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OF

SAMUEL FRANKLIN EMMONS

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SAMUEL FRANKLIN EMMONS.[a]

SAMUEL FRANKLIN EMMONS was born in Boston, March 29, 1841, and died at his home in Washington, March 28, 1911, lacking only one day to complete his seventieth year. He was the fifth child and third son of Nathaniel Henry Emmons, for many years a prominent and highly respected merchant of Boston, engaged in the East India and China trade.

His earliest known ancestor on his father's side was Thomas Emmons, whose name appears on the records of the Island of Aquidneck as aiding to found the Rhode Island Colony and later the town of Newport, from 1638 to 1641. He was admitted to be an inhabitant of Boston on March 29, 1648, one hundred and ninety-three years to a day before the birth of his lineal descendant, the subject of this memoir. On his mother's side his oldest known ancestor in America was Nathaniel Wales, of Yorkshire, England, who came to Boston in 1635 in the ship "James," sailing from the port of Bristol. All his American ancestors resided in Boston or its immediate vicinity. On the paternal side his grandmother was Hannah Franklin; his great-grandfather, Samuel Franklin, for whom he was named, was a cousin of Benjamin Franklin. His mother, Elizabeth Wales, was a daughter of Thomas B. Wales, well known for his activities in public and commercial enterprises and the first president of the Boston and Providence Railroad, one of the oldest railways in New England.

In his boyhood Emmons attended the select private school, held in the basement of the old Park Street Church, and in his twelfth year became a pupil in the then recently established Dixwell Latin School, and, as he said at the time, this was an event in his life, as he went there with the avowed intention of fitting for Harvard. Mr. Dixwell had the well-deserved reputation of being a gentleman of broad culture, of refined manners, and admirably qualified to prepare young men for college. Before opening his private school he had

[a] This memoir is revised and enlarged from a biographical sketch of Mr. Emmons, prepared by the writer for the Geological Society of America.

filled the position of principal of the celebrated Public Latin School of Boston. In addition to the prescribed courses to meet the requirements of college examinations, special attention was given to English composition, for which Mr. Emmons never ceased to be grateful. As he was well advanced in all preparatory studies, and in some of them belonged to the class that entered college a year in advance of his associates in school, he was given permission during his last year to take a special course in physical geography, a study which appealed to him; but what gave him particular pleasure was the construction of maps from memory without aid of instruments or field notes. It was an excellent training, both in the powers of observation and freehand topographical drawing. In later years, while engaged in exploration work in the Far West without maps, he realized that these boyhood studies stood him in good service. Every member of the class at the Dixwell School passed the final examinations without a condition. Many years later in life Mr. Emmons wrote: "I look back on Mr. Dixwell as the best teacher it was my lot to come in contact with. He had the power of inspiring his boys to love study for its own sake."

Emmons entered Harvard College in his seventeenth year and was graduated in 1861 with the degree of A. B. His class upon graduation numbered eighty-two, and though small even for that time, furnished its full quota of men who later occupied influential positions in the world and did their life work well, who were an honor to their university and to their classmates. Among them stood Samuel Franklin Emmons.

It is well worthy of note here that of the small number of those from the Dixwell Latin School who matriculated at Harvard, three of them later in life achieved wide reputation in the scientific world and were elected to membership in the National Academy of Sciences—Samuel Franklin Emmons, Henry P. Bowditch, and Charles S. Sargent. Bowditch and Emmons, lifelong friends from boyhood, served together as members of the Council of the Academy. They passed away within a fortnight of each other, and a few weeks before they would have taken part together in the semi-centennial anniversary of their graduation from Harvard. Justice Oliver Wen-

dell Holmes, of the United States Supreme Court, was also a classmate both in school and college.

Hon. Frank W. Hackett, formerly Assistant Secretary of the Navy, a college classmate, writes: "Emmons deserved praise for the fidelity with which he applied himself to his studies. He could always be depended upon as a man who was thoroughly prepared. His constancy in this respect won our admiration and esteem. I think he may be set down as one of the most diligent students of the class. In a word, it may be said that in his college course he was, with scrupulous care, laying the solid foundation of success in what turned out to be his happily chosen profession." All through his undergraduate career Emmons was active in college affairs relating to student life. He was fond of most athletic sports and took part in wrestling matches. His favorite recreation was rowing, in which he became proficient before entering college. He was a member of the Freshman crew.

Up to the time of entering college he had taken little interest in public or national affairs. Under the guidance of his classmate and warm friend, Wendell P. Garrison, later widely known as the literary editor of "The Nation," he began a course of reading on the issues involved in the slavery question. Among books which interested him was Helper's "Impending Crisis." Emmons joined the Sophomore Debating Society, known as the "Institute of 1770." Years afterward he said: "I got so interested in the national questions at issue in those days that I temporarily lost my painful self-consciousness and eagerly assumed the anti-slavery side in the debate, though it was unpopular among most of my classmates with whom I was intimate."

It is not out of place to recall here an incident in his college life. In the autumn of 1860 the Prince of Wales (Edward VII) traveled in America, and while in Boston visited Harvard. He was received on the campus with all college honors by the students. Each class turned out in full force with its own organization, but all under the direction of a chief marshal chosen from the senior class. During the reception the Prince expressed a desire to visit an apartment and see how the students lived. The Prince and his suite were taken to rooms

in Holworthy Hall occupied by Mr. Emmons and his cousin and classmate, Joseph Wales, greatly to the surprise of a company of young people gathered to witness the reception on the college green. In commemoration of his visit the room-mates hung a lithograph of the Prince on their walls, and upon graduation passed it on to the incoming occupants of the apartments. In 1886 Mr. Emmons, returning to Harvard on the twenty-fifth anniversary of graduation, found the likeness still on the walls, with the names of all those who had lived there since his time written on the back of the frame.

The seniors of 1861 had an experience which has fallen to the lot of no other class. The stirring events preceding the breaking out of the Civil War, followed by the election of Abraham Lincoln, created a profound interest in political and national affairs in the daily life of the students. Several of the class, including Emmons, organized a drilling club for military purposes, receiving instruction in Boston. The firing on the flag at Fort Sumter, April 12, and the subsequent attack of a mob in the streets of Baltimore on the Sixth Massachusetts Regiment on its way to aid in the defense of Washington aroused intense patriotic feeling. Intercollegiate sports, including the Yale-Harvard boat race, were abandoned, much to Emmons' disappointment, as he had given much time to his favorite exercise—rowing—and he had every expectation of handling stroke oar in the coming university race in June.

Events changed many matured plans. Several of the class, under special authorization of the faculty, were allowed to enlist in the army before graduation. Later many others volunteered, and no less than ten lost their lives in early manhood in the service of the Government. From purely patriotic motives Emmons earnestly desired to go to the war, but reluctantly yielded to the expressed wish of his parents, who were averse to his enlistment. A long-cherished ambition of the elder Emmons was that at least one of his sons should pursue a professional career. As Frank from boyhood had always shown the habits of a student, and was then completing a collegiate course, the choice naturally fell upon him, and as his own tastes led him to prefer an out-of-door life he began early to look forward to some form of engineering as a profession, although at that time he held no definite plans in mind. He

had suggested to his father that upon leaving college he should go to Europe for a three-years' course of study, but the parent at that time could not bring himself to agree to so long an absence.

In the spring of 1861, owing to the ill health of his mother, the family physician recommended for her restoration a summer trip to Europe. Probably because he was at that time the most available person to accompany her, and possibly because it took him out of the country during the early months of a disastrous civil strife, he was selected by the family to take his mother abroad. After passing creditably his final examinations, a few days previous to the closing exercises of the college, he sailed in June, on a Cunard steamer, out of Boston harbor for England, with his mother and a younger brother, who was nine years of age.

During the summer they made an extended journey, traveling as far as Switzerland, a country Emmons thoroughly enjoyed, having read with youthful enthusiasm while in college Tyndall's semi-scientific descriptions of glaciers and mountaineering in the Alps. Emmons himself did some good mountain climbing upon peaks which were at that time nearly untrodden ground. November found them in England, where he bade good-bye to mother and brother, who sailed for home. Emmons wrote: "Except for occasional blue spells that I was not with my classmates fighting for the preservation of the Union, my summer in Europe was an unending delight to me." Lingering for a while in London, December saw him again in Paris, bent upon some line of scientific work, but still undetermined in his own mind just where and what course to pursue.

It was his good fortune shortly after reaching Paris to make the acquaintance of the late Eckley B. Coxe, of Philadelphia, who was then a student at the École Impériale des Mines. It was an acquaintance which soon ripened into friendship lasting till the death of Coxe in the early days of a successful professional career. Emmons always regarded this meeting with Coxe as a turning point in his own life, and, acting upon the advice of his friend, he decided to prepare for the École des Mines. He found his college French totally inadequate for his purpose and his equipment for passing the required entrance examinations far from satisfactory. Settling down in the

Latin quarter among the students in the following February, he worked assiduously for nine months under private tutors, among other things going over the entire field of mathematics from arithmetic to differential calculus, without the use of text books, depending wholly upon verbal demonstration. In after life he alluded to this instruction as a masterly and brilliant course compared to anything in his previous student life. By good luck he was able to enter as a private pupil the chemical laboratory of the celebrated Prof. Adolf Wurtz, where he became sufficiently grounded in both chemistry and physics to enable him later to follow advanced studies in his scientific course.

In the autumn he entered the École des Mines as one of the few students enrolled in the class known as Éleves Externes, a privilege in those days granted only upon application of the foreign representatives of friendly governments, a privilege Emmons obtained through the courtesy of Hon. Wm. L. Dayton, the American Minister to France. Here Emmons worked industriously for two academic years, from November, 1862, to the summer of 1864. The faculty was regarded in Paris as an exceptionally brilliant one, but the two men who inspired the American student with enthusiasm were Élie de Beaumont and Daubrée.

At the close of the school year Emmons concluded that it would be more to his advantage to spend the last year of study in Germany than to complete the course in Paris. Two considerations influenced him: the one was that the practical side of mining engineering was taught more in detail at Freiberg, and the proximity of the mines to the town rendered access to the works far more convenient. The other was a desire to learn something of the German school of geology. Leaving Paris, he entered the Bergakademie at Freiberg, Saxony, in the early summer of 1864, in time to take the practical course of underground work in the mines, and also to familiarize himself with the language before lectures began in October. He remained in Freiberg till midsummer of 1865.

From Heidelberg, where I had devoted most of my time to chemistry and mineralogy in Bunsen's laboratory, I reached Freiberg in the spring of 1865, meeting Frank Emmons for the first time. His greeting was very cordial, and he gave me

much kindly advice based on his longer experience in the Bergakademie, advice which I found most valuable. Although he intended to follow the profession of a mining engineer, he devoted relatively little time to mechanical engineering, while I was always ready to lay aside metallurgical studies for field geology. Together we took all the week-end excursions with dear old Bernhard von Cotta, visiting many parts of Saxony and studying petrology as laid down in that now antiquated text book, Cotta's "Die Gesteinlehre" (Zweite Auflage, 1862). Many an evening Emmons and I spent together over the map of Saxony, acquiring our initiative experience in geological cartography, which later stood us in good service. Both came to realize the influence of Cotta upon our future careers, as he gave us much of his time. In this way, during these few months of German student life, was formed a friendship, which always endured. Emmons left Freiberg in mid-summer and traveled through parts of Europe, visiting many of the important mining centers. He spent the winter in Italy, making Rome his headquarters, and returned to Boston in June, 1866, after an absence of five years.

I returned to my home in Boston in December, 1866. A few weeks later, while in New York, I was offered a position as assistant geologist on the Geological Exploration of the Fortieth Parallel by my former fellow-student at the Sheffield Scientific School of Yale, Mr. Clarence King. Mr. King was then passing the winter in Washington, endeavoring by his individual efforts, aided by influential members both in the Senate and House of Representatives, to obtain the necessary legislation for carrying out the purposes of the expedition. The authorization was enacted by Congress without the customary delays. At the suggestion of Mr. King the official direction of the expedition was placed under the Chief of Engineers, Gen. A. A. Humphreys, notwithstanding that field work was to be carried on entirely by a civilian service. Mr. King was placed in full charge of the work and authorized to draw up a plan for the organization of the expedition, which he immediately proceeded to do, and which received the official sanction of his chief. On my return to Boston I sought out my friend Emmons, told him of the offer I had received, and

my acceptance of the position. He replied: "That is just the kind of work that would suit me. I heartily congratulate you." Shortly afterward I brought King and Emmons together, with the result that Emmons accepted a position as volunteer assistant, and in the following winter received an official appointment as assistant geologist, much to the gratification of all members of the organization.

On May 1, 1867, several members of the scientific corps, including Emmons, sailed from New York for San Francisco by way of the Isthmus of Panama and the Pacific mail steamer, along the coast of Mexico and California, the trip occupying three weeks. At that time the only other available route was by Wells, Fargo & Company's overland stage—a tedious, not to say dangerous, journey. After a delay of several days in San Francisco, gathering information of various kinds, including geographical data along the proposed line of the Central Pacific Railway across Nevada and Utah, a camp was established at Sacramento for equipment purposes. A ride of a few days across the high Sierras and down its eastern slope brought the party, early in August, to its first working camp on Truckee River, not many miles from the now flourishing town of Reno.

This ride over the Sierras followed a traveled route, but its physical and geological features were little understood. It was a glorious ride, the highway to the desert. All the party enjoyed it, but no one more than Emmons, who was full of youthful spirits and manly exhilaration over the work before us.

The first headquarter camp was pitched on what was then the western edge of the great American sage-brush desert, sparsely inhabited by a few frontier settlers expecting to become rich when the railway came along. There were practically no serviceable maps, and but slight knowledge of the country by those who lived in it except along the line of the overland stage route.

The first exploration work began along the California State line in the region of Pyramid and Winnemucca lakes. Some idea of the unsettled condition of things may be gathered from the fact that the party was frequently dependent upon information obtained from friendly Pah-Ute Indians. Much time was consumed in searching for water away from such streams

as the Truckee, Humboldt, and Carson rivers. Today it may seem difficult to realize that it was deemed essential by the War Department to provide a cavalry escort of twenty-five men to guard life and property. Not infrequently a mounted soldier accompanied a geologist when it was considered unsafe for any one to be quite alone on the mountains. Under such conditions the work from necessity took on more the nature of a reconnaissance than a survey.

The exploration as originally planned by Mr. King, modified by later experience and needs of the country, called for a survey of an area stretching from the Great Plains of Wyoming and Colorado over the Rocky Mountains, across the Salt Lake region and the desert valleys of Nevada, westward to the eastern boundary of California, determined by the 120th meridian from Greenwich. The proposed route of the first transcontinental railway was always included within the territory examined. This comprehensive plan called for a topographical map 100 miles in width, on a scale of 4 miles to the inch, based upon a system of primary and secondary triangulations, the elevations to be determined by a series of careful and frequent barometric readings, referred to a well-established main camp and checked by instrumental readings, by the railway from ocean level, across the Sierras, and thence along the Humboldt River. On these topographic maps geology was to be laid down. It should be borne in mind that such finished maps were seldom in the hands of the geologists till a year after completion of field work.

In addition to the corps of geologists and topographers, the party included an ornithologist, botanist, and, what was at that time an unheard of innovation, a skilled photographer. Under existing conditions, due in part to the large areas to cover in the limited time at our disposal and the lack of adequate funds to do the work commensurate with the standard of excellence desired, geology and topography were compelled to go hand in hand. Two well equipped organizations were constantly in the field during the summer and autumn, serving in quite separate areas, one known as the Emmons party, the other as the Hague party. Mr. King had his own camping outfit, dividing his time beween one or the other party, or else, as was usually the case,

conducting special investigations, such as the search for possible coal fields, and occasionally visiting areas outside the broad belt of exploration. Not infrequently both parties came together to talk over the complexities of geological problems. For instance, Emmons and I agreed regarding the front face of the Wasatch Mountains; King at first dissented from some of these conclusions, but was finally won over to our point of view. Again, Emmons and I disagreed on some structural problem connected with the Uinta Mountains. After much discussion King sided with Emmons, and the geology was represented on the maps in accordance with this decision. In this instance I declined to agree with them.

The short season of 1867 was devoted exclusively to western Nevada, in what was generally referred to as the Humboldt country, from the river of that name, whose principal tributaries had their sources on the Nevada plateau. The following year carried the survey across the remaining Great Basin ranges as far as the mountains bordering the western edge of Salt Lake Desert.

In 1869 the third season of field work was mainly confined to the desert ranges and the intervening arid valleys bordering the lake region, together with the imposing and strongly contrasted Wasatch Mountains. The year was signalized by the coming together of the Union Pacific and Central Pacific roads, one from the Missouri and the other from the Sacramento, the connecting rail with its silver spikes being laid just north of Great Salt Lake. In a sense it was an inspiration, as the practical reason for our work, as expressed in Congress, was to make known the natural resources of a country to be opened by a transcontinental railway communication. At all events it greatly facilitated the operations of the geological exploration. From the Wasatch eastward the belt of exploration traversed the elevated Mesozoic and Tertiary areas of Utah and Wyoming, crossed the relatively low divide separating the drainage of Green River from that of the North Platte, and, continuing eastward, included the Laramie plains, the northern extension of the Front Range, and the inclined slopes east of the mountains. It embraced a broad belt across the northern Cordillera. Mr. Emmons gave his attention mainly to geo-

logical problems connected with Green River Basin and to the Uinta Range and its dependencies. Field work was finally completed in the late autumn of 1872.

An illustration of Emmons' technical knowledge of the physical features of a country he had examined is well shown in the expedition undertaken by Clarence King in the autumn of 1872 to locate the recently reported new diamond field. The locality was kept a profound secret, although stock in the company was being liberally subscribed for in San Francisco. There was also good reason to question the genuineness of the discovery. In San Francisco it was the popular belief that the precious gems came from Arizona.

Mr. King was able to gather a few general facts about the supposed diamond field. He shrewdly suspected that the chosen locality was somewhere in western Wyoming, in an arid region south of the Union Pacific Railroad. The projectors of the swindle, who had visited the locality and carefully "salted" the ground with small diamonds and rubies, had left the railway at one station and returned to it at another still farther eastward. At that time, it will be remembered, there was but one transcontinental railway. These and a few additional facts induced Mr. King to search for the land of untold riches. Primarily he was impelled to seek the hidden treasures from the fact that he was unwilling to have such a source of wealth within the belt of exploration and know nothing of its occurrence and value. Equipping a small party, under the direct guidance of Mr. Emmons, the bogus diamond field was located on a small stream flowing into Vermilion Creek, a tributary of Green River. The precious gems were found sparsely scattered over the ground, presumably having been brought to the surface by the industrious ants, whose enormous heapings of fine gravel carried both diamonds and rubies. Mr. Emmons noted the fact that each diamond discovered was always associated with the same number of rubies. It was clearly evident to all members of the party that wherever a diamond was found the ground had been tampered with only a short time before. Clarence King returned to San Francisco. "The diamond swindle of 1872" was exposed and many thousands of dollars saved to the "get-rich-quick" investors. Mr. King, very properly, was highly

commended for his achievement. In the opinion of the writer, the success of the expedition was in great measure due to the expert knowledge and skill of Mr. Emmons.

An important investigation outside the belt of the Fortieth Parallel exploration, in which all the geologists were engaged, included visits to Mount Shasta, Mount Rainier, and Mount Hood, the primary object being a comparative study of the lavas of the volcanoes with the Tertiary igneous rocks of the Great Basin and incidentally also an examination of glacial phenomena. The latter proved to be both instructive and important. Active glaciers were found on all three mountains, being the first authentic discovery of typical glaciers within the United States.

Mr. Emmons climbed Mount Rainier, at that time a difficult ascent, the top having been reached only once before, and that earlier in the same summer. Mr. King spent several weeks on Mount Shasta, while the writer ascended Mount Hood, studying its glacial system. Several years later Mr. Emmons delivered a popular address on "The Volcanoes of the United States Pacific Coast" before the American Geographical Society, which was published in the Journal of the Society.

The first winter (1867-1868) after the inauguration of the work on the Exploration of the Fortieth Parallel was spent in Virginia City, in a study of the Comstock Lode and the geology of Mount Davidson and the adjacent country, situated just south of the southern line of the area of exploration. In successive years winter quarters were established either in San Francisco, Washington, or New Haven. After the completion of field work the offices for the final preparation of the report, with its accompanying atlas, were located in New York. Here Mr. King and his two colleagues worked together and lived together in ties of closest friendship.

In the first volume of the report issued, but volume III of the published series, Mining Industry, will be found a chapter by Mr. Emmons on the "Geology of the Toyabe Range," accompanied by a map of those isolated mountains, which extend in a north and south direction for over 60 miles, and at that time already well known for their silver deposits. Austin, in the northern end of the range, the headquarters for mining activity

in that region, was then the most important town in central Nevada. The same volume contains a shorter but characteristic paper entitled "Geology of the Egan Cañon District." Both contributions are of interest as being his first scientific publications on mining geology. In his field work he endeavored to visit every locality where silver and lead ores were reported, yet it was characteristic of the man that he invariably began his examination of such localities by a study of their geological features before taking up the occurrence of any ore bodies.

Emmons' great work, so far as the exploration of the Fortieth Parallel is concerned, will be found in the report on the Descriptive Geology, volume II of its publications. The entire report is the work of the two assistant geologists. It was presented to Mr. King in January, 1877, and by him transmitted, the same month, to Gen. A. A. Humphreys, Chief of Engineers, U. S. A., who was also one of the founders of this Academy. This volume, containing 890 pages, was printed by the close of the year and issued soon after. In it is a description of the country, treated geographically, beginning on the Great Plains and progressing westward across the widest part of the northern Cordillera. An endeavor is made to give the structural details and salient geological features lying between the meridian 104 degrees west and the meridian 120 degrees west, the latter being the eastern boundary of the State of California. The volume of atlas maps upon which the early geology was laid down, including the accompanying geological cross-sections, bears the imprint of 1876. A few advanced sheets, showing the geology of the Uinta Range, were distributed by Mr. King several months in advance of publication, as certain structural features were already a matter of discussion. Nearly all the great divisions of geological time are represented on the atlas sheets, and in volume II are described with more or less detail. In this volume the term Laramie formation is used in geological literature for the first time. The necessity for a formation name for a great series of beds covering many hundred square miles in area was readily recognized. The name was suggested by one of the authors of the volume and warmly indorsed by Mr. King, provided it would be acceptable to Dr. Hayden, who had, of course, observed the formation at a number of localities in

the Rocky Mountains. Dr. Hayden cordially agreed to the adoption of the term Laramie. During the last thirty years probably no geological horizon has been more discussed from many points of view, with all the accumulated evidence brought to bear upon the study of this series of beds.

Throughout all these years, in field and office, Emmons worked assiduously and with unfailing enthusiasm. Upon the completion of the Descriptive Geology, after ten years of service, Emmons resigned his position to give attention to personal matters. Among other things he engaged actively in cattle ranching, and for some time made his home in Cheyenne, Wyoming.

The act of Congress creating the Bureau of the Geological Survey and placing it under the Department of the Interior was approved March 3, 1879; three weeks later the President nominated Mr. Clarence King as its first director; on April 3 the Senate confirmed his nomination, and on May 24 Mr. King took the prescribed oath. By this legislation all existing surveys and exploring parties ceased to have congressional authorization.

It is not out of place to record here that the establishment of the Bureau of the Geological Survey was in large measure due to the action taken by the National Academy of Sciences in response to a request from Congress in the following clause: "The National Academy of Sciences is hereby required at their next meeting to take into consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Departments and the surveys of the Land Office, and to report to Congress as soon thereafter as may be practicable a plan for surveying and mapping the Territories of the United States on such general system as will in their judgment secure the best results at the least possible cost, and also to recommend to Congress a suitable plan for the publication and distribution of the reports, maps, and documents, and other results of said survey." The matter was referred to a special committee, whose report, after its adoption by the Academy, was transmitted to Congress by its President. The organic act creating a Geological Survey as a Bureau of the Department of the Interior followed closely the methods and

suggestions proposed by the Academy. The great value of this legislation and its far-reaching consequences are now apparent to all interested in the scientific work of the Government.

One of Mr. King's first official acts was to secure the experienced services of Mr. Emmons, and on August 4 of that year appointed him geologist in charge of the Rocky Mountain division, with headquarters at Denver. The first two lines of his instructions read as follows: "You will devote the first years of your administration of your division exclusively to a study of the mineral wealth of the Rocky Mountains." In accordance with these instructions he was requested to prepare, without delay, a monograph on the Leadville mining region of Colorado. The Geological Survey having undertaken the collection of the statistics of the precious metals in connection with the Tenth Census, the work was placed in charge of Mr. Emmons and Dr. G. F. Becker, who were authorized to prepare the statistical schedules and to employ the necessary staff of assistants. The men whom they selected were for the most part mining engineers. The results of the work were published in volume XIII of the series of Census reports. A feature of the volume is the publication of geological descriptions of the more important mining regions, and Mr. Emmons gives, for that time, an admirable chapter entitled "Geological Sketch of the Rocky Mountain Division," which can not be ignored by any one interested in the physical geology of Colorado.

Notwithstanding the time required for the Census volume, Emmons devoted the greater part of his personal attention and energy to the Leadville monograph. He brought to the task a well-trained mind and the exceptional experience of ten years on the Fortieth Parallel Survey; indeed, the monograph shows the influence of the earlier work and his method of thought. Nowhere is this more clearly shown than in his decision to acquaint himself with the geology of the Mosquito Range before taking up such intricate problems as the ore deposits undoubtedly presented. He felt he might be led into error or fail to grasp essential phenomena of ore deposition unless familiar with the structural features of the adjacent country. This mental attitude of Emmons has been well brought out by Whitman Cross, his field assistant and daily companion at Leadville.

Emmons conquered in a masterly way the details of the complex ore bodies, and he undertook to solve no problems until he assured himself that he knew his ground. Even as early as the autumn of 1880, in his report to the Director of the Survey, he presented many essential features of the region. An abstract of the monograph on the geology and mining industry of Leadville, accompanied by an admirable geological map, was published in the Second Annual Report of the Director, and served to meet the needs of the engineers working on the ground. The monograph itself, however, was held back for finishing touches and the results of chemical investigation, although the method of presentation and final conclusions remained essentially the same.

The monograph and atlas, containing 35 sheets of maps and sections, appeared in 1886. It attracted immediate attention not only of geologists and practical mine workers, but of all classes of scientific men. It won for its author an international reputation, being received both in America and Europe as a work of the highest order. Since its organization, probably no single publication of the Geological Survey has exerted a more beneficial influence and stimulated more discussion. It everywhere aroused investigation of the origin of ore deposits, and similar studies were prosecuted elsewhere throughout the northern Cordillera. The volume became a model for younger economic geologists. One thing which greatly aided the success of the monograph was the masterly, orderly way in which the author arrayed his facts, and the clear, concise English in which they were presented. After twenty years of active mining operations at Leadville and the exploitation in many directions of new ore bodies, Mr. Emmons, aided by Mr. John D. Irving, renewed his investigations, with the intention of bringing the earlier work up to date. Under the title of the "Downtown District of Leadville, Colorado," a few of the more salient features of this re-examination, with the light thrown by new discoveries, were issued as a bulletin of the Geological Survey in 1907, both names appearing as joint authors. The final publication of a revised monograph has been delayed, partly because of the failing health of Mr. Emmons and in part because the greatly increased development of mine workings has made

the construction of maps and sections far more laborious than was the case in the early days, when shafts and workings were comparatively few.

The sudden death of Mr. Emmons occurred before the monograph was finished. Fortunately, as the maps and sections by Mr. Irving were already well under way, it should be possible to publish them without much further delay. It is surprising to what extent Mr. Emmons' early interpretation of the structural features of the Leadville district have been borne out by the later developments, for only in the more complicated portions of the district, such as Breece Hill and East Fryer Hill, have any essential modification of his views been found necessary.

Mr. Irving tells me that Mr. Emmons left no finished manuscript stating his recent views with regard to the origin and genesis of the Leadville ores, so that we have no written record of the changes in his theories of ore deposition. He had, however, freely and often discussed the question of genesis with Mr. Irving in its many details. Mr. Irving writes me that "Mr. Emmons felt the influence of the recent tendency to ascribe the origin of the ores to the action of eruptive rocks. His original views as to the circulation of waters along contacts of limestone and porphyry suffered no modification, but he inclined to the belief that such waters were in part, if not wholly magmatic and not derived from surface or meteoric circulation."

During the following years of Emmons' active duties most of his important contributions to geological science were issued as official documents of the Geological Survey. As they are accessible to all, and the titles are found in the list of his scientific writings appended to the biographical sketch, it seems unnecessary to mention them all, considering the limited space available. They appear in one or another of the many forms of publications adopted by the Government Bureau. Several of them were published as descriptive texts accompanying folios of the Geologic Atlas. Many of these writings are of the highest value and bring out his power of presenting geological details in a lucid, simple style. In some of these he was the sole author, while in others he shared with his assistants

the preparation of the text. Among them may be mentioned a characteristic chapter on "The geology and mineral resources of the Elk Mountains," a rugged region in western Colorado, famous for the complexities of its structural problems and well known for its mineral wealth (Folio No. 9, 1894). Another area in Colorado, known as "The Ten-mile District," was described in detail and illustrated by a remarkable series of cross-sections. In this instance the explanatory text was written entirely by Mr. Emmons (Folio No. 48, 1898). In "Economic Geology of the Butte District," which appeared in the Butte Special Folio (No. 38, 1897), the fissure system is divided into typical fissure veins and replacement veins, with a discussion of the distribution of ores and ore deposition. In the Tintic Special Folio (No. 65, 1900) Mr. Emmons publishes only general conclusions upon ore deposition based on an array of facts presented by the authors of the folio, George Otis Smith and George W. Tower. In a few paragraphs he treats of the manner of fissuring and both contact and cave deposits. He regards the caves as the result and not the cause of ore deposition. The above publications are careful investigations upon widely separated mining areas in Colorado, Montana, and Utah.

To the annual reports he contributed a number of articles, among them an exhaustive one entitled "Mines of Custer County, Colorado," which appeared in the seventeenth report, published in 1896. In the same year there was issued from the press the well known and elaborate monograph on the "Geology of the Denver Basin," a volume devoted to structural problems of the broad region of country lying east of the Front Range, a work in striking contrast to Mr. Emmons' more recent contributions in the line of economic geology. In this volume he is aided by his two principal assistants in Colorado, Mr. Whitman Cross and Mr. George H. Eldridge, who furnished a large part of the text. In the series of Professional Papers published by the Survey may be found articles from Mr. Emmons' pen, serving as introductions to the work of younger men, upon mining districts in the far West.

Notwithstanding the fact that administrative duties occupied so large a share of his time, Mr. Emmons was able to con-

tribute to scientific journals and societies on a wide range of geological subjects, including dynamic problems, orographic movements, and the many phases of the genesis of ore bodies. In this connection it is only necessary to mention his papers and discussions on Secondary Enrichment of Ore Deposits, which appeared from time to time in the Transactions of the American Institute of Mining Engineers.

Mr. Emmons' keen interest in the geological and structural features of mining areas outside of this country is shown in his paper on the "Geological Literature of the South African Republic," printed in the Journal of Geology. Within a few months of his death he published articles on the Cananea Mining of Sonora, Mexico, and the Cobalt District of Ontario, both of which he had personally carefully studied. His last paper, entitled "Criteria of downward sulphide enrichment," will be found in Economic Geology, volume 5, an article closely related to his earlier contributions on the secondary enrichment of ore deposits.

In strong contrast to these technical papers is his loyal and sympathetic tribute to his old and dear friend, Clarence King, in the biographical memoir read before the National Academy of Sciences.

As early as 1874 Mr. Emmons was made a fellow of the Geological Society of London, and at the time of his death was one of the oldest members in this country. Throughout this long period he always kept himself in touch with its publications, especially contributions which treated of the geology of unexplored parts of the world. He joined the American Institute of Mining Engineers in 1877, took an active part in its proceedings and discussions, and was elected three times as one of its vice-presidents. He was one of the founders of the Geological Society of America, and chosen its president in 1903, delivering, on retiring, a notable presidential address on "The Theories of Ore Deposition Historically Considered." At the time of his residence in Denver, while in charge of the geological work in Colorado for the United States Geological Survey, he aided in the organization of the Colorado Scientific Society, and was elected its first president in 1882. The society now ranks among the most active scientific bodies in this coun-

try. In 1892 he was elected to membership in the National Academy of Sciences. He was also a member of the American Academy of Arts and Sciences, the American Philosophical Society, the Washington Academy of Sciences, and the Geological Society of Washington, of which he also served one term as president. He was an honorary member of the Société Helvétique des Sciences Naturelles. He received the honorary degree of Doctor of Sciences from his Alma Mater, Harvard University, and from Columbia University in 1909.

The fifth session of the Congrès Géologique Internationale met at Washington in the summer of 1871. Mr. Emmons ably filled the position of general secretary, which was in no sense a sinecure, requiring months of arduous work, as a large share of the responsibility for the success of the congress fell upon his shoulders. The conditions for such meetings in this country were essentially different from those in such European capitals as London and Paris. Ever afterward he took an active interest in similar congresses, and, attending several of them as delegate from America, served as vice-president at St. Petersburg in 1897, Vienna in 1903, and Stockholm in 1910, taking part in many of the more important geological discussions specially organized for the different congresses.

During his whole life Mr. Emmons' personal appearance had distinction; tall, erect, and slender, his carriage was graceful and unstudied. In the early days of his out-of-door professional work he was extremely active and alert. While he may have had a certain enjoyment in the pursuit of large game, he always seemed to prefer a long-range shot, perhaps at a rabbit in the sage-brush or a grouse in the pine timber. It was the exactness and finish of the shot, rather than the bagging something, that he cared for. A good mountain climber, he disliked a long walk on level ground. While in Leadville he wrote to a friend: "I fear boyish exuberance has left me, but keen zest for field work is as strong as ever." The probable explanation of this attitude can be traced to the fact that mental effort and physical exercise had to go together, and before long the sense of responsibility, which was always a strong characteristic, got the better of enjoyment of mere bodily exhilaration.

During the thirty years of his active service in the Geological Survey he gave to it a thoroughness and lofty devotion. If he demanded high standards of scientific work from those with whom he was associated, he afforded an example by maintaining them himself. While in charge of the division of economic geology he gave personal supervision to the investigations of others, and never wearied in aiding younger men, training them in methods of work, even advising them as to the form of recording their notes. He always sought to inspire them with love of research for its own sake. He often said, in the kindliest way, of young men fresh from the technical schools: "They have excellent powers of observation, but their English is wretched." They all loved Mr. Emmons and kept for him their appreciation and respect, and he cared very much for their affectionate regard. Under a somewhat indifferent manner he had a warm and tender nature. His closest friends, those of a lifetime, never knew him to be guilty of an unworthy action, and if he ever cherished a resentment it was not without good cause. He was always ready to discuss differences of opinion in a cool, dispassionate way, showing a desire to get at the truth rather than to carry his own point. He was charitable and modest, while preserving with proper dignity the high professional and personal position he had so honestly earned for himself. He was domestic in his tastes, but no recluse. His friends have the happiest remembrance of his refined hospitality, and his associates of the National Academy of Sciences can never forget his eagerness to enjoy the privilege of entertaining them during their annual meetings in Washington. He left a widow, but no children.

His later days were, it is to be feared, full of patient endurance of physical pain—it was patient endurance—but he worked all the time and was kindly and gentle always. The younger men of his profession may not always have realized how helpful he had been to them until he could help them no more. His oldest friends, with whom he had built up his character, as well as his professional standing, grieved for him most because they knew him best. There were many of these friends all over the world, but none were so close as the few with whom he worked as a young man.

While for a long time Mr. Emmons had been in failing health and his condition the cause of anxiety to all, the final end came as a surprise to family and friends. He passed away in peaceful, restful sleep during the early hours of the morning. He left a noble record of life's work well performed.

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