Chapter 2

Assistant geologist with USGS—I

EUREKA, NEVADA

During May and June [1880], I worked as a temporary assistant to Hague on the United States Geological Survey, and on the first of July, I received my appointment as assistant geologist and felt duly elated. It had been King's plan that Hague should have charge of the Division of the Pacific Coast with headquarters in San Francisco, and that he should study the volcanoes of that region beginning with Lassen Peak. But it seemed advisable that his first work should be of a more utilitarian character, so he was commissioned to investigate the geology of the Eureka Mining District in central Nevada.[1]

Leaving New York on the evening of the 16th of July, we were joined in Utica, New York, by a tall, slender, red-whiskered young man who was said to be a promising paleontologist, who had already made a reputation out of his studies of Trenton trilobites, and who had spent the previous season in the Grand Canyon of the Colorado [River]. The next morning, I made the acquaintance of Charles D. Walcott[2] and commenced a lifelong friendship full of interesting experiences and pleasant memories. At the end of the sixth day, we reached Eureka, after a journey, which, for a young geologist, became more and more fascinating and instructive as it proceeded. Nowhere can one see geological structures on a grander scale or in more easily comprehended exposures than in the barren ranges of the Great Basin desert! Its simplicity as well as its nakedness appeal to the eager student, and for me the ubiquitous volcanic lavas added to the charm.

Of course, there was no charm about the town of Eureka, a moribund mining community that had seen its liveliest days. Nor was there anything attractive about the rows of small wooden saloons on both sides of its wide main street, where dust blew up at every gust and tin cans and empty bottles littered vacant lots. Only the novelty of the situation, the freshness of the bracing air, the brilliancy of the atmosphere, and the anticipation of life in one's own camp under more favorable surroundings made the days spent there tolerable. Fortunately, it was possible to commence fieldwork on the mountain above the town and get somewhat acclimated before settling down to active camp life. It was necessary to get used to the intense heat of the direct sunshine and the chilling effect of a strong breeze and less frequent shade. Flannel underclothes were to be worn in the hottest weather and coat and vest removed as required. One had to acquire the habit of secreting saliva to keep one's mouth moist and of eating lunch slowly enough to keep from choking.

In the course of a couple of weeks, I was enjoying my first camp experiences in desert mountains. Walcott and I shared the same tent, and I learned from him how to make myself as comfortable as possible under desert conditions, how to hunt out the less stony spots to sleep on, and to remove offending pebbles. The first night in a clean white canvas tent with a full moon shining with the brilliancy of a strong arc light through the pure atmosphere of high altitudes was an eye-opener, so to speak, to one accustomed to sleeping in a darkened room. There was no way of putting out the lights. So strong are first impressions that the brilliancy of the moon that night has no equal in my memory. The same may be said of the pebbles; they have never seemed so sharp and obtrusive as on that first night. In time, I became inured to hard ground and harder saddles and, having the best of cooks and provisions and an adequate appetite, enjoyed the romance of the wilderness: the weird scenery of bare rocks, gray mountains, and brown ground with scattered bunch grass; and occasional groves of nut pines or less frequent, scrawny mahogany trees. The weirdest views were seen across the alkali flats, broad plains between mountain ranges, where the whitish soil is covered with gray-green sagebrush over which eddying winds whirled thin columns of dust hundreds of feet into the air, up toward the clear blue sky, where floated the whitest of clouds, dropping misty streamers of rain, like huge aerial medusas.

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The clearness of the atmosphere permitted long distance observations of rock structure and topographic detail. The multiplicity of mountain forms within one's range of vision, the sharpness of outline, and the variety of colors in neutral tones produced most impressive effects and offset the loss of what artists call "atmosphere" in most climates. From the summit of Diamond Peak [in Nevada], at an altitude of 10,040 feet [the currently accepted value is 10, 614 ft.], it was possible to see without binoculars the summit of a mountain one hundred miles distant, from which heliographic signals were being flashed.

For me, fieldwork was partly petrographic, collecting and mapping igneous rocks in those parts of the district where they occurred, and partly assisting Walcott in collecting fossils and in studying the position, thickness, and areas of the sedimentary rocks where there were no volcanic lavas. And so I learned the secrets of a good fossil collector. One must have one's eyes always open for the sign of a fossil, especially on steep slopes beneath cliffs or on mountainsides; must follow the traces until the ledge of rock is found in which they occur in place; and then work like the devil to get as much material as possible, being careful not to break the rock up into such little pieces that no whole fossils remain. One must not be afraid of carrying in rock, and plenty of it. From my observation of Walcott, I judged that keen eyesight and untiring energy are the prime requisites of a successful fossil collector.[3]

Petrographically my first season in the field was most interesting. I had everything to learn that was not included in a course in microscopical petrography, and there were no thin sections, just great masses of rocks, in many instances without any minerals large enough to be seen without a microscope. Of course, I had ideas as to what they might be, but they were not always correct. The very first rock I encountered appeared to be a fissile greenish shale, at least so I thought when I first saw it. Later, it appeared to be a vesicular lava with platy parting and without porphyritical crystals. The term *phenocryst* had not been invented at that time. Later on, I called it rhyolite and still later basalt. I would now call it pyroxene-andesite. It was an intrusive mass in rhyolite tuff, which it had metamorphosed to a compact lithoidal[4] rock, in places glassy with thin platy parting parallel to the plane of contact between the two rocks, the basaltic rock also having a somewhat similar platy parting. In time, I learned, though it took another field season to convince me, that it is not necessary or wise to give specific names to aphanitic, or even coarse-grained rocks, in the field. For the label, a number and locality are sufficient, and for the notebook, some general description is all that is needed in doubtful cases. One may become prejudiced by the persistent use of a misnomer, as I think we were in using the term *basalt* for some dark, aphanitic, non-porphyritic lavas. It got onto the field maps and into the notebooks, and became so firmly fixed in our minds that the subsequent microscopical study and chemical analysis didn't dislodge it, and mineralogical facts and definitions were warped to accommodate our preconceived notions that it ought to be called basalt. Our prejudice was undoubtedly based on the dictum of von Richthofen's law as to the order of succession of fissure eruptions of volcanic lavas—after rhyolite, basalt.[5] We were in that transitional period in the development of petrography when there was a constant effort to blend pre-microscopical definitions and conclusions with more exact observations and modified definitions, resulting in great confusion of ideas and terms. In the printed report after a correct description, I remark: "It is, however, not a normal basalt, and may be considered more properly an intermediate rock between basalt and pyroxene-andesite" (Iddings, 1892a, p. 392). I should now call it an olivine-bearing pyroxene-andesite. I remember that George Hawes pronounced it an augite-andesite.

My notebooks record the presence of trachyte, but it is not mentioned in the final report (Hague, 1892). A special feature of the Eureka rhyolite is the almost black color of the porphyritical quartzes; yet as dark-colored quartzes also occur in the dacites, and less often in the andesites, and occasionally in the basalts, its significance was commented on only in later years, in connection with a series of quartz-bearing rocks from other regions.

My petrographic enthusiasm was at its highest when I discovered, near Fish Creek Wells, a body of granite intruded into limestone with an apophysis[6] of granite-porphyry and, from this, off-shooting dikes of quartz-porphyry—the connections between them all well exposed. The size of the grain of the rock was so obviously dependent on the size of the rock mass, and the distance from the surface of contact that I recognized in the whole body a beautiful illustration of the relation between rock texture and the physical conditions attending solidification.

In this connection, I experienced my first disappointment as a young assistant. It was to be my privilege to publish the microscopical petrography of the igneous rocks of the district, all other phases of the petrography to appear in the report of my chief. Perhaps I wasn't advanced enough to describe the mode of occurrence and megascopic characters, but, of course, I thought I was. It seemed at the time quite a privation, but so many years elapsed before the monograph on the district was published (twelve, in fact), and I had advanced so far beyond my first field experience, that my interest in the matter had died out when my first scientific writing saw the light.

The report on the microscopical petrography of the Eureka District was finished and turned over to Mr. Hague in the spring of 1881. The monograph containing it was not published until the end of the year 1892. Before it was printed, some changes were made in the text, chiefly the change of the name augite-andesite to pyroxene-andesite on account of the discovery by Whitman Cross of the common occurrence of hypersthene in andesites and of our subsequent identification of this mineral in Eureka andesites. There were some textual changes and the introduction of the term *phenocryst*.[7]

One thing in the petrographic report seems creditable for a beginner, namely, the description and explanation of sections of Carlsbad twins of albite twins of triclinic feldspar, cut at right angles to the plane of twinning so as to show equal angles of extinction in adjacent pairs of lamellae, the angles being different in the Carlsbad parts and in different zones. The diagrams and explanation were made during the winter of 1880–1881; Michel-Lévy's paper on the same subject, mathematically elaborated and made generally useful, appeared in 1894 (Michel-Lévy, 1894). In the Eureka report, the gradations of optical properties from inner to outer zones in many triclinic feldspars were considered as conclusive evidence of gradation in chemical composition from strongly calcic to more alkali plagioclase, as claimed by Tschermak (1865).

A common form of alteration of olivine into a red laminated mineral, assumed to be a micaceous serpentine, colored by red oxide of iron, was described. Subsequently this alteration product was named *iddingsite* by A.C. Lawson (1893, p. 31–36),[8] but its chemical composition and physical properties have never been determined.

WASHOE DISTRICT/VIRGINIA CITY, NEVADA

Before finishing fieldwork at Eureka, Mr. King had a conference with Mr. Hague and announced his intention of giving up the directorship of the U.S. Geological Survey the following year—a great disappointment to all his friends. Our plans for establishing a branch office in San Francisco were abandoned, and, although King suggested I remain out there for the winter, Hague needed me in the east, and so we returned to the American Museum of Natural History in New York. However, a week was spent at Virginia City, Nevada, at Mr. Geo. F. Becker's request, to look over the volcanic rocks of the Washoe District,[9] which he had undertaken to study microscopically without previous experience with a petrographic microscope (Becker, 1882).

At this point, it is interesting to consider the influence of authority on the judgment of a beginner, in this instance on two beginners. In my Eureka fieldwork, I was guided by Hague in determining the lavas, which were like those he had collected in other parts of the Great Basin and on which Zirkel had passed judgment. I had had no experience in such matters and could have no opinion of my own. King's report (King, 1878) and speculations regarding the Great Basin rocks in volume I of the reports of the Fortieth Parallel exploration I pored over in camp and absorbed as far as possible. In the Washoe District, Becker followed King and von Richthofen, who had visited it with King. When I arrived, I was shown the diorites of Mt. Davidson and the various kinds of andesites and trachytes in place, or at least the places where rocks of these names were said to be. I saw the propylite,[10] which had been described microscopically by Zirkel, and many other things and was properly impressed and grateful for the opportunity of observing them in the field. When Becker asked for a letter confirming the correctness of his determinations, it was a simple matter to acknowledge that they conformed to the descriptions of Zirkel and must therefore be correct. Both Becker and I were following in the footsteps of the father of microscopical petrography, and we naturally were satisfied to keep step with our master in the science. Could beginners have done better?

In Virginia City, I met Carl Barus, who was studying certain physical phenomena for Becker and incidentally looking over his mathematics.[11] When his monograph was published, Becker (1882) thanked us collectively for assistance, in a negative sense. Years later, we were able collectively to contribute something to petrology in a positive sense on the basis of our experience in the Washoe District (Hague and Iddings, 1885).

On my way east from Washoe, I stopped in Salt Lake City to see a college mate, Al Webster, who was doing topographical work for the U.S. Geological Survey, and met G.K. Gilbert,[12] who was studying the ancient terraces of Lake Bonneville (Gilbert, 1890). He told me that if I had joined the Survey the year before, I would have been assigned to his division and have worked in the Salt Lake region. While there I visited the granite-porphyry near Tooele at Hague's suggestion.

EARLY PETROGRAPHIC STUDIES

At the museum in New York, we settled down to work on the Eureka report and the cataloguing and labeling of the Fortieth Parallel collection. It was a quiet, secluded place, the top story of the museum, far from the noise and confusion of the great city and out of the way of visitors in those days. There were few interruptions, except for frequent consultations with Becker, who had rooms across the hallway, where he was preparing his report on the Washoe District. He and I were constantly comparing notes on microscopical matters and discussing the identity of andesites and propylites, of feldspar and pyroxenes, of alteration products, and whether to call certain hornblendes brownish-green or greenish-brown. At the time Mr. Hague wondered whose assistant I really was, as he afterwards informed me. It was beginning to dawn on both of us that our faith in the correctness of our esteemed master in petrography was weakening. Becker was convincing himself that propylite was only an altered form of andesite in which the pyroxenes had been changed to a fibrous amphibole, uralite. We were both finding out the fallacy of Zirkel's determination of zonally built feldspar as sanidin,[13] and his failure to give proper weight to the plagioclase feldspar in the so-called trachytes of Washoe and the Great Basin, which turned out to be hornblende-mica-andesites and hornblende-andesites. I was also forming my own impressions of the rocks of Washoe, which I found an opportunity of expressing later on.

At lunchtime we met some of the members of the museum staff at a small mess table: Professor Bickmore,[14] the superintendent, interested in ethnology and in educational matters; R.P. Whitfield,[15] the paleontologist, occupied with the Hall collection of fossils and sympathetic with Walcott in Paleozoic studies and in recollections of James Hall[16] in Albany; and Gratacap,[17] the curator of the mineral collection, beside several others who were working on private investigations.

Owing to the change of directors of the Geological Survey, King having been succeeded by Major Powell,[18] no fieldwork was undertaken by Hague for several years, and our interest in the Pacific Coast volcanoes was transferred to another field. My time was devoted wholly to microscopical petrography, chiefly of volcanic rocks.

Soon after our return from Eureka, I got a note from George Hawes, who had come back from Heidelberg with a doctor's degree, summa cum laude, in part as follows:[19]

I have been busily at work on my own book since I got back in June, and have done some things very interesting to me. Hope they may prove so to you. One of my studies on contact metamorphism will be published in the January *American Journal* (Hawes, 1881). I think I have shown that we too possess beautiful phenomena of this nature…. I am at present about to enter into the service of Uncle Sam also, in the capacity of a special agent appointed to investigate the building material of the country. I hope to make an interesting work out of it.

He began his duties the next month and wrote me a letter concerning Rosenbusch in which he said:[20] "I suppose you know that Powell will doubtless be confirmed as geologist. Do you think that this change will affect you in any way? If I thought it would I should have something to say to you."

The change of directors of the U.S. Geological Survey did not affect me in the way Hawes had in mind, and later he engaged George P. Merrill[21] as assistant petrographer. Work on the building stones in the Old Museum in Washington proved very confining and affected Hawes' health so seriously that his friends became alarmed. In response to a letter, I received the following:[22]

My dear Iddings:

You were very kind to send me an invitation to make you a visit which I assure you I should gladly do were I in fit condition. I hardly like to appear among my friends as a defunct individual so I keep pretty close. I am thinking of making a western trip this summer. Will you very kindly remember me to your father?

Your friend,
George W. Hawes

This was my last letter from him. Six weeks later he passed away in Colorado Springs, one of the most lovable, modest, simple-minded of men; a genial as well as a faithful friend, wholly devoted to his studies in mineralogy and petrography and always enthusiastic over his work. The science of petrology lost an ardent and able investigator at the very threshold of his career, and his fellow workers were deprived of a comrade whose enthusiasm would have been an inspiration and whose sound judgment would have been of inestimable value. Of him Rosenbusch wrote:[23]

The news of the death of my friend Hawes has very deeply shaken me; I had secured the love of the completely honorable man like my own son and feel his loss as that of a son. None of my other dear students, however, was as close to me as a human being as he, and his true and warm friendship has been a consolation for me in the most difficult days and hours of my life. I had put great hopes on him for the promotion of petrography and mineralogy in America; others must now realize these hopes, and among those you also stand in front of the line, my dear Mr. Iddings. But that is the uplifting thing, which rests in every true friendship, that it safeguards our existence throughout life on earth; we live in memory of our friends and our friends in ours. So let us further labor and work in the spirit and in the mind of our various friends until our hour also arrives.

NEW ACQUAINTANCES

Frank Dawson Adams

In the summer of that year, I was invited to visit a young friend in Montreal, whose acquaintance I had made in New Haven in 1879, and whose advent to the chemical laboratory as a graduate student the previous autumn was announced in a letter from Sam Penfield as follows:

We have a post-graduate from McGill University, Canada, in the laboratory this year, over whom we have all lost our hearts. He is handsome, polite, gentlemanly, a good student, and in every way [a] just "boss."

More than this description in the vernacular could not have been said of a college student in those days, and such he has continued to be all his long, useful life. A fine type of a gentleman and a scholar, and withal a successful teacher and original investigator, who, when the world in later years was plunged into the most frightful of wars, laid aside his scholastic duties and devoted himself to mustering forces to maintain right and justice. A young petrographer then, he had studied with Rosenbusch the previous year, and in 1892 returned to Heidelberg to receive the degree of doctor of philosophy, summa cum laude.

In 1882, Frank Adams[24] was an enthusiastic young petrographer, assistant to Selwyn,[25] on the Geological and Natural History Survey of Canada, with headquarters at Ottawa, where he was devoting half his time to chemistry and half to the petrography of the anorthosites of the Saguenay. The occasion of my visit to his home in Montreal was a meeting of the American Association for the Advancement of Science, to which I was elected a member.

As a result of conversation with him at that time, he wrote me soon afterwards:[26]

I believe that you are right in remarking that the most satisfactory way of studying rocks is to examine a large collection of closely related rocks. It is, I am convinced, the only way to arrive at really accurate results on many points. The more I see of the Laurentian rocks, the more I am struck with the close resemblance which they bear to those of Scandinavia. Even the diabases which cut them in large dykes have the peculiar pegmatite grains composed of quartz and plagioclase which Törnebohm[27] has described from similar diabases in Sweden…. Why should this structure be found in these rocks even when so widely separated?

George Huntington Williams

Another enthusiastic young petrographer returned from Heidelberg near the end of 1882 and called on me at the museum in New York. He had been spending four years in Germany, part of the time at Göttingen; had entered Rosenbusch's laboratory the year I left, and was there with Frank Adams, but remained longer; and before he left secured his doctor's degree, summa cum laude, winning a high place in Rosenbusch's estimation. He was as brilliant and handsome as he was enthusiastic and he inspired confidence and friendship upon his first visit. Soon after his return, George Huntington Williams[28] became a fellow at Johns Hopkins University, began a study of the igneous rocks in the neighborhood of Baltimore, and gradually built up the Department of Geology and Mineralogy in the university. The intimacy that grew between us had a profound and lasting influence on my petrological career.

Joseph S. Diller

In the spring of 1883, still another student of petrography returned from Heidelberg, where he had been associated with Williams and Adams. J.S. Diller,[29] a Harvard graduate who had studied rocks under Wadsworth,[30] found his way through the good offices of W.M. Davis[31] to Captain Dutton[32] of the U.S. Geological Survey to whom had been assigned the study of the Pacific Coast volcanoes, for which Hague and I had been headed. And the following summer Diller began the study of Lassen Peak. Before starting, he came to New York to consult with Hague as to his experience with the Pacific Coast volcanoes, and in this way I made his acquaintance and had a chance to wish him good luck in his fascinating prospects. In later years, we worked as neighbors in adjacent rooms in the Survey office in Washington and exchanged many ideas and experiences.

PETROGRAPHY OF PACIFIC VOLCANOES

It was in connection with this change of plans, and probably in anticipation of Dutton's and Diller's work on the Pacific coast, that Hague thought it advisable to publish a brief account of the rocks from these volcanoes collected by King, Emmons, and himself in 1870, when King was considering the possibility of making a detailed investigation of the principal volcanoes of the Sierra and Cascade Ranges. And so I undertook a microscopical study of the rocks, while Hague wrote a description of the volcanoes, and together we prepared our first joint paper, which was to be my first appearance in print (Hague and Iddings, 1883).[33]

The timeliness of this publication was acknowledged in a letter from Diller,[34] in which he says:

> It is only a few weeks since I returned from a somewhat trying reconnaissance of the Cascade Range…. A few of the rocks from Lassen's Peak were examined and I was just beginning to be jubilant over the abundance and wide distribution of hypersthene, as well as the mistaken character of the nevadite of Richthofen, when my eyes fell upon your most interesting article in the *American Journal* [*of Science*]. I congratulate you heartily upon the way in which you have handled the subject, and have no doubt that I shall have abundant opportunity to corroborate your statements.

In this connection there was an interesting episode between George Williams and myself regarding the matter of transition rocks from hypersthene-andesites to basalts, which illustrates the advantage of giving specific names of things, labeling an idea or observation, instead of leaving it unlabeled. In the paper on the rocks of the Pacific Coast volcanoes, I had described four types of rocks, one of which was basalt, another hypersthene-andesite, remarking that while they were well characterized they could not be said to be sharply defined and distinct forms. Between any two in the order given there existed all possible intermediate varieties. Thus, among porphyritic basalts are found those with diminishing olivine and increasing hypersthene, which may equally well be called hypersthene-bearing basalts or olivine-bearing hypersthene-andesites. I also called attention to the chemical relationship between olivine and hypersthene and stated that, as the rocks became higher in silica, hypersthene took the place of olivine—one of my first attempts at chemico-mineralogical generalization in petrology. Subsequently Diller (1887) described volcanic rocks of this region, dwelt on the same relationship between basalts and hypersthene-andesites, and called intermediate varieties hypersthene-basalts. When Williams reviewed Diller's paper for the *Neues Jahrbuch,* the idea of hypersthene-basalt struck him as entirely new, and he forgot the description I had given some time before. Such is the value of a definite name. There resulted an amusing correspondence, and a general discussion of olivine-hypersthene.

In the beginning of the year, Whitman Cross, who was petrographer for Mr. S.F. Emmons in Colorado (and who had taken his doctor's degree in the spring of 1880 at Leipzig with Zirkel and had joined the Survey about the same time I did), had discovered, with the help of W.F. Hillebrand,[35] the chemist, that the pyroxenes in these lavas were almost wholly hypersthene and that hypersthene was common in the andesites of that region. Cross's paper on Buffalo Peaks was published as Bulletin 1 of the U.S. Geological Survey (Cross, 1883), a form of publication adopted largely as the result of an energetic remonstrance on his part to the time-consuming methods of publication then in vogue on the Survey, and the fact that material prepared for monographs often lay buried for years before seeing the light of publicity. This necessitated my review of the pyroxenes in the andesites of the Eureka District and in those of the Great Basin where the common occurrence of orthorhombic pyroxene was recognized. It proved to be the regular companion of monoclinic pyroxene in the lavas of the Pacific Coast volcanoes, and its chemical relation to olivine in olivine-bearing andesites and in basalts was clearly pointed out in the paper on the volcanic rocks of the Pacific Coast previously mentioned.

ROSENBUSCH AND ZIRKEL

During the first years of my petrographical work, Rosenbusch's letters were a source of the greatest inspiration and encouragement. They were generally written during vacation periods when his time was not crowded with lectures, laboratory work, and the revision of his textbooks, which he was constantly rewriting. Months often elapsed before replies came to questions I had asked or regarding accounts I had sent him of my latest problems, for he had invited the fullest disclosures of my petrographical projects and discoveries in the field, closing his first letter as follows:[36]

> Now perhaps you live for today, my dear Mr. Iddings, and may you be persuaded that you would always give me great pleasure whenever you would give me news about yourself and your works. I heartily shake your hand.

And in another letter:[37] "I really cannot wait to see the publication of your studies and expect much instruction from them."

His letters were filled with information as to methods of work and discussed petrographical matters of the first importance, including his own views regarding rock classification and the revision of his books. Their tone was more genial and intimate than his treatment of me while I was in his laboratory, for while he had been very kindly in his intercourse, he was at that time passing through the saddest days of his life, as he afterwards said, when he was crushed by the loss of his son and only child, and it may be assumed his interest in rocks was at its lowest ebb. Moreover, I was merely an absorbent student, having an imperfect knowledge of the language and no petrographical experience of my own to communicate.

In our correspondence I was in the habit of reporting promptly interesting observations made in the course of fieldwork so that his interest was awakened in my research, and his appetite was whetted for the published report to which, at times, Rosenbusch looked forward with mingled emotions as I was constantly attacking problems about which we were not always in accord. Often, however, we agreed on principles, and his commendation was both flattering and inspiring to the young petrographer. After a long discussion of the possible cause of rock variation and the series of lavas in the Great Basin, in which he expressed his views on possible magmatic differentiation, and suggested lines for future speculation, he concluded:[38]

> For me it is a truly heartfelt joy whenever I see my students on such a good path and read about their labors, which demonstrate such scrupulous observation and such correct thinking, like yours. I mention that because I may always demand more from you, and that's why I gladly point out such fundamental questions to you. In this respect you are allowed to see only a proof of my lively interest in your works.

If a new article contained a debatable point, and many of them did, I found myself framing the argument to convince Rosenbusch in most cases, and so was constantly aiming at a high mark.

Among the first matters to interest Rosenbusch was the discovery of hypersthene as a common constituent of andesitic lavas in America. He was rather skeptical as to its general occurrence and had his students in his laboratory examining andesites from various regions. Diller found it in rocks he collected in the Troad in Anatolia. In some andesites of Central Europe it was not found accompanying augite, and the augite in some instances exhibited pleochroism similar to that of hypersthene in andesites. The color of the very small hypersthenes in volcanic rocks is much lighter than that of hypersthene in peridotites, and I think this is the reason Rosenbusch often referred to the orthorhombic pyroxene in andesitic rocks as enstatite.

During the previous year, Dr. Szabó[39] of Budapest had visited this country and in New York had initiated Becker and myself in his method of distinguishing different kinds of feldspars by their coloration of a Bunsen flame and their degree of fusibility. There came with the demonstration, gratis, a carte-de-visite photograph of Dr. Szabó decorated with his courtly orders.

The microscopical study of the lavas in the collection of the Fortieth Parallel exploration, those of the Eureka District, and those from the Washoe District showed the absence of trachytes from the region of the Great Basin and suggested the importance of calling attention to the fact in print, so Mr. Hague and I prepared a joint paper on the volcanic rocks of the Great Basin (Hague and Iddings, 1884).[40] It showed that, owing to improving optical methods of study and the use of solutions with high specific gravity for the separation of the mineral constituents of rocks, it could be demonstrated that most of the feldspars called *sanidin* by Zirkel (1876) in his report on the *Microscopical Petrography of the Great Basin* rocks were plagioclase. Consequently the rocks called *trachytes* were andesites and some rocks called *rhyolites* were dacites. There is a transition from rhyolite, a very common lava in this region, to dacite and from dacite to andesite. Rhyolites and andesites are commonly associated in the region without the presence of trachyte, which is probably much rarer throughout the world than was formerly supposed in a consequence of a shift in definitions, as is now well known. Most rocks originally named *trachyte* because they are rough, contain plagioclase and no sanidin and, as the definition of *trachyte* was shifted from the character of roughness to the preponderance of potash feldspar, the name *trachyte* no longer applied to them. The real nature of nevadite was pointed out, and the significance of the term *granite-like* was noted as not holocrystalline or granitic but merely resembling granite at a distance, the rocks in some instances being actually glassy. Attention was also called to the universal presence of hypersthene in the andesitic and dacitic rocks of the region and to the absence of augite-andesite. Becker's determination of "propylite" as altered andesite was extended to the whole region. We were indebted to Sam Penfield for the chemical analysis of the mixed pyroxenes that had been separated from one of the rocks.

An announcement of the results of our study was conveyed to Professor Zirkel in a letter, which was in part as follows:[41]

Professor Ferdinand Zirkel
Dear Sir:

It has been my good fortune to have been entrusted for the past four years by Mr. Arnold Hague with a review of the petrography of the rocks collected by the Exploration of the Fortieth Parallel, together with such other collections from the same and neighboring regions as have by chance come into our hands. The doubtful rocks whose specific deter-

mination may long be open to question, and the unsolved problems still remaining after nearly four years of constant application to both hand specimens and thin sections, together with chemical analyses and field observation, impress me with a sense of the great disadvantages under which you must have worked ten years ago, when in the infancy of the science you undertook the determination of what to us at the present day appear very thick sections of very small chips.

Remembering also the rapid development and extraordinary growth of microscopic petrography, it is not surprising that the pioneer work of only a few years past should not accord with all the requirements of the more fully developed science of today.

If, then, after more recent and more protracted study of the rocks of the Fortieth Parallel collection, I am led to different conclusions from your own in regard to some portions of it, as appears in the article just published by Mr. Hague and myself in the American Journal of Science*, the changes may neither be charged to your debit, nor credited to my favor, but considered as the inevitable outcome of improving methods and advancing research.*[42]

You will notice in the article referred to that we make no mention of Dr. M. E. Wadsworth's work upon the collection (Wadsworth, 1880–1882, 1882–1883). *The truth is, that it is so faulty and confused with his own peculiar system, that it does not deserve notice, unless the treatment be after the manner of a destructive distillation, which would be an extremely unpleasant undertaking with such material. It is very unfortunate that he should have gotten himself into the position he has, which is the same towards all those he has anything to do with.*

I have the honor to be

Very respectfully yours,
Joseph P. Iddings

The severe criticism was well received by Zirkel, who showed his fine spirit in a letter to me, which deserves being quoted in full since it has to do with matters that profoundly agitated petrographers in those days. It is as follows:[43]

Very honorable Sir!

For your friendly letters and for the very kind transmission of the splendid photographs, which have greatly interested me, I am obligated to you to offer hearty thanks. Your articles, which you have had the kindness to send to me, have naturally excited my greatest attention, and I do not doubt that in them you have hit the mark. Do not think that the corrections, which have become necessary to my earlier descriptions, were viewed unfavorably by me. No one knows as well as I do, how great is the difference between the microscopic-petrographic experiences and methods of investigation from 1874–1875 and those of the present day. If I myself now had to accomplish the work of the Fortieth Parallel once again, it would truly be called off. In addition, I would demand more time for investigation than granted me at that time. Consider that I began my investigations at the end of October 1874, and already at the end of July 1875, after nine months, I had to send the finished manuscript to King. That was definitely too little time for such extensive material.

What especially concerned trachyte, however, it was at that time still a dogma that all feldspar sections unstriated or showing only two faces would be orthoclase. Only later have we recognized the incorrectness of this view. Among the geologists of the Fortieth Parallel, the "trachytes" played a special role, and I have in my description several occurrences, in which my firm conviction toward the striated feldspar prevailed, nevertheless counted among them because King spoke or wrote to me: "This number is geologically a 'trachyte'…. I can only wish you luck from my heart, that you have set matters straight."

Becker's investigations on the "Propylite" of Comstock still leave me with many doubts about it. It may be that some of those are old diorite porphyries (and then the Geological Survey has made the mistake of defining them as Tertiary). On the other hand, for the time being, I cannot believe that a banned hornblende andesite can transform itself into a rock of the habitus of propylite. Indeed we know completely exactly the alteration appearances of the hornblende andesite, such as the Siebengebirge or Hungarian [Mountains], which have always served as types. And there epidote or chlorite were never produced!

While once again I say my many thanks to you, and when you get a chance please kindly greet Mr. Arnold Hague. I remain in the highest esteem

Yours,
F. Zirkel

Two years previously, when I had been studying the lavas of the Great Basin and had become convinced of the situation with regard to the general absence of sanidin in the so-called trachytes, I wrote Rosenbusch of our purpose of calling attention to the matter in print and received a letter in which, among other things, he said:[44]

What you wrote to me about Prof. Zirkel's *Microscopical Petrography* is not entirely unexpected by me; that in the given instances, you yourself, my dear Mr. Iddings, with full independence in the substance would nevertheless steer clear of every personal injury in manners—I am convinced of it throughout. It makes me very sad when someone in America wants to criticize Prof. Zirkel the way that Mr. Wadsworth has done it. I really do not even want to maintain that, Mr. Wadsworth, for example, has done something wrong (although I cannot imagine that Prof. Zirkel has made such mistakes), but one must not make such harsh accusations without establishing them in detail and in depth. Moreover, one must never forget with all such critiques, that our methods improve from year to year with tremendous strides, and that, therefore, an understanding becomes easy for us today that we were unable to achieve only a few years ago.

RELATIONS WITH WADSWORTH

This brings to mind the trouble with M.E. Wadsworth over his sweeping criticism of Zirkel's report on the microscopical petrography of the Fortieth Parallel collection of rocks. It was published in connection with suggestions of his own regarding the definitions and nomenclature of volcanic rocks (Wadsworth, 1879, 1880–1882, 1882–1883), which definitions differed from those in common use at that time, so that the indefinite assertions of errors on Zirkel's part, which were not fortified by specific evidence by Wadsworth as to mistakes of mineral determination by Zirkel, coupled with the very obvious animosity of the author toward him, produced feelings of resentment in all those who had received any training in the systematic petrography of the German school. A reply was made by N.F. Merrill in defense of Prof. Zirkel, but it seemed hopeless to argue the matter with one who had redefined the common rock names according to ideas of his own, and whose criticisms were couched in such general terms that it would have been difficult to have confined them to specific cases.

My own experience with Wadsworth was brief and unpleasant. After the publication of the paper by Hague and myself on the rocks of the Pacific Coast volcanoes, he wrote me a short note of thanks and appreciation, adding that he liked the manner in which the work was done and that it reflected credit upon both of us. The following year he wrote a long letter concerning the rocks of the Fortieth Parallel collection, claiming credit for various discoveries of errors and restating some of his general assertions already alluded to, and asking for a fair recognition of his own work. To this I replied that some of the results of my studies of the rocks in question had already gone to the printer and would be published shortly, and that, as I differed from him so materially on many essential points, I did not care at that time to enter upon any discussion, a statement the tone of which seemed to him, as he wrote in a brief reply, to be "decidedly hostile and ungentlemanly." This ended our correspondence. I was not alone in having trouble with Wadsworth, for about this time Whitman Cross was laboring with him over the use of the term *nevadite,* and was fully persuaded that the only way to keep out of trouble with Wadsworth was to have nothing to do with him. Even his first student, Diller, who studied under him at Harvard in 1881, had this to say of him in 1884 in connection with the original *nevadite* of Lassen Peak.[45] That this rock

> is a dacite, as you have shown, there can be no doubt, Mr. Wadsworth to the contrary notwithstanding. I sincerely hope that his great work, which seems to be as important in his own eyes as the New Testament from a scriptural point of view, will soon be given to the world so that some of us young heathen may have an opportunity to escape from the inevitable perdition which, according to Wadsworth, hangs over the followers of Zirkel and Rosenbusch.

Wadsworth's term as a teacher of petrography at Harvard was short-lived; in 1883, he was no longer allowed by the Harvard authorities to teach the subject, according to a communication from George H. Williams.[46]

The experiences just recalled illustrate the possibility of transmitting friendliness or animosity from one person to another in human intercourse. In our criticism of Professor Zirkel's work, Mr. Hague had not only the reputation of the Geological Exploration of the Fortieth Parallel at heart, but a kindly feeling for Professor Zirkel, which was shared by his assistant by reason of his association with his chief, and through an acquired interest in the personnel of the Fortieth Parallel Survey, largely a Yale connection, so that it was the intention of the authors to state the facts with a due consideration for the changes in methods of study within ten years. The result has been a lifelong friendship between Professor Zirkel and myself, which has been a source of profound gratification on my part. In another instance when the youthful ardor of the beginner thought there was an opportunity to acquire merit by criticizing in print an error of a fellow petrographer, with whom he was not as yet acquainted, it was pointed out that a much wiser procedure would be to suggest the correction privately, as it was better to have the goodwill of one's colleague who might (and did) become a lifelong friend,[47] than to make an exhibition of one's self in print, even in the cause of science. In these and other ways, I have been indebted to Hague for wise advice in my interactions with other people.

The severe and badly directed criticism by Wadsworth of Zirkel's report on the Fortieth Parallel rocks may be cited as an illustration of the transmission of animosity from principal to assistant. This might be taken as an echo of the antagonism felt by J.D. Whitney for Clarence King, which I often heard discussed. It went back to the days when there was trouble between Whitney, who was State Geologist of California, and King, who was his assistant. But there was something in Wadsworth's temperament that was peculiarly susceptible to animosities.

NOTES

1. The Eureka Mining District, noteworthy for its silver, gold, and lead deposits, was one of several such districts in the Eureka Mountains, an area of about twenty miles square in the Nevada plateau, near the town of Eureka. The geology consists mainly of Paleozoic limestone and sandstone with some Tertiary and pre-Tertiary lava flows and intrusive rocks.

2. Charles Doolittle Walcott (1850–1927) was an invertebrate paleontologist and stratigrapher. In 1879, he joined the new U.S. Geological Survey as assistant geologist and worked with Iddings in the Eureka District. Three years later he was put in charge of the Division of Invertebrate Paleozoic Paleontology, and after another year he was in charge of all paleontological work of the Survey. Walcott was so able as a researcher and administrator that, in 1894, President Grover Cleveland appointed him as the Survey's third director to succeed John Wesley Powell. During his tenure as director, he also was assistant secretary of the Smithsonian Institution with responsibility for the National Museum. When Secretary Langley died, Walcott was the obvious choice to become the fourth secretary in 1907. At the beginning of the twentieth century, Walcott was instrumental in the establishment of the Carnegie Institution of Washington. As a researcher Walcott was renowned for his studies of Cambrian fossils, including the spectacular Burgess Shale fauna. For further biographical information see Yochelson (1967). The definitive biographies of Walcott are by Yochelson (1998, 2001).

3. Walcott's paleontological work in the Eureka District was reported in Walcott (1884).

4. The term *lithoidal* (or *lithoidic*) was used by von Richthofen (1868) to refer to a dense, stony rock or devitrified glass, as opposed to a glassy rock.

5. In discussing Tertiary and post-Tertiary volcanic rocks, von Richthofen (1868) distinguished between massive eruptions and volcanic eruptions. In the former, volcanic rocks were formed by "flowing from craters in the shape of lava, or being thrown out as scoria and rapilli [*sic*]," whereas in the latter case, "volumes of matter of the same kind have been forced to the surface through extensive fissures and accumulated above them in elongated ranges, when the origin of the outbreaks cannot be ascribed to volcanic activity" (von Richthofen, 1868, p. 9). He further claimed that the "succession of massive eruptions during the Tertiary and post-Tertiary ages had taken place in the following order: 1st Propylite, 2nd Andesite, 3rd Trachyte, 4th Rhyolite, and 5th Basalt."

6. Apophyses are composed of small, finger-like dikes from a larger igneous rock mass projecting into the wall rocks.

7. In a paper on crystallization in igneous rocks, Iddings (1892b, p. 73), having acknowledged consultation with J.D. Dana, applied the term *phenocrysts* to "all those crystals in a porphyritic rock that stand out conspicuously from the surrounding crystals or glass composing the groundmass. They may be large or small."

8. Andrew Cowper Lawson (1861–1952) was competent in several disciplines of geology. From 1883–1890, he worked for the Geological Survey of Canada, did some consulting, and then spent the remainder of his professional career at the University of California. He began as an assistant professor in 1890, working his way to full professor in 1899. He retired in 1928. For further biographical information see Byerly and Louderback (1964), and for a full-length biography see Vaughan (1970).

9. After a few years as a construction and mining engineer, George Ferdinand Becker (1847–1919) joined the U.S. Geological Survey as one of King's first appointees. Becker spent the remainder of his professional career with the Survey as geologist-in-charge. In 1880, King assigned Becker the task of working on western mineral deposits, but especially the geology of the Washoe District, already famous for its fabulously rich Comstock Lode, the chief locus of mining activity in the western United States at the time on account of its gold and silver production. The Washoe District was located on the slope of the Virginia Range, a northeastern offshoot of the Sierra Nevada, about twenty miles southeast of Reno, Nevada, near the towns of Virginia City and Silver City. Among the important rock types were granite, diorite, quartz porphyry, and propylite. For further biographical information see Merrill (1927).

10. *Propylit*e was a term introduced by von Richthofen (1868) for rocks resembling porphyritic diorite that were always porphyritic and contained oligoclase, green hornblende, a greenish groundmass, with small particles of fibrous hornblende. In the field, the rock resembled a greenstone. Eventually careful microscopical study demonstrated that propylite was altered andesite.

11. Carl Barus (1856–1935), among other things, studied the electrical activity of the ore bodies in the Comstock Lode in conjunction with Becker. He worked for the U.S. Geological Survey as a geophysicist between 1880 and 1892. In 1895, he became professor of physics at Brown University, where he remained for the rest of his career. For further biographical information see Lindsay (1943).

12. Grove Karl Gilbert (1843–1918), a brilliant geomorphologist, stratigrapher, and structural geologist, spent much of the 1870s with the Geographical Survey West of the 100th Meridian under Wheeler and the Geographical and Geological Survey of the Rocky Mountain Region under Powell. He then became a member of the U.S. Geological Survey. In addition to his studies of ancient Lake Bonneville, he is renowned for his investigation of the structure and mechanics of intrusion of laccoliths in the Henry Mountains and speculations regarding the origin of craters on the Moon and of Arizona's Meteor Crater. For further biographical information see Davis (1922) and Mendenhall (1920). A full-length biography is that of Pyne (1980).

13. Now spelled "sanidine."

14. Albert Smith Bickmore (1839–1914) was the superintendent and a naturalist at the American Museum of Natural History. For further biographical information see Kunz (1915).

15. Robert Parr Whitfield (1828–1910) was an assistant to James Hall at Rensselaer Polytechnic Institute from 1872 to 1878, and then served as the invertebrate paleontologist at the American Museum from 1878 until his retirement. For further biographical information see Gratacap (1911).

16. James Hall Jr. (1811–1898), arguably America's greatest nineteenth-century paleontologist, was affiliated with the Geological Survey of New York throughout his entire career. He was also the first president of the Geological Society of America. For further biographical information see Dott (2005).

17. Louis Pope Gratacap (1851–1917) was a mineralogist and conchologist at the American Museum. For further biographical information see Kunz (1918).

18. After distinguished service during the Civil War, John Wesley Powell (1834–1902) gained recognition leading the 1869 expedition to explore the Green and Colorado Rivers. Thereafter he contributed to an understanding of the geomorphology and structure of the Colorado Plateau through his leadership of the Geographical and Geological Survey of the Rocky Mountain Region in the 1870s. Upon the resignation of Clarence King in 1881, Powell was installed a few days later as the second director of the U.S. Geological Survey. He resigned from the Survey in 1894 and devoted his attention to the field of ethnology. For further biographical information see Davis (1915). A full-length biography of Powell is that of Worster (2001).

19. Letter from Hawes in New Haven to Iddings, dated December 5, 1880.

20. Letter from Hawes to Iddings, dated March 18, 1881.

21. George Perkins Merrill (1854–1929) was appointed as an assistant to Hawes in the work on the building stones at the National Museum (Smithsonian) in Washington, D.C. After Hawes' death, Merrill became the curator of mineralogy, in the process amassing, organizing, and supervising the museum's meteorite, mineral, rock, and fossil collections over half a century. From 1893 to 1915, he was also professor of mineralogy and geology at George Washington University. For further biographical information see Lindgren (1935).

22. Letter from Hawes to Iddings from Washington, D.C., dated May 4, 1882.

23. Letter from Rosenbusch to Iddings, dated July 21, 1882.

24. A close, lifelong friend of Iddings, Frank Dawson Adams (1859–1942) studied petrography with Rosenbusch. From 1880 to 1889, he was an assistant chemist and petrographer with the Geological Survey of Canada. After the retirement of Sir William Dawson in 1889, Adams was appointed as Logan Professor of Geology at McGill University, in which position he remained until retirement in 1924. Adams produced numerous important studies of Canadian crystalline rocks, such as the Haliburton-Bancroft area (Adams and Barlow, 1910) and the Monteregian Hills (Adams, 1903b), and papers on experimental rock deformation. He was also renowned for *The Birth and Development of the Geological Sciences* (Adams, 1938). He also contributed experimental studies on the flow and strength of rocks and minerals at elevated pressures and temperatures. For further biographical details see Flett (1942).

25. Alfred Richard Cecil Selwyn (1824–1902) worked with geological surveys in Great Britain and Australia and was director of the Geological Survey of Canada from 1869 to 1894. For further biographical information see Woodward (1899).

26. Letter from Adams to Iddings, dated December 3, 1882.

27. Alfred Ellis Törnebohm (1838–1911), a mineralogist and petrologist, served with the Geological Survey of Sweden from 1857 to 1907 and was director of the Survey from 1897 to 1907. For further biographical information see Högbom (1912).

28. George Huntington Williams (1856–1894) was a professor at Johns Hopkins University who specialized in igneous and metamorphic rocks of the Appalachian Piedmont region. He was one of the collaborators with Iddings, Cross, and Pirsson in preliminary discussions about reforming igneous rock classification. For further biographical information see Iddings (1894).

29. Joseph Silas Diller (1850–1928) labored with the U.S. Geological Survey from 1883 to 1923 in such diverse fields as igneous petrology, volcanism, stratigraphy, and economic geology. It was Diller who introduced microscopical petrography to the Survey. Many of his studies involved volcanoes of the Cascade Range, including the eruption of Lassen Peak in 1914. For further biographical information see Collier (1929).

30. While working on his doctoral degree at Harvard, Marshman Edward Wadsworth (1847–1921) was an assistant in lithology with Harvard's Museum of Comparative Zoology (1877–1885). In 1885, he was appointed professor of mineralogy and geology at Colby University (now College). Two years later Wadsworth became the first president of Michigan Technological University, a position he held until 1898. Between 1888 and 1893, he also was the State Geologist of Minnesota. He later worked with state geological or agricultural surveys in Michigan, New Hampshire, and Pennsylvania. For further biographical information see Lane (1924).

31. William Morris Davis (1850–1934), an eminent geomorphologist noted for his theories of landscape evolution, was professor of physical geography at Harvard from 1875–1912. For further biographical information see Daly (1945) and Chorley et al. (1973).

32. Major Clarence Edward Dutton (1841–1912) studied the stratigraphy and structure of the Colorado Plateau with the Powell survey. He later worked with the U.S. Geological Survey until 1890, when he returned to active military service. He developed the theory of isostasy. For further biographical information see Longwell (1958).

33. During the Geological Exploration of the Fortieth Parallel, members of the party conducted reconnaissance explorations and collected rock samples from several Cascade volcanoes during the field season of 1870. Clarence King climbed Lassen Peak and Mount Shasta, where he documented the existence of the first known glacier in the United States. Samuel Emmons climbed Mount Rainier, and Arnold Hague climbed Mount Hood. Hague described the volcanoes, and Iddings studied numerous thin sections of samples that were collected, and discovered that these volcanoes were predominantly composed of hypersthene andesite. He also showed that Mount Rainier consisted almost entirely of hypersthene andesite whereas Lassen Peak, the most complex, consisted of basalt, andesite, and dacite.

34. Letter from Diller to Iddings, dated January 22, 1884.

35. William Francis Hillebrand (1853–1925) was a geochemist and mineralogist with the U.S. Geological Survey from 1880–1885. After that he joined the U.S. Bureau of Standards. For further biographical information see Clarke (1929).

36. Letter from Rosenbusch to Iddings, dated 1882.

37. Letter from Rosenbusch to Iddings, dated October 4, 1882.

38. Letter from Rosenbusch to Iddings, dated September 6, 1884.

39. József Szabó (1822–1894) was a Hungarian mineralogist-petrologist at the University of Budapest and the Geologische Reichsanstalt in Vienna. For further biographical information see Gregory (1895).

40. For their study, Hague and Iddings prepared many new thin sections, not available to Zirkel (1876), of rocks that had been collected by the Fortieth Parallel exploration. They also restricted their study to Tertiary and post-Tertiary volcanic rocks. Their main rock types were basalt, pyroxene andesite (including both hypersthene- and augite-bearing varieties), dacite, and rhyolite. They divided rhyolite into four types: nevadite, liparite, lithoidal rhyolite, and hyalite rhyolite. They also discounted the existence of "propylite." "Our work," they wrote, "leads us to believe that trachytes occupy a far more restricted position among volcanic rocks than has heretofore generally been supposed" (Hague and Iddings, 1884, p. 463).

41. Letter from Iddings in New York to Zirkel, dated June 6, 1884.

42. Iddings then listed specific points of difference but did not include these in his manuscript.

43. Letter from Zirkel to Iddings, undated.

44. Letter from Rosenbusch to Iddings, dated March 31, 1882.

45. Letter from Diller to Iddings, dated June 15, 1884.

46. The communication from Williams was dated October 16, 1883.

47. Whitman Cross added a footnote to Iddings' manuscript at this point as follows: "It may be of interest to point out that the error here referred to was made by myself. The steady, long friendship was also mine. W.C."

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