefly with the old crystalline and metamorphic rocks of the earth's crust.

His work, however, on the structure of the palaeozoic rocks of Ontario and of the Gaspé Peninsula and its relation to the occurrence of petroleum was of the first importance. In a paper entitled "Notes on the History of Petroleum or Rock Oil," which appeared in the *Canadian Naturalist and Geologist* for August, 1861 (Vol. VI, pp. 241-255), referring to a large number of oil wells which had been sunk in the township of Enniskillen in the Province of Ontario, Hunt writes: "These wells occur along the line of a low broad anticlinal axis which runs nearly east and west through the western peninsula of Canada . . . the oil doubtless rises from the Corniferous limestone which contains petroleum, this being lighter than the water which permeates at the same time the porous strata, rises to the higher portion of the formation which is the crest of the anticlinal axis, where the petroleum of a considerable area accumulates and slowly finds its way to the surface through vertical fissures in the overlying Hamilton shales, giving rise to the oil springs of the region." Earlier in the same year, in a lecture which he delivered before the Board of Arts of Montreal and which was reported in the *Montreal Gazette* of March 1, 1861, Hunt pointed out this relation of the oil wells of Ontario to the anticlinal folds in this region. This relation of petroleum deposits to anticlinal folds, the recognition of which has led to such tremendous economic results, Hunt believed that he was the first to point out in the letter in question. In which belief he was apparently correct. Professor E. B. Andrews, in a paper on "Rock Oil, Its Geological Relations and Distribution," in the *American Journal of Science* for July, 1861, describes the occurrence of oil and gas springs on the axis of an anticlinal fold in Ohio. In his pamphlet "Petroleum, Its Geological Relations," published in Quebec in 1865, Hunt then acting as Director of the Geological Survey of Canada, Sir William Logan being absent from Canada at the time, makes a somewhat detailed report of the occurrences of petroleum in the Gaspé Peninsula in the Province of Quebec in which these petroleum occurrences also are shown to be directly connected with anticlinal folds, the oil rising from petroleum-bearing strata below into a pervious overlying series of beds with an impervious cover.

The wide range of researches and the extended contributions which he made to science will be seen by glancing over the bibliography which is appended. It is unnecessary to refer to all these but there are two subjects to which he devoted much time and study and to which attention may therefore be directed.

The first of these is that of the "Origin and Succession of the Ancient Crystalline Rocks of North America."

In his "Chemistry of Metamorphic Rocks," read before the Dublin Geological Society in 1863, he classified these into the following four series set forth in ascending order: 1. "The Laurentian System representing the oldest known rocks and supposed to be the equivalent of the Primitive Gneiss formation of Scandinavia and that of the Western Islands of Scotland." 2. "A great development of anortholites of which the hypersthenite or opalescent feldspar-rock of Labrador may be taken as a type. These strata overlie the Laurentian gneiss and are regarded as constituting a second and more recent group of crystalline rocks, to which the name of the Labrador Series may be provisionally given. From evidence recently submitted, Sir

William Logan conceives it probable that this series is unconformable with the older Laurentian System and is separated from it by a long period of time." 3. "A great series of crystalline schists (the Green Mountain Series) which in Canada are referred to as the Quebec Group, an inferior part of the Lower Silurian System. It appears to correspond both lithologically and stratigraphically with the schistose group of the Primitive Slate Formation of Norway. The Huronian series of Canada in like manner appears to correspond to the Quartzose Group of the Primitive Slate Formation. It has as yet been but imperfectly studied and will not be further considered." 4. "This is a series of quartzose and micaceous schists with Staurolite and red garnet," which he named the White Mountain Series.

He states in this paper that it cannot be doubted that in the earlier period of the world's history, chemical forces of certain kinds were much more active than at the present day. In the successive periods above mentioned, he believed that owing to successive chemical changes in the character of the ocean waters and of the detritus carried into the oceans from the land, the deposits laid down on the ocean floor—partly chemical precipitates and partly fine clastic material—were characterized by a progressive change in chemical composition, which when the deposits were metamorphosed gave rise to the distinctive differences in petrographical character displayed by the four series referred to above. He goes on to say that the question therefore arises whether the chemical conditions which have presided over the formation of sedimentary rocks have not so far varied in the course of ages, as to impress upon the rocks marked chemical and mineralogical differences, which in the absence of organic remains or stratigraphical evidence might be used as a means of determining the age of a given series of stratified rocks.

In his address as Vice President of the American Association for the Advancement of Science in 1871, he set forth a revised and extended classification of these ancient rocks, now arranging them in the following six series, again in ascending order: Laurentian, Norian, Huronian, Montalban, Taconian, and Keewenian.

His opinion both as to origin and succession of these ancient rocks was opposed by Dana, Logan and others and led to widespread controversy. His views as to their origin inclined largely to those of the old Neptunists and have not received much support from more recent studies. The Norian series has been shown to have no place in the succession, being composed entirely of intrusive rocks and many of the rocks which Hunt regarded as of sedimentary origin and characteristic of the other series have proved to be of igneous origin. He, however, carried on a vigorous campaign in support of his views to the end.

The last field work which Hunt did was in southeastern Pennsylvania in the years 1875 and 1878. This was for the Second Geological Survey of Pennsylvania under J. P. Lesley. He was to have written two volumes for this Survey, the first being an historical account of the development of the knowledge of "Azoic" or Pre-Cambrian rocks of North America, while the second volume was to have given an account of the rocks of this age in Pennsylvania. Only the first of these volumes was completed. It was published in 1878 under the title of "Special Report on the Trap Dykes and Azoic Rocks of Southeastern Pennsylvania." Professor Lesley in his introduction to this volume says: "It is a treasury of notes and suggestions of the greatest value to the geologists of Pennsylvania and of other States working in such districts as are occupied at the surface or are underlain at moderate depths by the Cambrian and sub-Cambrian formations, although no final demonstration has been accomplished by the author of those problems of superposition, unconformability and identification at which so many geologists are still half despairingly at work. But his opinion of the final solutions of these problems will reinforce their own when they agree and lead to discussion when they disagree." The very difficult problem of deciphering these half-obliterated palimpsests in which is set forth the history of the primeval world, cannot indeed be solved by any amount of discussion but only by long-continued, close and accurate observation in the field—a method of approach which, it is feared, was not congenial to Hunt.

Fourteen years later, when in 1892 Lesley presented a compendium of the results attained by the Second Survey of Pennsylvania in his "Summary Description of the Geology of Pennsylvania," the somewhat transcendental character of Hunt's geological studies and opinions seems to have impressed him, for in his chapter on the "Earliest Archæan" in Volume 1, he writes as follows:

"The surface of the earth was no longer hot enough to keep all the water of the planet in a state of vapour in the surrounding atmosphere; descending in local deluges of sour rain to boil upon the rocks and dissolve apart their mineral elements, sweep them into hollows and there leave them while it sprang aloft as steam to rejoin the universal canopy of cloud. All of this had taken place before the first age of which we have any geological monuments and is known only to God and Dr. Sterry Hunt, who has described it magnificently in his 'Chemical Researches'."

These views of Hunt referred to by Lesley are put forward in his paper on "The Chemistry of the Primeval Earth," which is to be found in his "Chemical and Geological Essays," published in 1874 and which volume of essays passed through four editions. This essay was developed and expanded in his later paper entitled "The Origin of Crystalline Rocks," which appeared in the "Transactions of the Royal Society of Canada," Section III, 1884. This paper is an exposition of his "Crenitic Hypothesis."

According to this theory a basic quartzless rock formed the exterior portion of the cooling molten globe and was the last portion of the globe to solidify. This was fissured and made porous through refrigeration and crystallization and was thus rendered permeable to considerable depths. The heated waters which condensed upon this surface thus passed downward but owing to the central heat of the earth, a system of aqueous circulation was set up in the mass. The materials which these heated waters dissolved out of this basic rock through which they were circulating would be essentially those which infiltrating waters in subsequent ages have removed from erupted masses of similar rock, namely silica, silicates of the alkalies and of lime and certain double silicates of these bases with alumina (zeolites and feldspars), together with oxides of iron and carbonate of lime, due to admixture of atmospheric carbon dioxide. These materials would be brought to the surface and there deposited, or they might be deposited in the fissures through which the waters rose. In fact they are, according to this theory, to be seen now in the pegmatite veins or dykes cutting the most ancient rocks of the earth's crust in all parts of the world where these are exposed. These waters, however, when they reach the surface would deposit their dissolved contents, as the temperature was lowered, in layers of crystalline acid granitic or gneissic rock, spread over the original surface of the cooling globe while the insoluble basic residue of the original crust represents the typical basaltic layer assumed by Bunsen.

Therefore all gneisses, hornblende and micaceous schists, olivine rocks, serpentines and in short all crystalline stratified rocks, are of neptunian origin and not the results of the metamorphism of either aqueous sediments or of volcanic materials. The chemical and mechanical conditions under which these rocks were deposited have not, according to Hunt, been reproduced since the beginning of Palaeozoic time. The eruptive rocks, according to this Crenetic Hypothesis are for the most part softened and displaced portions of these ancient neptunian rocks or of the basic shell on which they rest.

In another of his more important papers, entitled "On a Natural System in Mineralogy with a Classification of Natural Silicates," Hunt gives expression to certain ideas on another subject, which had been maturing in his mind for several years. This was read before the Royal Society of Canada in 1885 and printed in the "Transactions" of this Society in the following year.

Werner, who died in 1817 and was succeeded at the Freiberg School of Mines by Frederich Mohs, prepared a classification of the Mineral System based on external characters. Mohs in his "Mineralogy," which appeared in 1822-24, completed Werner's work and the method of classification thus introduced was designated by Jamieson as the "Natural History Method" for the classification of minerals. Dana adopted this method in the first and second editions of his "System of Mineralogy," but abandoned it in the third edition published in 1850, and in the preface to the fourth edition stated that in his opinion the system of Werner and Mohs had subserved its end and that a system more consistent with the new views on chemistry should be adopted. He accordingly, in his fourth edition, which appeared in 1854, adopted a chemical classification, the so-called Berzelian System.

In this paper Hunt proposes a system of classification in which he combines these two methods, holding that the physical features of minerals "had inherent and necessary relations with the chemical composition," and this system he therefore calls a "Natural System of Mineralogy." As organic chemistry is the chemistry of the carbon compounds, so Mineralogy is largely the chemistry of the compounds of Silicon, and in this new system Hunt strives to show that the structure of the silicate molecules in minerals is analogous to that found in the carbon compounds. "All species crystallizing in the same shape have the same equivalent volume so that their equivalent weights (as in the case of vapours) are directly as their densities and their equivalents of mineral species are as much more elevated than those of the Carbon Series as the specific granites are higher. . . . The laws of progressive or homologous series, previously recognized only in hydrocarbonaceous bodies, must be extended to mineral species and are of universal application. . . . The variations observed in chemical composition of mineral species are due not only to their high polybasic character, but also, in certain cases to indefinite admixtures of homoeomorphous species, as previously indicated by Delesse, Scheerer, and Von Wathershausen, extended and generalized by myself and subsequently adopted by Tschermak."

Hunt's "Crenitic Hypothesis" and his "Natural System in Mineralogy" have not met with very wide acceptance, but time will show whether, with the advance of science, they may not be found to contain some things which are worthy of more attention than they have hitherto received.

In addition to the immense amount of detailed analytical and descriptive work which Hunt carried out as Chemist and Mineralogist of the Geological Survey of Canada, he gave a course of lectures on Chemistry every Spring at Laval University in Quebec, from 1856 until 1862. These lectures he delivered in French, which language he spoke with fluency and elegance. He also for several years lectured at McGill University in Montreal. It was not, however, until he severed his connections with the Geological Survey of Canada to accept the Professorship of Geology in the Massachusetts Institute of Technology, in 1872, that he devoted his time exclusively to university work. He retained his professorship in Boston until the year 1878. Teaching, however, was not congenial to him. He had neither the desire nor the patience to follow what were to him the dry details of the geological study of periods of the earth's history in which he took no particular interest. Neither had he the peculiar qualities of personality which lead the teacher to take a special interest in his students, which in the case of so many teachers call forth a peculiar spirit of devotion to him on the part of his students. His talents lay in other directions, and so later his application for the Chair of Geology at Columbia University, although supported by Lyell, Murchison, Dana, Silliman, the Rogers and others, was rejected in favor of Newberry.

While devoting much of his time to problems of pure science Dr. Hunt was also attracted by chemistry and geology in their practical applications. When on the staff of the Geological Survey of Canada he made reports on the "Gold Mines of Canada" (1863) ; "On Petroleum in Gaspé" (1865) ; "On the Gold Regions of Lower Canada" (1866) ; "On the Gold Deposits of the County of Hastings, Ontario" (1867) ; "On the Goderich Salt Region in Ontario" (1869), etc., and wrote many other papers dealing with economic geology.

In 1857 he first suggested the use of sesquioxide of chromium as the basis of a green ink for printing bank notes, it being a substance which could not be removed by either an acid or an alkali without destroying the paper and which also could not be satisfactorily photographed. This invention was patented and being subsequently adopted in the United States for the printing of "greenbacks" became very valuable, but Hunt himself never reaped any substantial reward from his discovery.

Early in his career he became acquainted with Dr. James Douglas, of Quebec, an acquaintance which ripened into an intimate and lifelong friendship. Dr. Douglas, who later became associated with the celebrated Copper Queen Mine in Arizona, was at this time interested in the development of certain copper deposits in the Province of Quebec and with Hunt invented the Hunt and Douglas process for the extraction of copper by a wet method. This was described in a paper which appeared in 1871. Dr. Douglas read before the American Philosophical Society in 1898 an extended obituary notice of his friend Sterry Hunt, giving many details concerning his early life work which have been drawn upon in preparing the present memoir.

Dr. Sterry Hunt had an outstanding personality. He came of good stock and had cultivated his great natural abilities. Not only had he an intimate knowledge of those branches of science in which his work chiefly lay, but he possessed a wide general knowledge of the other natural and physical sciences. He had furthermore a wide acquaintance with literature and a highly cultivated literary taste. He had a peculiar charm of manner and was an excellent speaker and a brilliant conversationalist, conversations with him, however, generally passing into a monologue on his part, to which the other members of the party became interested and often delighted listeners. He always wrote and spoke with accuracy and, where the subject permitted, with elegance. He had a perfect command not only of English but also of the French language, speaking French readily and having a wide familiarity with French literature. The Abbe J. C. K. Laflamme, of Laval University, who knew Hunt intimately, in his presidential address to the Royal Society of Canada in 1892 writes of him "Il garda cependant toute sa vie un veritable culte pour la forme. On le constate facilement en parcourant n'importe lequel de ses ouvrages. La phrase est tonjours irreproachable et facile, souvent élégante."

He impressed the writer, who, when a student at McGill

University often met him, as a man of real genius; but if he was such it was not that "genius which is patience," according to Buffon's definition, for Hunt was somewhat impatient and sometimes even irritable in disposition. His mind, active and speculative, tended to pass rapidly from one great conception to another and would not brook the delay necessary to examine details which were often vital to the subject.

A characteristic which impressed many people unfavorably was his rather too frequent and definite insistence on priority for his many views and opinions. It is to be feared that, like some other great men, he possessed, together with other undesirable qualities, a certain amount of vanity in his disposition. Dr. Douglas in his memoir of Hunt, to which reference has been made, says of Hunt:

"His temperament was always distinctly religious. He went to Canada as a high-strung, imaginative boy, who had been brought up in the strictest school of Connecticut Congregationalism. In Montreal he was at once admitted into the inner circle of the French Canadian Society, which retained much of the culture and grace of the Ancien Régime, was devoutly Catholic, and was controlled by French ecclesiastics of great suavity, tact and intellectual acuteness. Under these influences Hunt adopted the Roman Catholic faith, and remained a devout son of the Church till after the breaking out of the war of Rebellion, when he abandoned the Church as openly and with the same courage and sincerity as he had shown in entering it, though in so doing he alienated some of his dearest friends. Whatever may have been his faults, cowardice and duplicity were not among them."

Hunt received many honors, degrees and decorations. The degree of M. A. was conferred upon him by Harvard University. The University of Cambridge, England, gave him the honorary degree of LL. D. in 1881, assigning to him while its guest, chambers in Trinity College near the rooms which had been occupied by Newton. It was under the inspiration which he felt on this occasion that he wrote his admirable essay "On Celestial Chemistry from the Time of Newton." Laval University conferred upon him the degree of LL. D. at its first convocation. He was elected a Fellow of the Royal Society of London in 1859, being the youngest man who up to that time had received this coveted distinction. In 1873 he was elected to membership in the National Academy of Sciences. He was also a Chevalier of the Legion of Honor and subsequently was raised to the rank of Officer.

After the Congress of Bologna, King Humbert decorated him with the Order of St. Mauritius and St. Lazarus. He took an active part in founding the Royal Society of Canada in 1882. Hunt was the first Chairman of the Section of Mathematical, Physical and Chemical Sciences and was elected President of the Society for the years 1884 and 1885.

Hunt remained a bachelor until late in life, but in 1877 married Miss Anna Rebecca Gale, who belonged to a very well-known family in Montreal.

In the early eighties his health began to fail and the last two years of his life were spent in his room at the Park Avenue Hotel, New York, or in St. Luke's Hospital. He, however, worked continuously till the very last and up to the day before he died spent several hours each day at his desk engaged in the preparation of a new book. During these last dreary months of confinement his chief solace was in tending his flowers and plants, in which he took a deep interest, not only as a well-trained botanist but as a lover of all things of beauty, having probably in mind the well-known words of St. Francis:

Laudato si, mi Signore, per sora nostra madre terra
La quale ne sustenta et governa,
Et produce diversi fructi con colorite fiori et herba.

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ABBREVIATIONS

A. A. P.—American Academy Proceedings.
A. C.—American Chemist.
A. N.—American Naturalist.
B. A. R.—British Association Reports.
C. & G. E.—Hunt's Chemical and Geological Essays.
C. G. S.—Canadian Geological Survey.
C. J.—Canadian Journal.
C. N.—Canadian Naturalist.
C. News—Chemical News.
C. R.—Comptes Rendus, Paris.
D. G. S. J.—Dublin Geological Society Journal.
E. & M. J.—Engineering and Mining Journal.
Erd. J. P. C.—Erdman Jour. Prakt. Chem.
Geol. Mag.—Geological Magazine.
I. M. E.—American Institute of Mining Engineers Transactions.
M. P. & P.—Hunt's Mineral Physiology and Physiography.
P. A. A.—Proceedings of American Association.
P. M.—Philosophical Magazine.
Q. J. G. S.—Quarterly Journal of the Geological Society of London.
R. S. P.—Royal Society Proceedings.
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EXTRA LECTURES

1866-1867.—Lectures on chemical and physical geography, delivered before the Lowell Institute, Boston.

1872.—Twenty lectures on chemistry, delivered before the Ladies Educational Institute, Montreal.

1874.—Six lectures on chemistry of the waters, delivered before the Boston Society of Natural History, Boston.

1875.—One lecture on the constitution of water as related to modern chemistry and physics, before Examiner Club.

1875.—One lecture on the glacial period, delivered before the Literary and Historical Society of Quebec.

1875.—Eighteen lectures on the practical Geology of the United States, Boston.

1876.—Eighteen lectures on elementary geology.

1876.—A course on the older rocks, before the Boston Society of Natural History.

1876.—The building of the earth, delivered in Salt Lake City.

1877.—Chemical history of the earth, before Chestnut Street Club.
1881.—Coal.
1883.—Twelve lectures on mineral physiology, before Lowell Institute.
1884.—The manufacture of iron, before Finance Club, Cambridge, Mass.
1885.—On Arbor Day, Montreal.
1886.—On the Alps, Liverpool, England.
1888.—Theory of volcanoes, Montreal.
1889.—Goethe and modern science, the Concord School of Philosophy.