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JOSEPH PAXSON IDDINGS

1857—1920

A Biographical Memoir by

H.S. YODER, JR.

Biographical Memoir

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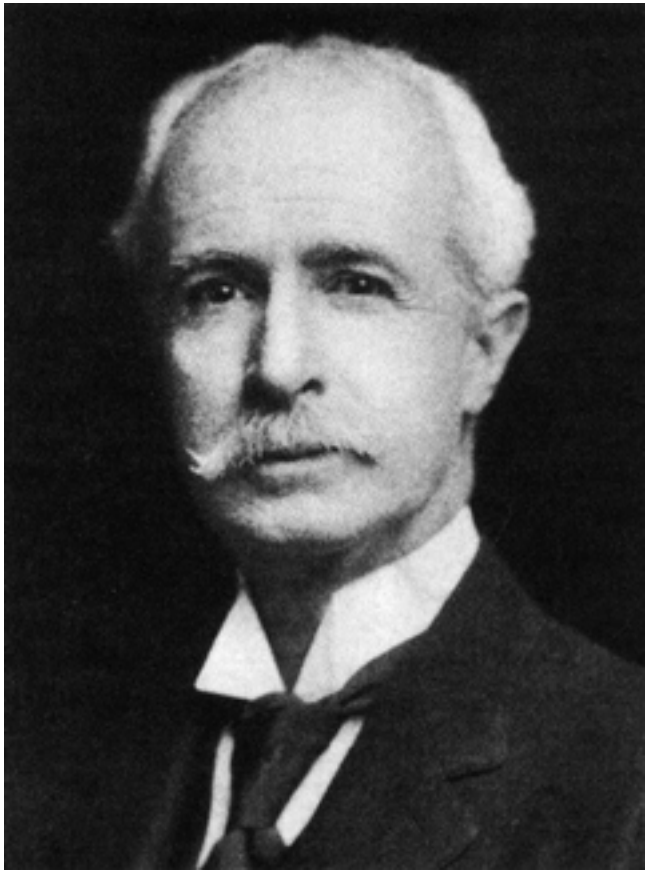

Jos. P. Addicks

JOSEPH PAXSON IDDINGS

January 21, 1857–September 8, 1920

BY H. S. YODER, JR.

JOSEPH PAXSON IDDINGS WAS an outstanding leader of petrology widely cited at the turn of the twentieth century, although little known to the present generation of petrologists. He was one of a small group to introduce, about 1880, the microscopic investigation of rocks to the United States and apply the petrographic observations to the then-new inquiry of the origins of rocks called petrology. His fading into the history of science can be attributed no doubt to his gentlemanly, retiring nature and his early withdrawal from the academic and societal scene. Nevertheless, Iddings's record of discovery, both observational and theoretical, initiated many of the ideas that served the more heralded petrologists who followed him. Those ideas, for which he was reluctant to claim originality, were "established or improved by subsequent research."

The writing of Iddings's biography was originally assigned to his lifelong friend, C. Whitman Cross, to whom he had given his autobiographical manuscript, "Recollections of a Petrologist," for editing and publication. Unfortunately, Cross died (in 1949) before a biography could be prepared or the autobiography published. Iddings's manuscript, dated

March 19, 1918, was not among the papers retained by Cross's namesake grandson but was discovered by Carol A. Edwards in the Field Records Library of the U.S. Geological Survey in Denver. The present memoir was undertaken before the writer was alerted by Dr. E. L. Yochelson of the availability of the autobiography. The principal incentive resulted from a renewed appreciation while investigating the history of petrology[1] of the vital role Iddings played in developing the quantitative aspects of petrology.

Joseph Paxson Iddings was born in Baltimore, Maryland, the second son of William Penn Iddings (1822-1906) of Philadelphia and Almira Gillet (1826-96) of Baltimore. His father was a wholesale dry-goods merchant (1900 census). His grandfather was Caleb Pierce Iddings (1778-1863), who built the family estate in 1855 in Brinklow, Maryland, where Joseph later lived. The genealogy of the Iddings family has been established through five generations and is available in open file at the Montgomery County (Maryland) Historical Society in Rockville. Caleb Pierce Iddings was a Quaker but was "disowned" for marrying "out of the unity." For this reason there are no Quaker records in Philadelphia of the family after 1812, the date of Caleb's marriage. Joseph was named after the husband, Joseph S. Paxson (1814-89), of William's older sister, Deborah J. Iddings (1815-77).

EDUCATION

After a brief stay in New York City, Joseph Iddings's father established a home in Orange, New Jersey (100 High Street) when Joseph was about ten years old. With the preparation at the private school of Rev. F. A. Adams, Iddings registered for the civil engineering course at the Sheffield Scientific School of Yale University. His father had recommended that he become a mining engineer in light of

Joseph's early interests in collecting rocks and butterflies. According to the records of his class of 1877, he was treasurer of the Yale Football Club, recording secretary of the Yale Society of Natural History, and class treasurer. In his freshman year, Iddings divided a prize for German, a skill that was to prove especially useful to him. In his junior and senior years, respectively, he received prizes in mathematics and civil engineering. He participated in the Alpha Chi, Phi Gamma Delta, and Berzelius societies.

Following graduation at which he was a commencement speaker, Iddings spent the next year at Yale in graduate studies in chemistry and mineralogy. He also assisted in courses in mechanical drawing and surveying, but it was the ongoing study of George Wesson Hawes (1848-82) on thin sections of New Hampshire granites that attracted his attention. The academic year of 1878-79 was spent at the Columbia School of Mines in New York City under the tutelage of John S. Newberry (1822-92). In late spring Iddings abruptly changed directions toward geological research as a result of the influence of the enthusiastic Clarence King, who had lectured at Yale; the fascinating microscopic work of Hawes; and a general loss of interest in mining as a profession. In the fall of 1879, on the recommendation of G. W. Hawes, who was then studying in Heidelberg, Iddings became a student of Karl Harry Ferdinand Rosenbusch (1836-1914), the most outstanding petrographer of the day. This opportunity arose while Iddings was awaiting a response to his application to the newly formed U.S. Geological Survey under the directorship of Clarence King. During July 1879 he learned that his young pastor, Joseph A. Ely of the Orange Valley Congregational Church, was to tour the Swiss Alps, and it seemed a golden opportunity to see spectacular geology in his company and then spend the winter with Rosenbusch. His experiences under the enthusiastic

Rosenbusch resulted in Iddings setting a course for a career in petrography.

CAREER COURSE DETERMINED

His three-week tour in the Alps, two months of private language study, and five months with Prof. Rosenbusch were recorded in great detail in his diary and letters to his family. These were summarized with considerable literary style in his autobiography. Iddings's reception of the first lecture in German from Prof. Rosenbusch is especially descriptive:

> It is a positive pleasure now to hear him lecture, to listen to him roll off those long, and to us, complicated sentences; here and there throwing in a phrase in parentheses, which is rendered like lightning; and then the whole wound up with a string of participles and infinitives that have a most pleasing effect, when someone else has to get them off. It's like watching the development of some great piece of fireworks. It is certainly a complicated language. You can see how he has to figure out his cases and endings, and have everything in his mind's eye before he begins his sentence. Sometimes he may want to change the number or case of his noun, after he has gone on for some time qualifying it with innumerable adjective phrases.

The lectures and almost private laboratory sessions with Rosenbusch had great impact on Iddings and significantly influenced the course of his future career in petrography. Although King had recommended Prof. Zirkel in Leipzig over Rosenbusch as a tutor, Iddings stayed in Heidelberg. Had he gone to Leipzig he would have met C. Whitman Cross, who became his lifelong friend several years later. Iddings's friendship with Rosenbusch continued for many years until their "views diverged seriously and correspondence ceased." In Rosenbusch's instruction, emphasis had been placed on mineral composition and rock texture with little reference to chemical composition, a factor Iddings eventually believed was dominant. This view no doubt arose from his close association with Samuel Lewis Penfield, a

classmate at Yale, who was then doing graduate work on chemical mineralogy under Prof. George Jarvis Brush. There was "little or no discussion of the origin and mode of eruption of igneous rocks" and nothing on the physical chemistry of magmas. Nevertheless, Iddings was captivated by the study of rock thin sections, presented with great enthusiasm by Rosenbusch. He was indeed impressed by the beauty of the colored minerals and especially the brilliancy of their interference colors, which he related to the colorful stained glass in the windows of his church.

"HIGHEST EXPECTATIONS"

Iddings had the good fortune to arrange for his return to the United States on the same ship as Arnold Hague, who was returning from studies in China. Hague was to be his first supervisor at the U.S. Geological Survey, his appointment having been secured by mail through Clarence King. By obtaining a position in the USGS[2] Iddings hoped to realize his "highest expectations." During May and June of 1880, he worked as a temporary assistant to Hague at the American Museum of Natural History in New York, where King had "temporarily" stored the rock collections from the 40th Parallel Survey.

Iddings's next assignment with Hague took him to the mining district around Eureka, Nevada, where he mapped igneous rocks. There he shared a tent with Charles D. Walcott, who was later to become director of the U.S. Geological Survey, also assisting him in collecting fossils. As a result of his first field efforts, Iddings developed a very cautious attitude toward naming a rock, especially one where crystals could not be identified by eye. An ideal outcrop of granite with off-shooting dikes led him to think that rock texture was governed by the physical conditions attending solidification. It was twelve years after the fieldwork was completed

before his microscopical petrography of the rocks from the Eureka District was published by Hague (1892) as Appendix B. A printed note dated November 1893 that was glued to the first page of the monograph expressed Iddings's dismay over the delayed publication and also the fact that this was "a production of the first year of the writer's work in this field of research, and as such needs no apology." In this appendix the term "phenocryst" was introduced[3] to describe the megascopically visible crystals in a fine-grained groundmass of a porphyritic rock, but the term appeared in print earlier (Iddings, 1889). Iddings's part of the monograph is also noteworthy for the method by which he determined the composition of feldspars, a method that was attributed to A. Michel-Lévy[4] more than ten years later. He also provided strong evidence for the gradational change in composition of the plagioclases—first proposed by T. Sterry Hunt[5] and later attributed to G. Tschermak[6]—a major concept to which he eventually contributed to its experimental demonstration (Iddings with Day and Allen, 1905). In addition, Iddings described a "red laminated mineral," a common alteration of olivine that was later described as "iddingsite" by Lawson.[7] The alteration process became known as "iddingsization."[8]

Before returning to the U.S. Geological Survey offices at the American Museum of Natural History in New York, Iddings spent a week with George F. Becker examining the volcanic rocks of the Washoe District, Nevada, previously examined microscopically by Zirkel. While in Virginia City, Nevada, he met Carl Barus, with whom he reviewed the mathematics of certain physical phenomena being studied by Becker. In New York, Hague, Iddings, Walcott, and Becker cooperated on the study of the Eureka and Washoe rocks and fossils as well as those from the earlier 40th Parallel Survey. It was this experience that persuaded Iddings that

the most satisfactory way of studying rocks is to examine a large collection of closely related rocks—a philosophy he was to embellish in later years.

Iddings's first paper in print was a description with Hague (1883) of the principal volcanoes of the Sierra and Cascade ranges. They were impressed with the "gradations in the microstructure in the groundmass of rocks of the same mineral composition from a purely glassy form to one wholly crystalline. . . ." The second paper, also with Hague (1884), contained notes on the volcanic rocks of the Great Basin. In it they recognized the chemical relationship between olivine and hypersthene; as the rocks became higher in silica, hypersthene took the place of olivine. Their first attempt at chemico-mineralogical generalization was of exceptional importance and became a major factor in petrologic theory.

In their discussion of the Washoe District, Nevada, igneous rocks, Iddings and Hague (1885) attacked the widely held view shared by Becker that there was a distinction between Tertiary and pre-Tertiary igneous rocks. After examining Becker's large collection and material from the extensive mining network in the celebrated Comstock lode around Virginia City, they concluded that all the rocks were of Tertiary age. In their view the Comstock lode occupied a fissure along a fault line in rocks of Tertiary age and "could not be considered as a contact vein between two different rock masses." They held that the structural character of eruptive masses was not a function of their age but of the physical condition controlling crystallization.[9] The paper did not "promote good fellowship" with Becker, but they eventually became friends despite continuing opposing views. On the other hand, the paper was widely acclaimed in Europe by the leading petrographers of the day.

MAPPING YELLOWSTONE NATIONAL PARK

Iddings's major field experience under the leadership of Hague was in Yellowstone National Park, established in 1872. Seven consecutive field seasons (1883-90) were spent in the region, where he focused on Obsidian Cliff, Electric and Sepulchre mountains, Crandall Basin, and Haystack Mountain. From an examination of the now-famous Obsidian Cliff, Iddings described the lithophysae (hollow spheres due to expanding gas bubbles), spherulites (spherical bodies with radiating crystals), columnar partings, and variations in the degree of crystallization, and he emphasized the role of water in magmas. Within the lithophysae he discovered the first natural occurrence of fayalite, the iron end member of the olivines, previously identified in lumps of slag carried as ship's ballast and dumped on a beach in the island of Fayal in the Azores. He realized that the inflation of pumiceous glass was due to escaped gases and appreciated the nature of layers described as welded tuff, outlining the process itself.

The intrusive rocks of Electric Mountain and the extrusive rocks of Sepulchre Mountain provided an exceptional opportunity for comparison after it was established that the two groups of rocks had essentially identical chemical compositions. The glassy extrusive andesites, with pyroxene and brown or red hornblende phenocrysts, contrasted with the coarsely crystalline diorites containing biotite and green hornblende. The different assemblages from the same bulk composition were attributed by Iddings to different conditions of crystallization. Recent experimental studies on the oxidation of hornblende and the breakdown of biotite verified this important relationship also emphasized by Washington.[10] In addition, Iddings viewed the magma as a homogeneous fluid in which the constituents could combine

in different mineralogical associations depending on the conditions of crystallization. He also recognized that volatiles contained in magma were more effective as mineralizers when in the magma conduit, in contrast to a magma that reached the surface.

Crandall Basin and Haystack Mountain were also centers of old volcanoes, and the data collected by Iddings reinforced his views on the role of the physical conditions attending consolidation in defining the mineral assemblages. In February 1890 he took a two-month trip to England to meet J. J. H. Teall, A. Harker, and J. W. Judd; pay his respects to Rosenbusch in Heidelberg; visit Vesuvius and the Sicilian region; and stop in Paris to see A. A. Lapparent. Michel-Lévy was ill, and F. Fouqué and A. Lacroix were on Easter vacation. The summer of 1890 was spent studying the eastern and central portions of the quadrangle immediately north of Yellowstone Park, with Louis V. Pirsson as his assistant. The western and northern parts were explored by W. H. Weed. The publication of that work (in 1894 by Iddings and Weed) on the Livingston, Montana, quadrangle constituted the first folio of the geological atlas of the United States.

Sandwiched between the work on the Yellowstone rocks, Iddings managed after office hours to translate the second edition of the first volume of Rosenbusch's book, *Mikroscopische Physiographie der petrographisch wichtigen Mineralen.*[11] He abridged the book to serve the needs of the average student, eliminating most of the historical portions and inserting notes on American occurrences. After a review by George H. Williams of the Johns Hopkins University, it was published in 1888, with revised editions in 1889, 1892, and 1898; publication was terminated because of copyright problems, and Iddings was beginning to think about preparing a textbook on rock minerals himself. He collected and sum-

marized prevailing views on the crystallization of igneous rocks in 1889; however, his own philosophy on the origin of igneous rocks was put forth in 1892. That paper had the same effect as N. L. Bowen's classic of 1928 and established Iddings as a leader in petrologic thought.[12]

The year 1892 may have been an intellectual triumph for Iddings personally, but it was a disaster for the U.S. Geological Survey. On July 14, 1892, the appropriations for the Geologic Branch were severely cut and all fieldwork was stopped.[13] Iddings's position as geologist was eliminated! (Major Powell's friend, Joseph S. Diller, head of the petrographic laboratory in Washington, was retained by shifting him to a temporary position, in preference to Iddings.) Iddings had been considered a possible successor to James D. Dana, who had relinquished his duties at Yale in October 1890 due to ill health, but Dana felt his "experience in general geology too slight," an objection he later withdrew. Nevertheless, Iddings turned to a university position. After turning down an offer from Leland Stanford, the University of Chicago offered him an appointment in August 1892 as associate professor of petrology, the first chair in petrology in the world.

RELUCTANT TEACHER

The new Department of Geology at the University of Chicago was staffed with a spectacular group: R. D. Salisbury, R. A. F. Penrose, Jr., and J. P. Iddings, with T. C. Chamberlin as chairman. In addition, there were three nonresident professors: C. R. van Hise, W. H. Holmes, and C. D. Walcott, who was never able to attend and resigned after the second year. Iddings disliked teaching and objected to teaching mineralogy and crystallography in addition to petrology. Although only two Ph.D. theses (Charles H. Gordon, 1895, and William H. Emmons, 1904) were completed under

Iddings, advanced degrees were not yet a necessity in the academic world. He started teaching in January 1893 and was immediately confronted with the problem of the kind of rock classification to be presented to the students. The classification of Rosenbusch was based at first on textural features and then on a geological occurrence basis, neither scheme appealing to Iddings. He believed that the chemical composition of a rock was fundamental, whereas the mineral assemblage, texture, and structure were dependent on the conditions of formation.

Iddings "approached the problem of petrological instruction as a student among students, knowing how many things were as yet undetermined, how many were matters of opinion, and to what extent definitions of rock kinds (types) were arbitrary and illusory." Early in 1893 he wrote to his friends C. Whitman Cross, Louis V. Pirsson, and George H. Williams for their opinions on classification. The response was extensive, and Cross in particular considered the query a challenge to revise the entire rock classification system. Williams suggested a conference during the Easter vacation. Iddings could not attend but sent a list of ideas. As a result it was proposed that each write a proposal and exchange them among the group. Williams provided an outline of the field and listed the difficulties in classifying rocks. Cross described the weaknesses of existing classifications and suggested that the first criterion should be "chemical composition, as expressed in mineral composition, perhaps by molecular ratios. . . ." Pirsson reviewed the French system and urged "making the magma as the initial idea and running it out through various grades of structure, with subvarieties according to mineralogical variations." Iddings pushed for differentiation of rocks as petrographical entities and rock bodies as geological units and magmas "as solutions of chemical compounds capable of crystallization

and differentiation," and he thought that differentiation led to natural rock families (= consanguineous groups). Further letter exchanges took place, but the project received a severe blow with the sudden death of Williams[14] from typhoid fever in 1894.

ROCK CLASSIFICATION

Iddings found his own classification difficult to defend before his students and shifted his views after a visit with W. C. Brøgger in Norway and discussions with other petrographers at the International Geological Congress in St. Petersburg in 1897. The shift was from the genetic relationships, advocated by Brøgger, to one in which chemical and mineral compositions were interdependent and fundamental. His ideas were recorded in 1898 in two papers in the *Journal of Geology*,[15] titled "On Rock Classification" and "Chemical and Mineral Relationships in Igneous Rocks." In the spring of 1899 a circular letter was received from the International Committee on Rock Nomenclature asking for opinions. Iddings responded, but Cross did not believe that widely divergent international discussion would influence the result. The circular letter, however, did rekindle the classification project initiated in 1893, and Cross, Iddings, Pirsson, and H. S. Washington,[16] who took Williams's place in the group, met in Washington, D.C., during the meeting of the Geological Society of America in December 1899. They declared that a new system of classification was needed, one based on the quantitative proportions of minerals and chemical components. They recognized the need for a method to express the chemical composition of a rock in terms of minerals in a quantitative way.

Washington[17] had been assembling chemical analyses of igneous rocks and testing various schemes of classification. It was in December 1900 that Washington made the gener-

ous offer to publish his collection of chemical analyses classified in the proposed system, but the others "thought it too much of a sacrifice on Harry's [H.S.W.] part to share the authorship of his great work. . . ." After numerous conferences, much correspondence, and openly expressed mental stress, Iddings was commissioned to handle the quantitative form of the classification and Washington was to attend to the nomenclature because of his familiarity with the taxonomic methods in botany. They all appreciated that the new classification scheme was indeed different, logical, and of considerable importance. The authorship of the final manuscript was alphabetical—Cross, Iddings, Pirsson, Washington—despite a sincere protest from Cross. The quantitative system published in 1902 became known as the CIPW system, from the first letter of each of the authors' last names. The quantitative method of reducing a chemical analysis of a rock to a set of ideal end-member minerals (the norm), close to those observed in the rocks (the mode), has had a profound influence on both field and experimental petrology. On the other hand, the drastic, complex, and foreign nature of the nomenclature was never accepted by practicing petrographers. All of the authors of the system had contributed in a major way to the successful conclusion of the ingenious project, but Iddings's colleagues acknowledged his leadership and persistence.[18]

PROGRAM FOR EXPERIMENTAL PETROLOGY

The CIPW system displays a remarkable understanding of the physico-chemical relationships of most of the major igneous rock types in the early stages of the systematic investigation of silicate melts.[19-22] The calculation of normative minerals, especially from analyses of fine-grained rocks and natural glasses, has been a cornerstone for choosing critical components in the phase equilibria studies of ex-

perimental petrologists. Its formulation appears to have had a major role in fostering and expediting the experimental approach to petrology. As a result of discussions among Charles D. Walcott, George F. Becker, and Charles R. Van Hise, Iddings was asked to "draw up a list of possible problems which might be studied in a chemico-physical laboratory." He presented a preliminary list in June 1903 to his CIPW colleagues as well as to F. D. Adams, James F. Kemp, John E. Wolff, and Alfred C. Lane. After obtaining their additions and suggestions, the revised list from the Committee of Eight was submitted to the trustees of the newly formed Carnegie Institution of Washington (*Year Book 2*, 1903, pp. 195-201). It served as guidance for selecting experimental programs for which funding was provided to Becker and Arthur L. Day at the U.S. Geological Survey and F. D. Adams at McGill University. As a result of their successes in dealing with geological problems experimentally, the trustees voted in December 1905 to establish a geophysical laboratory, and Day became its first director. The first paper published in 1905 by the laboratory was "The Isomorphism and Thermal Properties of the Feldspars." The thermal study was by A. L. Day and E. T. Allen, and the optical study was by J. P. Iddings. The thermal study was actually carried out at the U.S. Geological Survey and examination of the thin sections of the feldspar preparations was carried out by Iddings at Chicago. In recognition of the support of the Carnegie Institution, the USGS consented to have the work listed as paper no. 1 of the new laboratory. The program for experimental petrology outlined by the Committee of Eight became the initial scientific program of the Geophysical Laboratory[23] and continues "to play so important a role in the advancement of petrology." It appears that Iddings again was the leader of a productive group, not only providing direction to a highly successful

enterprise but also contributing personally to its first scientific results.

TEXTBOOK PREPARATIONS

For an extended period, Iddings's colleagues encouraged him to produce a textbook on igneous rocks. Even his mentor, Rosenbusch, had suggested to him, after consenting to a translation of *Mikroskopische Physiographie*, to write "a more general book on the petrography of igneous rocks." With the problems of classification and nomenclature of igneous rocks in hand, despite criticisms from abroad, Iddings believed a student of petrology should first have a firm foundation in the minerals that compose the rocks. The result was a 617-page treatise called *Rock Minerals: Their Chemical and Physical Characters and Their Determination in Thin Sections* (1906).

In the same year his book was published his father and older brother, Charles Fry Iddings, died. To his grief was added the loss in the same year of Sam Penfield, his classmate and very close friend. Despite recent trips to Yellowstone Park, field trips through Skye, Scotland, with Alfred Harker, a scenic tour of France with C. W. Cross and Frank Adams, participation in the centenary celebration of the Geological Society of London, election to the National Academy of Sciences (1907), and an honorary Sc.D. from Yale (1907), the variety of events apparently did not cure Iddings's need for "rejuvenation." The long-contemplated book on the petrology of igneous rocks—proposed some twenty years before—was still foremost in his mind, and he began work while still absorbed in university teaching.

THE SUDDEN COLLAPSE

In the spring of 1908 Iddings suddenly departed from the University of Chicago. The nature of his departure was

recorded by two students in his class at that time. In a letter from Albert D. Brokaw to D. Jerome Fisher,[24] Iddings was alleged to have received word that an aunt had died in Maryland and an inheritance was involved. The present descendants in the Iddings's family do not have record of an aunt dying at that time. Arthur C. Trowbridge gave a lecture to the Geology Club of the State University of Iowa on February 28, 1968, that was recorded and transcribed.[25] After describing Iddings as a gentleman and scholar, Trowbridge recalled the day Iddings failed to meet his class. After waiting the prescribed ten minutes for a professor, a student committee went to his apartment near the university to inquire. Salisbury lived in the same building and said he had breakfast with Iddings and that "he seemed to be all right then." The students were later told that he had inherited a fortune in England and left to settle the estate. The present Iddings family knows of no relatives in England at the time and has no knowledge of an inheritance.[26] His departure has also been described as merely retirement.

The events are perhaps best revealed by Iddings himself in a letter dated May 19, 1908, to his close friend, Whitman Cross, written at the home of his younger sister, Lola LaMotte Iddings, in Winchester, Massachusetts:

> I am here as the result of a rather sudden collapse and am taking rest and fresh air treatment. Owing to contributing causes which you will please keep strictly to yourself for the present, is a determination to cut loose from my colleagues at the University. Whether this is strictly a cause or a result, may be a psychological question. They are pretty well mixed up. The situation is not clearly understood out there, and you can see how it is better to keep strictly mum on the subject until I can find out whether I can get a foothold somewhere else.

There is no letter of resignation or request for leave on record at the University of Chicago, but there is reference by T. C. Chamberlin in a letter dated June 23, 1908, to a

note Iddings wrote on June 8, 1908, requesting a leave of absence, which was granted. Iddings never returned to the University of Chicago.

"FREE TO WANDER"

Iddings spent the summer of 1908 visiting Frank Adams in Montreal[27] and camping with Whitman Cross in the mountains north of Durango, Colorado. The camp life and hunt for butterflies brought about the desired renewal. He set to work again on the book on igneous rocks at the family estate "Riverside"[28] in Brinklow, Maryland, just fifteen miles from Washington, D.C. The book was completed in the spring of 1909 and published that year. It applied the "modern conception of physical chemistry to the elucidation of the phenomena of crystallization, and of genetic relationships among igneous rocks." It was indeed a new treatment of the subject, emphasizing differentiation, chemical reactions leading to hybrid rocks, assimilation, sequencing of magmas, and eruption processes. These aspects dominated over his favorite topics of crystallization and texture, modes of occurrence, classification and nomenclature, and diagrams for plotting the analyses of igneous rock types. A congratulatory letter was received from A. Harker, who dispatched him a copy of his own *Natural History of Igneous Rocks*, also published in 1909. Other flattering letters were later received from Judd, Geikie, Zirkel, Barrois, Lawson, and others.

With completion of volume 1 of the book on igneous rocks, Iddings felt "free to wander." With funds obtained from serving on a legal case related to calcium carbide, a subsidy from the Smithsonian Institution arranged by Walcott (then its secretary) to collect Cambrian fossils in Manchuria, and a sum from his friend Charles M. Pratt for rock collections to be made for two colleges, plus his own re-

sources, Iddings set out for Japan, the Philippines, China, and other countries on a round-the-world tour, passing through Suez and the European continent.

Following his worldwide observations on volcanoes, extensive collections, conversations with other petrographers, and enforced periods of contemplation, which accompanies long-distance travel, Iddings was prepared to put his views on paper. He wanted to collate the interrelationships of the chemical, mineralogical, textural, and occurrences of rocks. Fortunately, he did not use the new nomenclature of 1902 but the names previously employed for igneous rocks "both in order to be understood by petrographers already familiar with them and also to make it possible for students to understand the literature of the subject." He recognized the continuous-series aspect of rocks but proceeded to partition the series into quantitatively definite parts. His divisions were fivefold: rocks were characterized by (1) quartz and feldspar, (2) feldspars with little or no quartz, (3) feldspars and feldspathoids, (4) feldspathoids, and (5) chiefly mafic minerals. For the most part he depended on the chemical composition, the mode or the norm when aphanitic, and "occult minerals" dependent on lesser constituents or in glass but nevertheless represented in the norm. Almost half the text pages of the monumental work are devoted to occurrences of igneous rocks in the world. During the writing of the book, Iddings attended from 1910 to 1914 the Petrologist's Club, which initially held its meetings in the home of Whitman Cross. Papers were presented on four different occasions, and his discussions at ten meetings were recorded by the secretary. He also enjoyed conversations with various scholars at the Cosmos Club, to which he had been elected in 1885. The quiet country atmosphere of the Riverside estate was greatly conducive to writing, but consultations with his friends and use of the library at the

U.S. Geological Survey were essential for such an encompassing compilation. The book was completed in April 1913 and published that year.

Early in 1911 Iddings's good friend, Louis Pirsson, invited him to give the Silliman Lecture Series at Yale University on the problems of volcanism. Eight one-hour lectures were to be prepared, one of which Pirsson hoped would be on Reginald A. Daly's stoping hypothesis, which was not acceptable to either of them. Preparation of the lectures was undertaken as soon as the second volume of *Igneous Rocks* was completed. The date was set for the spring of 1914. Iddings took the opportunity to range widely from discussions of T. C. Chamberlin's nebular hypothesis to the physical characteristics and dynamic status of the earth and ended up with three lectures on the mechanics of the intrusion and eruption processes. The subject of overhead stoping received only two paragraphs of discussion, but Iddings saved his ammunition for a severe criticism of Daly's book, *Igneous Rocks and Their Origin*, in a separate salvo later in 1914. The lectures were given as scheduled, and the manuscript for book publication, as "The Problem of Volcanism," was turned over to Yale University Press the day after the last lecture!

SECOND CIRCLING OF THE GLOBE

The wanderlust hit again and Iddings circled the globe for a second time, this time from east to west, financed in part again by his good friend, Charles M. Pratt. He was booked in June 1914 for a short course of lectures at University College, London, repeating some of his Silliman lectures but focusing on the normative calculations of the CIPW system, petrographical provinces in North America, and the philosophy of physico-chemical petrology. From England he visited his old friends in Norway, France, and Italy. He

stopped in Java and took time to write a piercing analysis of Daly's new book, already mentioned, criticizing his "remarkable distortion of petrographic relationships," grotesque conclusions, and "indifference to rational geodynamics," but admitting to his "tireless energy, vigorous methods of attack, and honesty of his convictions."

Month-long collecting tours of both rocks and butterflies were undertaken in Borneo,[29] the ancient volcanic island of Bawéan with its rocks rich in leucite and nepheline, and the potassic lavas of western Celebes. In the Celebes Iddings learned of the onset of World War I, to his great distress in light of his Quaker ancestry, descendence from English[30] and French ancestors, and many friends throughout Europe. Following stops in Java and Australia, he settled down for three months in New Zealand before journeying on to his prime target, Tahiti, where he arrived on April 8, 1915. His rock collecting was confined to the fresh-stream boulders in the many deeply eroded gulches, the interior of Tahiti being mostly wild and inaccessible. After six months in Tahiti and the Leeward Islands, Iddings visited the Marquesas with a full month on Hiva-Oa, which he managed to explore on horseback. Bouts of influenza reduced his energy, and he wrote, "I have reached an age [58] where the comforts of civilization are a desideratum." He landed in San Francisco in the fall of 1915, bringing eleven substantial boxes of rocks.

On return from his second world tour, Iddings and his sister Lola leased the Grove Hill Farm (established ca. 1796) near the family estate in Brinklow, Maryland, in October 1915. In the peaceful surroundings of the farm, Iddings was able to write, withdrawing almost completely from societal affairs. He is listed, however, as being vice-president of the Geological Society of America in 1916. From a petrographic study of his collections, seven papers were produced

from 1915 to 1918 describing the rock types of those relatively little known regions of the world that he had explored. The papers contain only brief descriptions of the rocks but provide ninety new chemical analyses by E. W. Morley, H. W. Foote, and H. S. Washington, which were funded by the National Academy of Sciences. With the exception of his revision of the first volume of *Igneous Rocks* (1920), Iddings became withdrawn upon the death of his sister Lola, a poet, on April 3, 1918, from pneumonia. Iddings, himself an occasional poet (some of his poems are recorded in his autobiography), assembled Lola's poems, added an introduction, and had them published as a book[31] after her death. He never married.

Iddings died at the Montgomery County, Maryland, Hospital in Olney on September 8, 1920, from chronic intersilial nephritis according to the official death certificate. His youngest sister, Estelle Iddings Cleveland, was the sole beneficiary of his estate (see section on Honors). His rock collections were given to the Smithsonian Institution; most are identified as the Iddings East Indian Collection, and some are under the Petrographic Reference Collection. His extensive butterfly collection and library also were turned over to the Smithsonian. Burial was in the Woodside Cemetery adjoining the family estate in Brinklow, Maryland, alongside his parents and sister. As is fitting for a petrologist, his tombstone is a large boulder. The plaque is enscribed with "Blessed are the dead which die in the Lord" (Rev. xiv-xiii), but his middle name is misspelled even though his namesake is buried nearby.

HONORS

Among the honors already mentioned, Iddings was elected a foreign member of the Scientific Society of Christiania in 1902 and the Geological Society of London in 1904, an

honorary member of the Societé francaise de Mineralogie in 1914, and the American Philosophical Society in 1911, and was a fellow of the Geological Society of America. In 1914 he was made an honorary curator of petrology in the U.S. National Museum. In addition to the mineral "iddingsite" named by Lawson, he was honored by the naming of an early Cambrian trilobite, "*Olenellus iddingsi* Walcott" (1884),[32] which was later recognized as a new genus and called "*Peachella iddingsi* Walcott" (1910).[33] Walcott also named a brachiopod *Orthis (Plectorthis) iddingsi.* The trilobite genus *Iddingsia* was established by Walcott in 1924 in memory of his field associate.[34] The Iddings Scholarship for Graduate Studies was set up at the Sheffield Scientific School at Yale by his sister, Estelle Iddings Cleveland, with the residua of his estate and supplementary funds. One of its famous recipients was Aaron C. Waters. The fund was later transferred to general departmental use and continues to support students and research in petrology.

SCHOLAR AND GENTLEMAN

Iddings is described as a reserved gentleman of broad culture who made lasting friendships wherever he went in the world. He visited and corresponded with most of the leaders in petrology. He held to his views with tenacity and was not reluctant to promote them. He dealt with the initial severe criticism of the CIPW system by presenting the arguments in greater detail but devoid of humor.[35]

Despite his extensive worldly travels Iddings was not an outgoing conversationalist like his friend Harry Washington. Nevertheless, there was a personal charm that attracted friends. Even his close friend Pirsson recommended that Iddings read his Silliman lectures rather than attempt to give them extemporaneously. His love of the rugged western U.S. scenery and camplife was in sharp contrast to his

poetic and romantic view of his surroundings and attention especially to the dramatic display of colors of a sunset, a rock, or a butterfly. The allure of the South Sea Islands, a long coveted dream did not result in the customary abandonment of civilization suffered by so many visitors. In the end it only strengthened his appreciation of the comforts and intellectual stimulation of his own culture. Iddings remained a conscientious and devoted worker to petrology throughout his travels.

After seventy-five years it is difficult to understand why his contributions have not received the attention they deserve. Iddings himself did not believe he was endowed with originality but did recognize his ability to analyze and synthesize observational facts. As one of the pioneers in introducing petrography to the United States,[36] he must be given a large measure of credit for developing that field into petrology. He was a promoter of King's[37] one-magma hypothesis, an early advocate of magma differentiation, and a supporter of the basic-to-acid sequencing of magmas. He recognized the significance of Judd's[38] concept of petrographic provinces and was the first to recognize that igneous rocks of the same bulk composition produced different assemblages under different conditions of crystallization. He was quick to adapt Reyer's[39] use of diagrams representing rock composition to explain rock relations. As a result of his strong support of Bunsen's concept of magma as a solution, Iddings helped bring about the transition from descriptive petrography to a physico-chemical view of igneous rock interrelationships. In his quiet way he exercised leadership in the construction of the CIPW system and in formulating the experimental program of the Geophysical Laboratory. He was among the first to recognize the role of volatiles in volcanic eruption and to show concern for the physics of the eruption process. All in all, one can easily

agree with his peer group of 1903 that Iddings was one of the giants in petrology at the turn of the twentieth century.

THE PRIMARY SOURCES OF information for this memoir were the published works of Iddings, all of which have been assembled at the Geophysical Laboratory. A draft of recollections compiled by Iddings from letters written to his parents and family from Switzerland and Heidelberg in 1879-80 and his autobiography, edited and amended by C. Whitman Cross, are available in the Field Records Library of the U.S. Geological Survey in Denver. An inventory and finding guide of other items in Denver has been prepared by Carol A. Edwards. Letters written during Iddings's travels to the South Pacific during 1914-15 and correspondence with Charles D. Walcott are in the archives of the Smithsonian Institution. Correspondence with Arthur L. Day, director of the Geophysical Laboratory from 1907 to 1920, is in the archives of the laboratory. Letters to T. C. Chamberlin are in the archives of the Department of Geophysical Sciences, University of Chicago. Iddings's activities during his college days are described in the *Class of 1877 Sheffield Scientific School 1877-1921* and the *Obituary Record*, available in the Manuscript and Archive Division of the Yale University Library. His days at the University of Chicago have been described by Fisher.[23]

Through the kindness of Mrs. Sylvia Nash of the Sandy Spring Museum (Olney, Md.), copies of the pages from Thomas and Kirk's *Annals of Sandy Spring: History of a Rural Community in Maryland* (vol. 4, 1929, Times Printing Co., Westminster, Md.) relevant to the Iddings family from 1914 to 1920 were made available. Mrs. Elizabeth Iddings Small Hartge, current owner and resident of "Riverside" and member of the Woodside Cemetery Association, provided information from the records available and introductions to living Iddings family relatives.

A detailed biography and an almost complete bibliography of J. P. Iddings were written by E. B. Mathews ("Memorial of Joseph Iddings," *Geol. Soc. Am. Bull.* 44(1933):352-74). Brief biographies are also given by G. P. Merrill, "Obituary," *Am. J. Sci.* 50(1920):316; L. J. Spencer, "Biographical Notices," *Min. Mag.* 29(1921):247-48; J. J. H. Teall, "Joseph Paxson Iddings," in R. D. Oldham, "The Anniversary Address of the President," *Proc. Geol. Soc. London* 77(1921):lxi-lxiii; and W. C. Brøgger, "Mindetale over Prof. Dr. Joseph Paxon

(sic) Iddings," *Furhandl. Videns-selsk. Kristiania*, 1921:45-50 (in Norwegian).

Portions of the Brøgger memorial were translated by Bjørn Mysen.

The diaries of his paternal grandfather and grandmother are at Duke University, and a finding aid is available. A family photo album and Iddings's photographs of Yellowstone National Park are at the University of Wyoming, Laramie. Iddings's family notes from the Steinmetz and Gearhart collections were consulted at the Genealogical Society of Pennsylvania in Philadelphia.

Finally, it is a pleasure to thank the Geophysical Laboratory's librarian, Shaun Hardy, and his assistant, Merri Wolf, for their energetic and enthusiastic help in the investigation of a very cold trail. The reviews of R. M. Hazen, C. M. Nelson, E. L. Yochelson, and S. Hardy were greatly appreciated.

NOTES

1. H. S. Yoder, Jr. Timetable of petrology. *J. Geol. Ed.* 41(1993):447-89.

2. The USGS Appointments Ledger records the fact that Iddings joined the USGS on July 1, 1880, from New Jersey's 6th Congressional District as an assistant geologist (temporary) for work in New York and the field. He was promoted after several salary increases to Geologist on August 10, 1888, and transferred by J. W. Powell to the permanent rolls on January 21, 1890. As a result of the general reduction in force, Iddings resigned on December 31, 1892. He was reappointed by J. D. Walcott on a per diem basis on January 17, 1895.

3. Iddings is also credited with the introduction to the petrological literature of the terms bysmalith, chadacryst, consanguinity, laminated texture, lithophysae, occult mineral, oikocryst, soda-orthoclase, and spherulite. Attributed to him are the following rock names: banakite, hawaiite, kanaiite, kohalaite, langenite, llanite, marosite, shoshonite, and tautirite (A. Johannsen, *A Descriptive Petrography of the Igneous Rocks*, vol. I, Chicago: University of Chicago Press, 1939).

4. A. Michel-Lévy. *Étude sur la détermination des Feldspaths dans les plaques minces*. Paris: Librairie Polytechnique, 1904, 16 pp.

5. T. S. Hunt. Illustrations of chemical homology. *Am. Assoc. Adv. Sci. Proc.* (1854):237-47.

6. G. Tschermak. Chemisch-mineralogische Studie-I: Die Fedlspatgruppe. *Sitzberichte Akad. Wissenschafter Wien* 50(1864):566-613.

7. A. C. Lawson. The geology of Carmelo Bay. *Bull. Dept. Geol. Univ. California* 1(1893):31-36.

8. The alteration was first thought to be a single mineral but is now considered an intergrowth of two or more phases resulting from a continuous transformation of an original olivine crystal, presumably during the deuteric stage of consolidation of a magma. See, for example, P. Gay and R. W. LeMaitre, Some observations on iddingsite, *Am. Miner* 46(1961):92-111.

9. Iddings specifically stated that the chemical composition of a rock was not indicative of its age in "With notes on the petrographic character of the lavas" in C. D. Walcott, *Pre-Cambrian Igneous Rocks of the Unker Terrane, Grand Canyon of the Colorado, Arizona, U.S. Geological Survey Annual Report* 14, Part II(1894):520-24.

10. H. S. Washington. The magmatic alteration of hornblende and biotite. *J. Geol.* 4(1896):257-82.

11. Iddings's Survey Division was moved from New York to Washington in 1885. In the Washington directories Iddings is listed as living at the following addresses: 1886-87, 1528 I St., N.W.; 1888-89, 1330 F St., N.W; 1890-91, 1028 Vermont Ave., N.W.; and 1892-93, 730 17th St., N.W.

12. Bowen, N. L. *The Evolution of the Igneous Rocks.* Princeton: Princeton University Press, 1928. 334 pp.

13. M. C. Rabbitt. *Minerals, Lands, and Geology for the Common Defence and General Welfare, 1879-1904.* Washington, D.C.: U. S. Government Printing Office, 1980.

14. According to F. J. Pettijohn (pp. 30-31, *A Century of Geology, 1885-1985, at the Johns Hopkins University*, Baltimore: Gateway Press, 1988), Iddings was considered as a replacement for Williams by W. B. Clark, head of the Geology Department at The Johns Hopkins University. The offer was made in 1894 but declined by Iddings. In 1913 Iddings did present five lectures at Hopkins as part of the guest lecture program.

15. The *Journal of Geology* was established at the University of Chicago in 1893 by T. C. Chamberlin. Iddings served on the editorial board from 1893 to 1909.

16. Washington had first introduced himself by letter to Iddings

in 1894. He was the cousin of Iddings's cousin, Elmsie Gillet. Washington had studied petrography under Zirkel at Leipzig in 1891-92 and made chemical analyses of rocks under Pirsson at Yale in 1895. He was independently wealthy at the time and had a complete laboratory for the analysis of rocks in his boyhood home. In 1898 Washington published a paper on the alkaline rocks of Essex, Co., Mass., in which he urged a systematization of nomenclature and classification (H. S. Washington, Sölvsbergite and tinguaite from Essex Co., Mass., *Am. J. Sci. Ser.* 4,6(1898):176-87). His training and interests were eminently compatible with the other members of the group.

17. H. S. Washington. Chemical analyses of igneous rocks published from 1884 to 1900, with a critical discussion of the characters and use of analyses. *U.S. Geological Survey Professional Paper 14*, 1903.

18. In 1903 a group of peers listed the 100 leading men of science in the United States in geology and arranged them in order of distinction. The CIPW group were included: no. 14, Joseph Paxson Iddings (1857-1920); no. 32, (Charles) Whitman Cross (1854-1949); no. 49, Henry S. Washington (1867-1934); and no. 55, Louis Valentine Pirsson (1860-1919). The results were not published in *American Men of Science* until 1933 (pp. 1274-75). Only Cross and Washington lived to learn the results.

19. C. Doelter. Synthetische Studien. *Neues. Jahrb. Min.* 1(1886):119-35.

20. F. Fouqué and A. Michel-Lévy. *Synthese des minéraux et des roches.* Paris: Masson, 1882.

21. J. Morozewicz. Experimental Untersuchungen über die Bildung der Minerale in Magma. *Tschermak's Min. petr. Mitth.* 18(1899):1-90.

22. J. H. L. Vogt. Die Silikatschmelzlösungen: I. Über die Mineralbildung in Silikatschmelzlösungen. *Norsk Videnskaps-Akad. Mat.-Natur. Klasse* 8(1903):1-236.

23. H. S. Yoder, Jr. Development and promotion of the initial scientific program for the Geophysical Laboratory. In *The Earth, the Heavens and the Carnegie Institution of Washington*, vol. 5, pp. 21-28. Washington, D.C.: American Geophysical Union, 1994.

24. D. J. Fisher. *The Seventy Years of the Department of Geology, University of Chicago, 1892-1961.* Chicago: University of Chicago Press, 1963.

25. The tape was originally provided through the courtesy of Richard A. Davis, transcribed by J. V. Cole, and edited by B. F. Glenister

in March 1976. A copy of the transcription is on file at the University of Chicago.

26. The possibility was investigated that an inheritance may have been forthcoming from his father's estate that presumably would have been settled by that time. He died in Orange, N.J., on June 20, 1906, according to the official death certificate. Unfortunately, there is no record of William Penn Iddings's will or letters of administration in Essex County, N.J. He is buried, however, in Woodside Cemetery adjoining the Riverside Estate in Brinklow, Md., but there were no details recorded by the cemetery association of his death.

27. It was presumed by others that Iddings had taken a position at McGill University, but a search by the university's archivist revealed no record of his being on the staff or cited in the newsletter, newspaper clippings, or calendars for that period.

28. The estate was along the Patuxent River in the eastern portion of Montgomery County. It is described by R. B. Farquahar (*Old Homes and History of Montgomery County, Maryland*, pp. 257-59, Silver Spring, Md., 1962) along with other historic homes in the county. The estate is shown on the 1865 homeowner's map of the county by Martenet and Bond under the name of Charles A. Iddings (1831-98), the youngest son of Caleb Pierce Iddings (1778-1863).

29. At this point, Iddings appears to have abandoned his customary daily record of events. His friend Whitman Cross reconstructed the remainder of his tour from Iddings's detailed letters to his family and friends.

30. According to J. J. H. Teall, Iddings hoisted "The Union Jack alongside the Stars and Stripes at his country house on 'British Day' during World War I, when he returned to the United States.

31. L. L. Iddings. *Poems*. New Haven: Yale University Press, 1920.

32. C. D. Walcott. *Olenellus iddingsi* Walcott. *U.S. Geol. Surv. Mongr.* 8(1884):28.

33. C. D. Walcott. *Peachella iddingsi* Walcott. *Smithson. Miscl. Coll.* 53(1910):343-45.

34. C. D. Walcott. Cambrian geology and paleontology V. No. 2. Cambrian and lower Ozarkian trilobites. *Smithson. Miscl. Coll.* 75(1924):1-60.

35. One brief, subtle, humorous comment on the CIPW system is given by A. Johannsen (*A Descriptive Petrography of the Igneous Rocks*, vol. I. Chicago: Univesity of Chicago Press, 1939) who gave in the

chapter heading two bars of music from an old (about 1828) German folksong, "Du, du liegst mir in Herzen" ("You, you lie in my heart"). The fourth line of the stanza was omitted, which in one version runs, "Weiss nicht wie gut ich dir bin" ("You know not how good I am to you"). It reflects Johannsen's disappointment with the reviews of his own monumental work on petrography. It was Johannsen who replaced Iddings as professor of petrology at the University of Chicago.

36. C-H. Geschwind. The beginnings of microscope petrography in the United States, 1870-1885. *Earth Sci. Hist.* 13(1994):35-46.

37. C. King. *Systematic Geology.* Washington, D.C.: U.S. Government Printing Office, 1878.

38. J. W. Judd. On the gabbros, dolerites and basalt of Tertiary age in Scotland and Ireland. *Q. J. Geol. Soc. Lond.* 42(1886):49-97.

39. E. Reyer. *Beiträge zur Fysik der Eruptionen und der Eruptiv-gesteine.* Wien: A. Hölder, 1877.

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With A. Hague. On the development of crystallization in the igneous rocks of Washoe, Nevada, with notes on the geology of the district. *U.S. Geol. Surv. Bull.* 17:1-44.

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rocks of the Eureka District, Nevada, pp. 335-96. In *Geology of the Eureka District, Nevada.* U.S. Geological Survey Monograph 20.
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With A. Hague et al. *The Geology of the Yellowstone National Park*, part II. U.S. Geological Survey Monograph 32, 849 pp.

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