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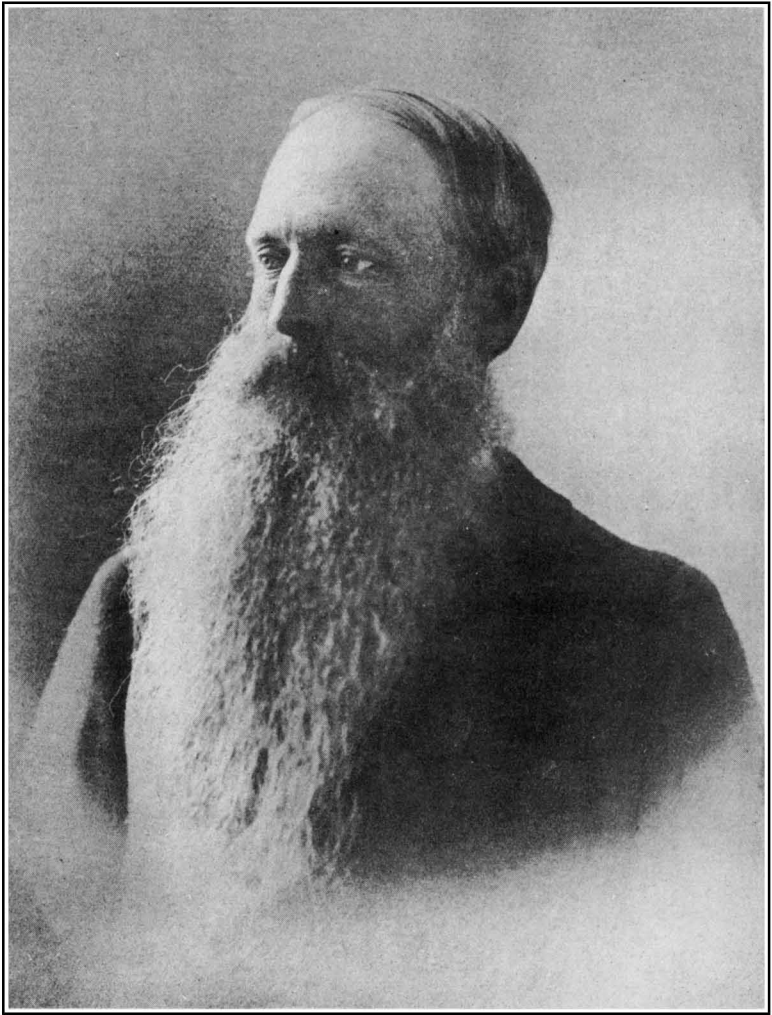
RAPHAEL PUMPELLY

1837—1923

BY

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Raphael Pumpelly

MEMORIAL OF RAPHAEL PUMPELLE¹

BY BAILEY WILLIS

CONTENTS

	Page
Foreword	23
Boyhood	23
Freiberg, 1856 to 1860.....	29
Corsica, 1856 to 1857.....	31
Arizona, 1860 to 1861.....	34
Japan and China, 1861 to 1864.....	36
Lake Superior, 1865 to 1877.....	42
Missouri, 1871 and 1872.....	47
Loess and Secular Disintegration, 1863 and 1876.....	47
Official Surveys, 1879 to 1890.....	49
Green Mountain Studies.....	52
Explorations in Central Asia, 1903 to 1904.....	56
Dublin, New Hampshire.....	60
Bibliography.....	61

FOREWORD

Pumpelly's place is among the great explorers. He inherited the spirit; his environment gave the motive; he achieved the career by virtue of his physical endowment, his high courage, and his mental and moral fitness.

His interest in geology was first aroused by his mother, an unusually gifted woman, and was fixed by early incidental opportunities for observations in Germany and Corsica, followed by a chance meeting with the German geologist, Noeggerath, which led to his going to the mining school at Freiberg. He used his profession of mining engineer, but never devoted himself to it. He served his adopted science, geology, but not exclusively; yet his contributions to its principles and knowledge remain unchallenged after thirty to fifty years of later intensive research along the same lines. He cherished for forty years a dream of carrying out investigations in the archeology and ethnology of the Asiatic and European races and at the age of three score and ten realized it with that same thoroughness and devotion to truth which characterized all of his scientific studies.

BOYHOOD

Pumpelly's paternal grandfather fought through the French and Indian wars and the Revolution. At the close of the latter he moved

¹ Reprinted from the *Bulletin of the Geological Society of America*; vol. 36, 1925.

out onto the then frontier of New York, near Ithaca, with his four sons, of whom John, the oldest, had spied out the land and William, a blond, six feet two in height, became Raphael's father. William is described by his son as a man of noble features and fine presence, of equable and kindly temperament, and with broad sympathies. He transmitted his nobility of spirit, his optimism, and his kindly sympathetic nature to his son.

Raphael's mother came of families that had ruled colonial Connecticut. He says of her: She was of medium stature, erect and energetic, affectionate, and artistic in temperament. He was not trained, as she was, to be an artist, but he inherited from her an appreciation of the beautiful, which she cultivated, and it is evident from his reminiscences that she exercised a dominant influence upon his intellectual and moral development from boyhood on.

Raphael Pumpelly was thus born of English colonial stock, pioneering on the forested frontier, engaged in surveying the boundaries of new states and land grants, clearing the timberlands, exploiting the wealth of the wilderness, and building up the young Commonwealth of New York. Owego, his birthplace, was but forty-five years old when he was born; yet such had been the energy of the settlers that the forest felling, the rafting of lumber down the Susquehanna, the building of roads, and other truly pioneer activities had begun to give place to the established life of an American country town, with good schools and schoolmasters whose wholesome, though stinging, discipline Raphael remembered after threescore years and ten.

N. P. Willis, writing when Raphael was ten or twelve years old, thus described the scenes among which the boy grew up:²

"At Owego there is a remarkable combination of bold scenery and habitable plain. A small, bright river comes in with its valley at right angles to the vale and stream of the Susquehanna, forming a star with three rays or a plain with three radiating valleys, or a city (in the future, perhaps) with three magnificent exits and entrances. The angle is a round mountain, some four or five hundred feet in height, which kneels fairly down at the meeting of the two streams, while another mountain of an easy acclivity lifts gracefully from the opposite bank, as if rising from the same act of homage to Nature. Below the town and above it the mountains for the first time give in to the exact shape of the river's short and capricious course; and the plain on which the town stands is enclosed between two amphitheatres of lofty hills, shaped with the regularity and even edge of a coliseum and resembling the two halves of a leaf-lined vase, struck apart by a twisted wand of silver."

² N. P. Willis: Rural letters, letters from under a bridge, 1849.

Of the Susquehanna Willis wrote:

"This delicious word, in the Indian tongue, describes its peculiar and constant windings; and I venture to say that on no river in the world are the grand and the beautiful in scenery so gloriously mingled. The road to Owego follows the course of the valley rather than of the river, but the silver curves are constantly in view; and from every slight elevation the majestic windings are seen, like the wanderings of a vein, gleaming through green fringes of trees and circling the bright islands which occasionally divide the waters. It is a swift river and singularly living and joyous in its expression."

We may not assume that the scenery impressed the boy as it did the poet, but the river played an important part among the youngster's early stimuli. Twice nearly drowned, he feared to swim beyond his depth; yet, fearing ridicule even more, he dared the boys to follow him on thin ice, or to shoot a dam on a plank, or (most daring of all) to navigate the river in flood on a cake of ice. This last, he records, found no takers and twice nearly finished him. He afterwards looked back on this "bravado" as a most valuable part of his training, for "it taught quickness of perception, the instant cooperation in emergencies of brain, hands, and feet, and that balance between caution and action that forms a basis of judgment."

But it was not alone as a dangerous playfellow that the river entered into the boy's life. Its swift current, coming from who knows where and flowing on into the unknown, became to his adventurous spirit a symbol of life, leading him on, unconscious of its influence, to that career of exploration for which he was so eminently fitted. He knew nothing of the lands he was to visit—Corsica, Arizona, Japan, China, or Siberia. He had no idea of the geological and ethnical problems in which he later interested himself. All that was around the bend. But the shining river, flowing swiftly westward in gleaming curves, can not but have led his fancy on, as he watched the great timber rafts float out of sight, or listened to stories of voyages beyond his ken.

He studied at the Owego Academy, perfunctorily apparently; his real school was out of doors. There he trained his faculties, very much as young Indians had done in the same environment but a few decades before him. His self-respect had not developed beyond the childish principle that one should not be found out. But a piratical downward course on which he and his youthful followers had entered was brought to a sudden close by a serious offense, and he was led to a sense of responsibility for his acts through the searching, though loving, reasoning of his mother and the sound chastisement she gave him in due sequence. Following this, when eleven years old, he was sent away to school to General

Russell's at New Haven, where he spent the next six years, developing by his own account into a manly and honorable, but daring and irresponsible, youth.

In the natural course of events Raphael would have followed the lead of a majority of the scholars of General Russell's Academy and have entered Yale; it was therefore in keeping with the scheme of his life that he went to Europe instead. The thought of so doing was first suggested by his chum, who in the end did not go, but it was the cordial interest taken by his mother in a European journey which made possible the realization of the boy's unusual proposal. It is evident that he and she were comrades in initiative, congenial in spirit and in tastes, and that she, no less than he, looked forward eagerly to the pleasures of a tour abroad. In 1854 the parting on such a journey was a very different thing from what it is today, but her eager, artistic spirit rose to the opportunity without thought of consequences, as was ever his instant impulse.

The experiences of an American boy of seventeen or eighteen as a free lance in Germany or France are the reactions of his character with his environment, as definitely fixed as are chemical combinations. Pumpselly's were no exception. Frankly interested in everything about him—languages, social ways, or scenery—he met every new impression eagerly, instinctively gathered the good from it and passed on in search of further novelty. He acquired French, German, and Italian by listening and talking rather than by study. He readily adopted the ways of congenial companions and made friends among young and old; but one experience of students' carousing disgusted him. He turned rather to his independent life, attending lectures on all kinds of subjects for what he could learn of the language and wandering far afield among the picturesque and romantic scenes of central Germany. Long afterwards he remembered that.

"During the month of May (1855), wonderfully beautiful that year, I tramped up and down the valley of the Rhine and into the interior on each side. To my young imagination that month was a delight. The valley was as yet untouched by the wand of modern industrial desecration, the air was still pure, the sky serene, and the castles crowning the hills were still real moss- and plant-clothed ruins.

"Who can describe the effect of it all on the impressionable imagination of a boy fresh from the land of modernity; the charm of the ever-varying scenery, the vineclad slopes, the echoing cliffs of the Siebengebirge, the castles, the Lorelei-baunted Drachenfels, and the romance and legends of the past?

"Then to me there was another interest which seemed to intertwine itself with the romance and poetry of the region. Here for the first time I came in contact with eruptive rocks, the striking sanadine trachyte cliffs of the

Drachenfels and the porous sapphirine-bearing lavas of the Laacher See. Truly I was entering, though gropingly, into geology through the gate of romance."

Thus Pumpelly gives us the clue to his interest in geology; but the picture of himself is not complete without the added touch of interest in his fellow-men, which was always the dominant one of the two. He continues:

"Bon Cœur (a Newfoundland dog) was always with me, sleeping on or near my bed at night and tramping alongside by day. Admired by all, he introduced his master to many; so that I never lacked chances to talk with men and women of every class, whether residents or travelers."

His attention had been attracted, when he was still a mere boy, to the fossils which are abundant in the strata of the gorges about Owego, and a teacher with whom he had wandered along the Bronx near New York had stimulated his interest in the minerals and metamorphic rocks of that region. While at Hanover he collected ammonites, crinoids, etcetera, from the Deister Mountains, and, hearing that there was a geologist in the neighboring town of Hildesheim, he made an unsolicited visit on the well-known paleontologist Von Roemer in order to see his collection. He was kindly received, and the scientist then and afterwards gave him further insight into the realm of geology and the line of relationships which link extinct forms with the living. Darwin had not then "hurled the bomb of evolution," but the seeds of that understanding were planted in Pumpelly's mind by von Roemer.

More than a year was to pass, however, before his growing interest in geology was to give a definite purpose to his education. In the meantime he continued to develop the habit of observation, with special reference to geologic phenomena and human nature. He made a summer excursion in Switzerland, where the grandeur of the mountains did not fail to make an imperishable impression on his memory. He spent part of a winter in Paris, and left there for Naples to recover from a cold which attacked his lungs. At Naples he resumed his roaming about the country to satisfy his curiosity—we had better call it, rather than interest—in the volcanic phenomena and in the romantic background of Nature and people. He wrote:

"I haunted Vesuvius. I liked to trace the destroying streams of lava that during centuries had coursed down the slopes to the sea, and I noticed as well as I could their difference in structure. Then there was the pleasure in searching for the fragments of limestone hurled out from great depths. They had been changed in the subterranean laboratory to marble, and often contained a variety of beautifully crystallized minerals peculiar to Vesuvius.

Of course, I did not know anything about these minerals, except that they were beautiful in my eyes."

He visited Solfatara, where in the extinct crater he saw the rocks undergoing decomposition by gases with the formation of new minerals. He realized that rocks and minerals are not dead.

"Their stories were in process of forming before my eyes, though to me still unreadable. Having as yet no knowledge of this alphabet, chemistry, I began to draw more remote inferences from grouped observations, and to generalize. Here were two neighboring volcanoes, each showing a different kind of activity; in one the activity was constructive, in the other it was destructive."

Pumpelly thus was led by his own observations to the inference that "heat and gas and water were active agents in building up one volcano and destroying another," but that there was some other factor beyond his reasoning. He traversed the volcanic formations around the bay of Naples until he could have made a geologic map of them, had he known how, and the field of volcanism, with all its diverse phenomena, became correlated in his mind as a whole.

The invaluable character of this effort to unravel a skein of intricate geologic relations, even though with one-eyed understanding, was later fully realized by Pumpelly. It may have been with the kindest purpose that in 1879 he sent a very young and wholly inexperienced geologist, without assistance, to investigate the geology of the iron ores of the eastern United States. It is certainly a testimony to his kindness toward young men that he never uttered a word of criticism of the results.

But Pumpelly's interests were never single. Referring to his roamings around the historic bay, he says:

"The stately lines of Virgil haunted me and, lying on the citadel mound of old Cumæ and on the heights of Baiæ, I reveled in daydreams—the Trojan wanderers and the Sibyl, the Phlegraem fields and Avernus, and the brilliant life of Baiæ all became real. Those weeks are in my memory one continuous happy dream."

There followed a summer in Corsica, of which more anon, and the autumn of 1856 led the wandering youth and his mother, who had been his constant companion wherever it had been practicable, to Vienna, where he by chance strolled into a meeting of the Deutscher Naturforscher Verein. It was a turning point in his life.

Noeggerath was then a great name among German geologists and it belonged to a kindly old man whom Pumpelly happened to address on entering the meeting. Their conversation resulted in an acquaintance and excursion together and Noeggerath, recognizing the boy's qualities

and enthusiasm, advised him to go to the Royal Mining Academy in Freiberg, Saxony. His advice was accepted and thus the decision was made between the interest in geology and the attraction toward a wider, general education, which might have led to concentration on history and ancient literature. Even so, Pumpelly's inclination toward studies in those branches of science which deal more directly with men, such as ethnology and the evolution of civilization, was never lost to him. It led him during his first journey across Asia to grasp the problem of the ancient migration of the Aryan race, and later, in his seventieth year, to return to those deserts to search for buried cities in the kurgans of Turkestan.

FREIBERG, 1856 TO 1860

Freiberg in the middle of the nineteenth century was approaching its centennial (it was founded in 1765) and had great reputation, as well as established traditions of training, for the profession of mining. It was the foremost school of practical mining in existence. It drew students from all countries. To be a Freiberg graduate was to hold a diploma of the highest grade in the profession. Having been established at Freiberg because of the ancient mines still being worked there, it was an outgrowth of practical experience, and practice dominated the then relatively simple theories of mining and metallurgy in the curriculum of the school. Today the requirement of scientific knowledge of geology, chemistry, and physics, in their vastly more complex applications to the arts, has wrought a change in the training of the mining engineer and metallurgist. Although some great schools still use working models of machinery and other equipment for demonstration, even these tools have been subordinated or abandoned in the more advanced curricula, and training in practice has given place to founding in principles. Things have changed at Freiberg also. The mines, after having been worked for some years in order to maintain the school, which sprang from them, have been shut down, and with the growth of mining schools in other lands, especially in America, the former center of the art has lost its pre-eminent position. In Pumpelly's student days it had, however, no equal.

The old Freiberg held another tradition worthy of imitation and which Pumpelly greatly appreciated. It was *Gemuetlichkeit*. Militarism had not yet chilled the genial German spirit. Authority and learning, instead of presenting a barrier to youthful aspirations, opened the doors and pointed the way blazed by experience. Cotta, Weisbach, and Breithaupt met their students in the true fellowship of knowledge and became

in a sense their comrades while retaining their respect. Pumpelly entered readily into this comradeship. Referring to the frequent excursions taken with Cotta, he says:

“During the years I was in Freiberg these trips covered not only the neighboring region, but extended to Bohemia and Thuringia, sometimes lasting a week or even longer. In some of these, in the holidays, several of the other professors joined and the whole became a jovial picnic. These men, old and middle-aged, were quite as good comrades as any of us. Outside of the lecture room they were young as we were; we liked to mingle with them at the restaurant tables, drinking beer, smoking, or telling stories, or in serious talk; and they joined us in the same spirit. I hold this to have been an important element in education. It is a phase that seems to be lacking in our universities and is only partially represented in our conferences on special subjects. Professor Shaler, of Harvard, was the only American instructor I can recall who was a representative of the type of these men in that respect. Bless them and him, for they are remembered with affection and gratitude.”

It may not have been difficult for Pumpelly's generous spirit to learn this lesson of encouragement for the young. That he did learn it and practiced it in all his relations with associates of every degree, none who has come into contact with him would fail to testify. It was his influence, joined to that of Chamberlin, Gilbert, and Powell, which introduced into American geology the habit of give and take in research. It has become so general that he who does not exchange ideas with his fellow or fails to give credit where credit is due achieves something of the unenviable reputation of a miser, as one who is to be condemned for his avariciousness of thought and to be pitied for what he loses.

It was typical of Pumpelly's impatience of close thinking that he never acquired a thorough knowledge of mathematics. This was a great drawback to him, on entering Freiberg as well as later, but as a student he took heroic measures to overcome his deficiency. Finding himself obliged to take private lessons and having no time during the usual waking hours, he hired a student to bring him a tub of cold water at half past three in the morning, pull the bedclothes off him, and start the fire in the big porcelain stove—all under pain of quick dismissal if he failed. This discipline was kept up during three years and was followed each morning by a lesson in mathematics over the coffee cups. The procedure was, however, only partially successful. Pumpelly never developed a memory for detailed minutia, such as the mathematician must possess. He saw the world as the condor sees it, yet could focus his vision intently for the moment.

Cotta seems to have been the chief influence in his studies at Freiberg, but Breithaupt interested him in crystals and in their systematic rela-

tions. Teaching crystallography without mathematics and by the use of models, he pointed out the relationships, an understanding of which transforms the barren description of figures into a fertile field of thought. The study of paragenesis and pseudomorphs, pursued under that able teacher, was developed later in Pumpelly's contributions to metasomatism, especially of the Lake Superior copper ores.

It is difficult after three-quarters of a century to translate our thought to the stage of development of the sciences in that day. We no longer refer to the writings of the men who were then the ultimate authorities: Humboldt, von Buch, Cotta, Lyell, Murchison, Elie de Beaumont, d'Orbigny. Science was then exceedingly simple, but it opened a vast prospect, a fascinating opportunity to a young man with a genius for exploration.

Pumpelly remained at Freiberg until 1860, when, having completed his courses of study, he returned via Paris to America. He had left home as a boy of seventeen; he came back not only grown to manhood, but with a knowledge of the great world, unspoiled yet experienced. Among his companions at Freiberg had been James D. Hague and the brothers Henry and Louis Janin, all three of whom achieved enviable reputations in their profession. They, however, pursued its more technical opportunities, while Pumpelly, after a first essay at mining, struck out into the broader fields of geological exploration.

CORSICA, 1856 TO 1857

It was foretold of Pumpelly, when he was but seventeen, that he would make long journeys by sea and through dangerous lands, but that he would escape, unless taken unawares from behind by some one of his companions. He tells us that the saying made him cautious as to conditions in his rear and elsewhere—that is, it put him on the alert and enabled him to pass safely through various dangers. Whatever the effect of the prophecy upon his imagination, he undoubtedly owed much to his keen, highly developed habit of observation. Again and again in the story of his life it happens that an incident, too slight to be commonly noticed, gave him warning and enabled him to act effectively, in time.

Two summers spent in Corsica, one as a rambler on the lookout for bandits, the other as a companion of the bandits on the lookout for gendarmes, introduced him, while still a youth, to the thrilling delights of a life of romantic risks.

He first saw Corsica while en route from Marseille to Naples, and as his steamer slowly passed the peaks, which rise to nearly ten thousand

feet above the Mediterranean, he longed to roam among them. The realization of his desire came about in a manner so characteristic of himself that it can not be omitted.

One beautiful day in May, 1856, Pumpelly, having grown weary of Florence, where he was with his mother, left her for a day or two at most, not knowing whither fancy might lead him. His impulse took him by train to Leghorn; then by a chance steamer to Bastia, in Corsica, and on to an idyllic visit with a forester and his charming Parisian wife; thence he climbed among the mountains, wandered carefree with the Corsican shepherds, shared their primitive life, and steeped himself in the wild beauty of the heights and in freedom. In September he returned to his mother, to find that his occasional notes, sent back through shepherds, had never reached her, and he was mourned as dead.

There are no more fascinating chapters in Pumpelly's reminiscences than those which describe his two summers among the Corsican shepherds, in whom he found the stern character and virility of ancient Rome, the piety of the early Christians, and the fierce spirit of the Italian vendetta. But only the geologic observations which he made incidentally are appropriate here.

During his early excursions he penetrated to the heart of the island and saw for the first time the core of a granitic massif laid bare by the profound gorges. Later he reached the porphyries of Monte Baglia Orba and observed the variations of color and texture which distinguished the, to him, still unknown rocks. He recognized them, however, as the same that he had seen in the ruins of the palace of the Cæsars in Rome. Noting that one dike would cut through another led him to infer differences of age between the two, and he became interested in tracing out these relationships. The sketches he then made in his notebook (he was but nineteen) afterwards helped to introduce him to Noeggerath, and thus to open the way to Freiberg. During his second visit to the islands he made a systematic study of the porphyries and correlated the dikes according to their differences in age and the rocks they traversed.

Pumpelly also recognized evidences of glaciation in the mountains of Corsica, and thus established the fact that the Glacial Period had left its traces there. His account, published in the *Neues Jahrbuch für Mineralogie*, describes the polished and striated surfaces of the hard porphyries, the transported blocks of rocks not found in place on the slopes where the erratics lie, and a terminal moraine. Referring to three great fragments, 30 to 40 feet through, which were so piled on each other as to form a cave in which he camped with shepherds, he argues:

“Now that one no longer believes in floods of boulders, what transporting agent other than glaciers can have operated here to carry these great rocks down a valley where the average slope is not far from 8 degrees, and to have left them in their present positions without having rounded them off in the least.”

We must remember that Agassiz's hypothesis of glaciation was then in its infancy, and what is today a commonplace of elementary science was an unfamiliar, somewhat daring inference; but, accepting the facts he observed, Pumpelly ranged on into the realm of hypothesis, as was ever the habit of his far-reaching imagination. He reasoned that glaciation should depend on heavy precipitation, as it does, and he sought for geographic conditions to which a greater precipitation in Corsica at an earlier epoch might be ascribed. It was generally believed that the Sahara Desert had formerly been covered by a sea, and he found in that hypothetical water body a source of moisture which the southerly winds should have carried to the Pyrenees, the Alps, and Corsica. He sought confirmatory evidence, not without success, and he was encouraged by Cotta and Reich, his instructors, to write out his hypothesis. They even suggested that it was worthy of the degree of Ph. D. from Heidelberg. Nevertheless, when he came to write down his observations he excluded the theory, because he had no definite evidence that there ever had been an inland sea covering the Sahara. Thus an instinctive caution characteristic of the true scientist withheld the young investigator in his first original essay from falling into error.

In these his earliest steps in geology Pumpelly employed two methods which afterwards characterized his geologic studies and which he has passed on. He grasped the salient facts in bird's-eye view, and from them framed an explanation, an hypothesis. This he tested, modified, proved, or discarded, as additional facts appeared, going on, *pari passu*, to another hypothesis if the first was proved wrong. It is the method of *Sequential hypotheses* in contradistinction to that of *Multiple hypotheses*. The former is as essential and as appropriate to reconnaissance work as the latter is to exhaustive research. The capacity to seize essential facts and to detect their correct relations at a glance is vital to success in exploration and is an attribute of the great explorers. But it requires to be held in check by detailed studies of key phenomena, of those details in which the true relations are demonstrable on a small scale, perhaps, or for a single locality. Only thus can the observer avoid superficial and probably erroneous conclusions. The power thus to guard against false inferences by painstaking investigation of details of key facts is too often lacking in men of the eagle eye, but Pumpelly had it. It was demon-

strated even in his earliest work by the care with which he sketched the relations of the porphyry dikes of Corsica.

ARIZONA, 1860 TO 1861

Arizona in 1860-1861 was a land of hell and sudden death. A majority of its white inhabitants cared little what came after. They knew no law save their own caprice; were exiles from that portion of the frontier where laws could be enforced. Mexican peons constituted another part of the population, indispensable laborers, dangerous cut-throats. The small body of United States soldiers, who had kept a semblance of order, were withdrawn in the spring of 1861, leaving the ranchers and miners to that extermination which had been sworn by the Apaches, whom outrages of every sort had driven to desperation.

Into this lawless land came Pumpelly as mining engineer in charge of the Santa Rita Mine. He was twenty-four. Behind him were Freiberg, Vienna, Rome, and Paris; Corsica also; and if in that far island he had lived among outlaws, they were so only in opposition to the established order. Their own code they obeyed implicitly. Here was a land without law, where a man's only safeguards were physical strength, cool courage, and alertness. Pumpelly possessed these qualifications in high degree. He could ride and shoot, but, most important, he let nothing escape his observation. His cat, sniffing the breeze, warned him of Indians who had just killed his associate, Grosvenor. He himself was one of the very few mining engineers who escaped massacre.

The problems presented by the geologic structure of the mine and the smelting of the ores fully occupied the young engineer during his first few months at the mine. The Santa Rita was reputed to have yielded fabulous wealth to the Spaniards. It was expected to yield accordingly to the new American company, which, like many another, thought to acquire riches for nothing. The working capital was very limited, equipment there was none beyond what the natural resources of the region afforded. The richness of the ores had been exaggerated or the richer ores had been exhausted. The general facts of the geology, the existence of two distinct groups of mineral deposits of which the older was the more valuable, the general character of the ores and their proper metallurgical treatment, none of these now well-known things had been worked out. Pumpelly faced an intricate complexity of problems, which he must solve unaided and without essential materials. He has put the situation into a paragraph:

"We needed fuel, fireproof furnace materials, machinery and power, and the supply of these furnished by Nature in Arizona was of a kind to necessitate

a great deal of trouble and experimenting when taken in connection with the peculiar character of our ore. The season was promising to pass without our hacienda being troubled by Indians, when one morning our whole herd of forty or fifty fine horses and mules was missing. Several times during the remainder of the winter and spring we were attacked by Apaches and our mines were the scene of more fighting than any other part of the Territory."

When the Territory was abandoned to the Indians by the withdrawal of the soldiers, those in charge of the few isolated mines which had been opened could only take such measures as might most speedily and safely enable them to save the movable property and escape. Money was needed and could be had only from the ores. The Santa Rita had no sufficient supply, since the Indians had for some time made it impossible to work the mine, but payment of a debt due from the Heintzelman Mine was accepted in ore worth \$2,000 a ton. It cost the lives of two Mexicans and of Grosvenor to get the ore to the Santa Rita, where Pumpelly and Robinson, the bookkeeper, were thus left to carry on with the aid of a chance American and their unpaid Mexican peons. The Mexicans, armed with rifles to withstand the Indians, were scarcely less dangerous and were not allowed to cross a dead line. Wood had to be cut, hauled in, and burned to charcoal. The furnaces, standing on a point between two ravines, lighted up every object near them and exposed the workers constantly to the fire of the Apaches. Pumpelly's chief smelter was shot and he was obliged to finish the separation of the silver and lead almost without sleep for fifty hours or more.

"The two other Americans, revolver in hand, kept an unceasing guard over the Mexicans; whose manner showed plainly their thoughts. Before the silver was cool we loaded it. We had the remaining property of the company, even to the wooden machine for working the blast, in the wagons and were on the way to Tubac, which we reached the same day. Here, while the last wagon was being unloaded, a rifle was accidentally discharged and the ball, passing through my hair above the ear, deafened me for the whole afternoon. Thus ended my experience of eight months mining in an Apache stronghold."

Truly he may be said to have borne a charmed life.

Geologic studies could not well be carried on satisfactorily under the conditions which governed Pumpelly's movements during that adventurous eight months. Yet he assembled observations bearing on the rocks with which the ores are associated, as well as on the mineralogical nature of the ores themselves and on the sequence of the minerals. These he laid before the California Academy of Sciences in August, 1861. In view of the great advances which have since been made in all branches of mining geology and of the development of the mining districts of

Arizona, his essay is chiefly of historical interest, a milestone from which to measure how far we have come and what a fruitful epoch in science his long life covered.

JAPAN AND CHINA, 1861 TO 1864

At the age of twenty-four Pumpelly was a man of fine physique, combined with a frank, easy manner and a record of achievement. He had been a leader among the students at Freiberg, not because he sought leadership, but through his native qualities—initiative, courage, ability, and good fellowship. His wide and varied associations with all classes of society had given him the bearing of a gentleman of the world, a gentleman without blemish. His unique experiences in Corsica, described with the gift of a born raconteur, had early given him a reputation for daring and geologic understanding, and his success in salvaging the property of the Santa Rita Company under desperate circumstances had confirmed that reputation in America. He was already a prominent figure in his profession.

Thus it happened that he was one of two experts appointed by our Government in response to a request from that of Japan for a geologist and a mining engineer to explore certain lands in southern Yesso and, possibly, to introduce foreign methods of mining and smelting.

Feudal Japan pondered long and gravely the vital question of rank before receiving the experts, Pumpelly and W. P. Blake, but upon assurances from our Minister finally accorded them distinguished standing, such that they were called upon first by the Governor of Yesso. It would have been practically impossible for them to have executed their commission otherwise, since they could hardly have escaped insuperable opposition, if not death, from the natives, had they not been guarded accordingly. There was with very good reason a strong anti-foreign party in Japan, which opposed every move of the weak central government toward opening the empire to the outside world, and the incident of the engagement of the two experts was used as a ground of attack by the great nobles. They accused the Taikoon of throwing the resources of the country open to foreigners, and after a year forced the government to bring the engagement to an end.

Pumpelly has left the record of his observations in Japan in his book of travel, "Across America and Asia," and in the work "Geological Researches in China, Mongolia, and Japan." The former is a graphic description of the strange peoples, their lands, their cities, customs, and politics, sympathetic in feeling and liberal in attitude. The latter consists, so far as Japan is concerned, of geologic itineraries in the island

of Yesso. The author describes them as hasty jottings, made during reconnaissance journeys, at a time when he expected to make a much more thorough study of the geology of Japan. They served, nevertheless, to enable him to distinguish the foundation rocks of the island, a sequence of metamorphosed sediments penetrated by granitic and basic eruptives, and the superjacent volcanic deposits of various kinds. His studies in Corsica and of Vesuvius thus came to his aid on the other side of the globe. He also noted the coastal terraces and identified them as recently elevated, finding marine shells in which the organic matter was not entirely decomposed. The distribution of the various rocks, so far as he was able to observe them, is shown in a sketch map, one of the earliest geological maps of Japan.

Driven out of Japan by the daimios, whose opposition to the more liberal policy of the Tycoon led practically to a state of civil war, Pumpelly proceeded on his own resources to China, to gratify his taste for exploration in that unknown land, so recently opened to modern travelers.

In speaking of the reopening of China, we are apt to forget that between 1541 and 1720 Jesuit missionaries penetrated to every part of the Empire, that they exercised an important influence at the court, and almost succeeded in converting the Emperor himself to Christianity. China was then open to Europeans, but was closed by the anti-Christian agitation about 1720 and remained so for more than a century. During that time China stood still, while Europe advanced by leaps and bounds. America stood in the vanguard of that advance, and Pumpelly, coming from the frontiers of America, yet equipped with the science of modern Europe, looked upon the ancient people through youthful eyes, the eyes of hope and fair play. "Across America and Asia" contains a chapter on the Chinese as emigrants and colonizers, in which the author analyzes the relations of the Chinese and Caucasian races with an intimate understanding of the social and economic problems, and the dedication of that work, written in 1870, expresses the optimism with which he characteristically regarded the long future:

"As so many of the following pages relate to experiences illustrating the wisdom of that diplomatic policy which, in bringing China into the circle of interdependent nations, promises good to the whole world, I dedicate them to the chief author of that policy—to Anson Burlingame."

Fifty years have passed since that was written, and the impartial observer must admit that much evil has developed from the meeting of the races, as well as good. Nevertheless, one who has trodden in Pumpelly's footsteps, who knows how often the patient, long-suffering Chinese have

risen Phoenix-like from chaos, and who believes in the inevitable supremacy of justice and fair play among Americans, must agree with Pumpelly in his faith in the ultimate preponderance of good to flow from the establishment of mutual relations among the races of men.

Pumpelly was the pioneer geologist of China. The scientific labors of the Jesuits were purely geographical and could not, in view of the lack of geological knowledge at that time, have yielded any understanding of the rocky structure of the country. They did serve, however, to furnish that indispensable prerequisite to geological research, a base map on which to present the geographic relations of the facts. From the Jesuits down to Pumpelly's day certain diplomatic missions had been permitted to traverse the interior, and it had not failed that botanists and zoologists had in a few instances penetrated the land; but such journeys were undertaken only by special permission or at very great personal risk.

From 1860 to 1862 there had been in China a German diplomatic mission, attached to which was a young geologist, Ferdinand von Richthofen, who was eager to explore. He found the conditions so unfavorable, however, that he confined his movements to the coast. Completely thwarted in his efforts, he visited the East Indies and finally crossed the Pacific to California, where he remained until 1868. He had then developed a plan for a systematic exploration of the Chinese Empire and, backed by Professor Whitney, he secured funds for an expedition from the Bank of California. Returning to China, he entered upon his task, to which during four years he devoted all his energies, with the result that his name, Von Richthofen, is identified in the annals of science with the unveiling of the "Middle Kingdom." His researches into the physical geography and geology of the country continued throughout his life, and he left a third volume of his great work, "China," unpublished at the time of his death, in 1905.

In 1863, after Richthofen had left for California, Pumpelly arrived in Shanghai, where he remained some weeks. Seeing on the Yangtze river a boatload of excellent coal from far in the interior, he was seized by a longing to explore. In his "Reminiscences" he says:

"Excepting missionaries, few travelers had penetrated far into the interior. Huc had descended the Yangtze from Tibet. Blakeston had described that river. The geology of the Empire was absolutely unknown, for Richthofen had not yet undertaken his monumental work. So here, as in Corsica, yielding to the call of the unknown, I engaged passage on the steamer *Surprise*, bound for Hankow, the end of steam navigation up the Yangtze."

Thus, like a boy starting on a pleasure trip, Pompey's struck out into a country devastated by nine years of rebellion and scarcely less lawless,

so far as foreigners were concerned, than the Arizona from which he had so recently escaped. He was not in search of adventure. Danger was merely incidental to satisfying that interest he felt in the strange people and their unknown land. But neither did danger deter him, either out of regard for his safety or because it would interfere with the attainment of that knowledge which he sought. In this latter respect he differed from Richthofen.

It is interesting to contrast these two great explorers, who had so much in common, yet pursued their ends so differently. It was the writer's privilege to know them both. They were equally bold in conceiving their plans, equally broad in their interests in the Chinese as a people and in China as a land. They differed radically, however, in their ultimate purposes. Pumpelly sought knowledge for knowledge's sake. He wished to know the as yet unknown, but he felt no impelling desire to inform others, nor any special obligation to do so. In his generosity he gave as freely of his thoughts as of things material and always with the desire that others should derive the greatest possible benefit from the intellectual largesse that he scattered so liberally. It might contain the seed of a vital contribution to science; he who could cultivate it was welcome to the reward of its harvest. With Richthofen it was otherwise. He was a guardian of learning. He felt responsible for it. In its pursuit he was farsighted, systematic, patient, and persistent. What he acquired he cultivated. His harvest he shared with those whom he deemed worthy. To do so and to welcome any contribution, of fact or of right inference, these were part of the obligation laid on him by his station and his standing.

The difference between the two was temperamental and not merely individual, but racial. Pumpelly derived from the roving Vikings, happiest when driving care-free down the winds of opportunity beyond the ken of men. Richthofen was a modern Roman, obedient to the system in which he had been drilled and of which he knew himself to be a leading exponent. They typify the spirits of America and Prussia.

Pumpelly's excursions in China were limited as compared with Richthofen's journeys. He did not wait for favorable conditions, but even he, when low with fever, could be turned back by a Chinese mob. Thus it happened that he and his companion, the Rev. Josiah Cox, cut their houseboat adrift before the charge of thirty thousand and abandoned the examination of the coal fields of Hunan, the province in which the natives were most violently opposed to foreigners. They were not deterred, however, from proceeding on their voyage up the Yangtze, which they ascended to the head of the Lower Gorges. Pumpelly was deeply

impressed by the superb scenery, where the huge river coils through the narrow pass between towering cliffs of limestone. He watched with intense interest the progress made by a hundred and fifty coolies, who dragged the junk up against the tumultuous current, as had been the custom for thousands of years. He probably felt a thrill not unmixed with delight when the bamboo ropes parted and they went swirling downstream, for who could know what would happen next?

Eight days were required to warp up through the Gorges, and Pumpelly observed the vast arch in which the strata, that at Ichang emerge from under the plain of the Yangtze, rise and descend again, after arching to such a height that the underlying granite is exposed in the center. The axis of this arch, or anticline, trends northeast-southwest, as Pumpelly noted. Subsequently he connected it with the marginal ranges of the Mongolian plateau and other features having the same trend and thus identified a major structural feature of the Asiatic continent. He gave it the name of "Sinian" trend or axis, from the ancient Hebrew name *Sinim* for China. He thus recognized and named one of the cornerstones of the geology of Asia, both the structure and the name having been accepted by all later observers.

The limestone formation which constitutes the walls of the gorges impressed Pumpelly with its extraordinary thickness. The grandeur of the cliffs suggested the vastness of the seas in which the strata had been deposited and made an impression that influenced his views on the area covered by it. He estimated the thickness of it at 11,600 feet. It has since been determined to be about 8,800 feet, including a parting of shale. He found no fossils, but thought that certain Devonian forms which had been identified from China must represent it, and therefore assigned the entire thickness to that period. We now know that the lower part belongs to the Cambrian and Ordovician ages, while the upper limestone pertains to the Carboniferous.

The recognition of the Sinian trends and the assumption of a widespread Devonian limestone gave a clue to the general structure of China, which Pumpelly embodied in the first geological map of the empire ever attempted. Beneath the "Devonian" limestone he grouped all the rocks in a "granito-metamorphic series." The Coal Measures he placed in the Triassic on the evidence of plants identified for him by Newberry. The alluvium of the eastern plains he assigned to the "Tertiary and post-Tertiary." He traced the distribution of these few formations by the occurrence of characteristic minerals, as reported to him by Chinese scholars whom he employed to search the records for that purpose. Thus he expanded his own meager observations to a sketch which, if necessarily

erroneous in many ways, nevertheless contains a large proportion of correct inference.

In turning to Chinese records for information regarding the distribution of mineral resources, Pumpelly was not deterred by the volume of the material, which was enormous, nor by his ignorance of the language. He found natives to glean the scanty data from the huge volumes of ancient and recent writings and missionaries to translate them. It was a characteristic effort, due rather to his German training than to any personal inclination toward exhaustive research, but one which was frequently repeated in the course of his career. He appreciated the value of details, even though he himself would only reluctantly go through the drudgery of digging them up. He willingly left to others both the labor and the credit. Van Hise, a master of detail, whose volumes outbulk Pumpelly's writings a thousand to one, presents an interesting contrast. He also employed others to work with him, but very differently. Meticulously accurate and systematic, he planned his work far in advance, estimated his own ability to execute the more essential part, and availed himself of the aid necessary to secure completion within the allotted time. Single in purpose, he completed each task according to a preconceived plan. Pumpelly, on the other hand, conceived a fruitful thought as lightly as a boy sees a vision in the sunrise, as lightly he gave it wing, and he was happy if another thought it worthy of attention. He congratulated himself that there were others trained and more than willing to follow out the lines of investigation which he spontaneously suggested, leaving him free to turn to any one of the manifold interests which claimed him.

Pumpelly's journeys in China during the autumn of 1863 were accomplished under official escort in search of coal for naval use. They served to broaden his understanding of the relations of the Coal Measures with the great limestone formation and gave him the foundation upon which he expanded his observations in the Yangtze Valley to northern China. They also afforded him material for amusing chapters in *Across America and Asia*. He spent 1864 partly in China, partly in Japan, and in November of that year started to return to America by crossing Mongolia and Siberia to Europe. On this journey he made those observations of the inland basins of Asia and of the disintegration of rocks in an arid climate which appeared subsequently in his theory of the loess as a lacustrine deposit.

In his scientific contributions to the geology of Asia, Pumpelly apologizes for the often meager results on the ground that the expeditions were carried out with private funds and were attended with difficulties

due to the hostility of the natives. He also mentions the intense cold of a winter journey across the plateaus of Tibet as a limitation to geologic observation. To these we may add the very inadequate state of geologic knowledge and theory when considered as a key to the problems he had to face. Thus he reasoned regarding the origin of the rock-rimmed basins of central Asia. Having no outlet, they could not be stream-eroded valleys. Wind, however, was an obvious eroding agent which could excavate basins, and so he attributed to the wind effects whose magnitude surpasses its reasonable activities. There was then no hint of the physiographic clue by means of which we have since learned that the surfaces of the continents, and notably of Asia, have been warped recently in a way which gives rise to wide depressions as well as to broad plateaus.

He recognized that the Yellow River in its north-south course, before it turns east toward the plains, follows an unusual channel across east-west mountains, but since science knew nothing of the changes which may be imposed on a river by stream-capture, he sought an explanation in a catastrophe, an upheaval, of which he found suggestions in very ancient Chinese traditions.

He was impressed by the enormously wide distribution and thickness of the fine-grained loess deposits and, following the accepted theory of lacustrine origin, he postulated the former existence of extensive lakes. Thus he reasoned according to the state of theory at that time, and failed to find the correct solution of the problems because they were beyond the reach of contemporary understanding; but he grasped the problems.

LAKE SUPERIOR, 1865 TO 1877

Upon his return to America in 1865, Pumpelly encountered the changes wrought by the Civil War. With the exception of what may be called a brief visit to his home in 1860, he had been away sixteen years—years of growth from boyhood to maturity for any man and for him years of extraordinary experience. Writing of it fifty years later, he refers to the desultory character of his schooling, comprised in the preparation for Yale and three years at Freiberg, and stresses the value of that broader education which flows from intercourse with the world:

“One can not in young manhood be in more or less intimate and confidential and unprejudiced association with men and women of many peoples without getting some insight into the complexity of human nature, into the relation of virtues and weaknesses to subconscious motive forces. Such experience makes for introspection and charity.

“I had learned also the sameness of the fundamentals of human nature,

whether evident on the surface in the savage, or veiled by conventional restraint in civilization, or again in the white man when unrestrained beyond civilized environment. I had employed men of many kinds and races—Corsican mountaineers, Indians, Mexicans, white men (both normal and outlaw), Japanese, Chinese, and Mongolians—and had learned to understand racial character well enough to get on smoothly. In Japan, in official position, under the feudal régime, I had established intimate, in some cases affectionate, relations with my staff of Samurai officers. In extended travels in China my experience had ranged from the receipt of courteous hospitality to the necessity of turning a hostile mob into a friendly one.

"In commercial Shanghai I had seen the causes of dislike of the foreigner. In Peking I had purposely been allowed to see at first hand the attempts of a broad diplomacy intended to remove those causes. And as the head of an Imperial Chinese commission consisting of civil and military mandarins, I had come in contact with local magistrates and had seen something of Chinese character in dealings of the central government with the local democracy.

"I had seen nature in all its aspects, of mountain and desert and cultivation, between the tropical and Arctic circles, and its corresponding influences on man and civilization.

"These were some of the factors in my deeper education up to my twenty-eighth year. If I had been conscious of the fact that I was going through a great school, I should undoubtedly have profited vastly more than I did. However, in its gradual growth that school had helped me through dangerous or delicate situations, and had moved me to give weight to the better instincts of men of all races when those instincts are properly appealed to. It had developed in me a racial sympathy and made clear the dangers of racial prejudice."

Thus, before reaching the age of thirty, but a third of his life gone by, Pumpelly had graduated from the school of human nature with the degree of *advocate of tolerance*. He is a rare exception to the rule that most men never enter that school understandingly and few get beyond its most elementary lessons, however long they may live. Those who attain to his degree are apostles of the millennium.

The Civil War left a number of men in the prime of life accustomed to danger, initiative, and large undertakings. A post-war period is intensely stimulating when the exhaustion of resources has not gone too far, and in the United States the vast wealth native to the country was scarcely touched. It was an environment in which Pumpelly found many congenial friends and opportunities for the exercise of his special gifts and training. He did not immediately enter upon the practice of his profession, but gave himself up to the enjoyment of society, where his personal charm, his geniality, and his broad knowledge made him universally welcome, and to the writing of his two books, "Across

America and Asia” and “Geological Researches in China, Mongolia, and Japan.”

He became closely associated with Whitney, whom he had known in California, and through him he was invited to accept the Chair of Mining at Harvard under the Sturgis-Hooper Endowment. As the available income would not suffice to pay him a professor's salary, Pumpelly accepted; his duties would be light and he would have much freedom. He is therefore listed as having been a professor at Harvard, but he never entered seriously upon the work of teaching in the university. Inspiring as he was as an instructor in the presence of Nature, he was ill fitted for systematic teaching in an institution.

In the summer of 1866 Pumpelly made a first excursion to Lake Superior to report on a copper property, and became acquainted with the possibilities offered by exploration of the iron ore ranges as well. He was by nature a prospector, and here was a prospector's chance, upon which he prepared to embark, risking his own and his brother's resources. But, given an opportunity to locate a floating land grant, he was enabled to do justice to his employers while at the same time he studied the conditions of occurrence of the iron ores and became acquainted with lands they could not acquire. Thus left free to exercise the right of second choice, he threw himself into the exploration with the definite purpose of investing his savings in timber and iron lands. At this time he became acquainted with Major T. B. Brooks, who had already worked out the geology of the Marquette iron district, and the two entered into an informal association, which lasted without any written contract for nearly forty years. Confiding each in the other, they invested from time to time such funds as each could individually spare in lands that one or the other of them might select.

Brooks was a self-made engineer and geologist, who by force of character, ability, and indomitable energy had developed himself from a farmer's boy to the position of vice-president and general manager of the Clifton iron mine on the practical side and in the scientific world to that of the leading authority on the geology of the iron deposits. He was a year older than Pumpelly—that is, just thirty—when they met; but, having spent three years under the stern discipline of war and possessing a far more exacting habit of life, he seemed much older by comparison. The two men came together on the common ground of their interest in exploration with both practical and scientific objects in view. They became united by bonds of mutual respect and confidence, which were never broken. Their families came into relations of intimacy. Yet there must ever have remained in each a phase with which the other

could not readily sympathize. Brooks was intensely practical, definite, and devoted to the business in hand. Pumpelly was habitually impatient of details, eager to be done with them, so that he might be free to roam in any one of the intellectual fields so attractive to his brilliant mind. Ten years later the writer received his earliest training in field-work from these two geologists. Brooks might have been a father, Pumpelly Phœbus Apollo.

The State of Michigan was fortunate at this time, when the exploitation of its resources was just beginning, to have two such men as Brooks and Pumpelly interested in that development. They accepted the tasks of surveying the iron and copper districts and laid sound geological foundations for prospecting and mining. The insignificant appropriation made by the State was inadequate even for expenses. The investigations were thus a gift to the Commonwealth as well as to science.

Pumpelly undertook the study of the copper deposits. The limitations of the work required that he should decide between a general reconnaissance of the forested and drift-covered area or limited but accurate observations of certain sections and deposits. In contrast to what one might have expected, he chose the latter, rightly judging that specific information regarding the stratigraphy and conditions of mineralization of the copper-bearing rocks would be of more value than loose generalizations, such as had characterized the exploratory work of his predecessors. The problem was one for which his German training had prepared him advantageously.

Delegating the measurement of sections across the series of strata to his assistant, Marvin, he himself undertook the investigation of the broader stratigraphic relations, especially those of the bedded copper-bearing sandstones and volcanics with the Cambrian, which had been described as conformable. This required field observations of a kind in which we might expect him to excel, as he did—observations demanding the correlation of facts assembled from a wide area and interpreted with keen perception of their relative value and significance. He recognized the now well-known unconformity between the Keweenaw and Cambrian sandstones and published jointly with Brooks an article on the age of the copper-bearing rocks.

Pumpelly's major contribution to the study of the copper deposits reminds one of Breithaupt, his instructor in crystallography. Seeking the conditions under which the native copper had been deposited in association with quartz, epidote, prehnite, calcite, and other minerals, he examined under the microscope hundreds of thin-sections, which he ground himself, measured the angles of microscopic crystals, and distinguished

the older from the younger minerals by the interpenetration of one by another or by the forms assumed by pseudomorphs. He thus determined the paragenesis of the copper and traced its reduction to the metallic state through the chemical reactions with ferrous minerals present in the associated rocks. He attributed the concentration of the metal to descending surface waters. In this he followed Whitney and has been followed by Wadsworth.³ Van Hise was of the opinion that ascending waters had brought in the copper, but this is not sustained by the evidence, according to Lindgren. In identifying the copper as indigenous to the series of rocks in which it occurs, Pumpelly thought it to have been derived originally from seawater. Van Hise later called attention to the widespread occurrence of it in the Keweenaw traps and looked on the lavas as the source. Lane has suggested that the submarine outflow of the lavas gave rise to reactions with the seawater, which led to the reduction of the copper. This is a modification of Pumpelly's idea, which postulates ferrous oxide as the reducing agent. Exhaustive research has thus to some extent supplemented or modified the views of the pioneer in this field, but the body of fact and inference which he assembled remains the accepted truth. The surprising thing to one who has followed his adventurous career through Arizona and Asia is that he could patiently devote himself to tedious microscopic studies with such success. He began his work on the copper deposits in 1870 and his last paper on the subject, "Metasomatic development of the copper-bearing rocks of Lake Superior," was finished in 1877.

Pumpelly's work on the Lake Superior copper deposits would present no novelty if carried out today, when the processes of metamorphism have become familiar to all students of ore deposits, but they constituted an original contribution of very great value fifty years ago. Among those who then came under his influence was Waldemar Lindgren, at the time just entering on that career in economic geology in which he has rendered such valuable service to science and mining. He, like Pumpelly, was a graduate of Freiberg and, of Swedish birth, had recently come from Europe when he entered the Transcontinental Survey. He writes:³

"I first met Pumpelly in November, 1883, and remained in his office at Newport until February, working during that time on thin-sections of rocks obtained during the field-work of the Transcontinental Survey in the summer of 1883. I was tremendously impressed, both by his knowledge and personality, and I shall always remember his kindness to me, at that time a recent graduate from the schools. His advice on petrographic work was extremely

³ Personal communication.

helpful, but I was not then acquainted with his epoch-making work on the minerals of the Lake Superior district. As I began to dip into metasomatism later on, I soon found that he was really a pioneer in the study of changes which minerals undergo. Of course, this matter had been discussed previously by Naumann, Blum, and others in Germany and elsewhere in Europe, but Pumpelly was the first to apply the microscope to these problems. He was probably the first one in this country who undertook petrographic examinations by using thin-sections. Neither the microscopes nor the sections were as good as they are now, but it remains as a great credit to his genius that the conclusions he arrived at stand, with minor exceptions, practically unchanged today. His work showed great originality, and in this direction of the microscopic study of minerals he was as much of a pioneer as he proved to be in geological explorations: Our geology of today certainly owes a great deal to his pioneering work."

Thus Pumpelly opened up a new line of research in this country, one which has proved a mine of wealth in a material as well as scientific sense. His ideas are reflected in Brooks's early suggestion of the secondary origin of the Lake Superior iron ores, fully developed and established later by Van Hise, and they have borne fruit in the comprehensive studies of secondary enrichment which characterize the investigations of ore deposits during the last two or three decades.

MISSOURI, 1871 AND 1872

Appointed State Geologist of Missouri in the autumn of 1871, Pumpelly took up the task with the intention of remaining in the official position only as long as might be necessary to study the geology and distribution of the iron ores of the State and to prepare the way for a systematic study of the other mineral resources. Being taken seriously ill after a year in office, he resigned in the winter of 1872-1873. His contribution to geology during this eighteen months is comprised in the report of the Geological Survey of Missouri for 1872. He himself wrote only on the geology of Pilot Knob and vicinity and he confined himself to a description of the occurrences and kinds of the iron and manganese ores. It was a preliminary, perhaps, to a systematic study of their origin, but if so it was never carried further. In resigning, Pumpelly left a good working organization, which was taken over and carried on by his successor, G. C. Broadhead.

LOESS AND SECULAR DISINTEGRATION, 1863 AND 1876

Earlier in this memoir reference has been made to Pumpelly's observations of the widespread deposits of loess in China and central Asia, which he explained as of aqueous sedimentary origin, consisting of glacial mud

laid down in a chain of lakes. It was not known in 1863 that northern Asia had not been extensively glaciated, and the topography of the continent had not been mapped with sufficient detail to render improbable the former existence of great lakes. Richthofen's extended journeys gave him a better opportunity to observe the extraordinary facts of the distribution of Chinese loess and led him to the correct hypothesis of its carriage and deposition by wind.

The origin of the material of which loess consists Richthofen sought in the disintegration of rocks under changes of temperature and in wind erosion of soft desert formations rather than in glacial erosion, as Pumpelly had done.

But both of them in their earlier thought had failed to recognize that the processes of grinding or disintegration are far too slow to keep pace with the transportation of loess. The current local supply would be exhausted and loess accumulation would cease long before quantities such as exist could possibly be assembled. Pumpelly, reviewing Richthofen's work in 1876, recognized this weakness in the former's hypothesis of loess origin. While he accepted the revision of his own ideas and endorsed as correct Richthofen's theory of transportation and deposition by wind, he brought his observation of the deep decay of rocks in moist climates to bear on the problem of original supply and supplemented the theory at a vital point. He also extended his idea to the origin of ice-transported material. We may best quote his own words from his "Reminiscences" (page 612). He says:

"My argument was:

"(1) That during long ages of normally moist climate the rocks of a region become disintegrated and decomposed often to great depths. This is evident in all regions that have not been denuded by glacial action.

"(2) That any climatic change that permanently destroys the vegetation leaves the disintegrated mass a prey to forces of transportation.

"(3) Through a climatic change causing a glacial period there would come the removal of the altered rock-mass in all the forms of glacial debris—boulders, gravel, clay, and glacial flour, which is the product of the grinding of debris and rock bed under the moving ice. This material is in part left by the retreating glacier as moraine and glacial drift or till, and in part is carried as coarser or finer debris by streams to be spread over the lowlands or carried to the sea. The downward disintegration acting on rocks of different power of resistance would leave an abnormally irregular topography of the solid rock surface in which depressions scoured out by the loaded ice would remain as rock basins.

"(4) If the change is to aridity, the region becomes a desert, vegetation disappears, and the disintegrated rock-mass becomes prey to the winds.

"In Asia the products of glacier work were spread out to dry on the flood-plains of rivers emerging onto the deserts. Thus water had played an

intermediate part in the origin of a portion of the loess. But the final stage of its transportation was, as shown by Richthofen, by the winds that sifted it out from the sands and carried it beyond the barren desert to find rest in the grass, which protected it and which it nourished. Richthofen accepted my view and published it with credit in his second volume."

Here was a broad deduction, based on extended observation and carried to its logical consequences. It embraced the concepts of changing climates, altered conditions of erosion by ice, wind, or water, varied results in sedimentation, and the effect of modified environment on organisms. In Pumpelly's presentation before the National Academy of Sciences he touched upon each of these aspects of the subject and demonstrated his grasp of them. Yet he did not follow them further, did not develop the lines of investigation which radiate from this central group of ideas.

Another great mind, a contemporary of his, similarly brought face to face with the problem of climatic change, pursued its ramifications till led to a new theory of cosmogony. His was the mind of a profound and philosophic thinker. Pumpelly's was that of the explorer in the realm of thought as in that of observation. He glimpsed a truth; he described what he saw from the mountain top; he did not descend to launch his thought on an eddying current; he had no impulse to survey in detail the scenes among which he would not permanently abide.

Yet his argument rounded out the suggestions of other geologists and introduced the climatic factor as an essential element of reasoning regarding the processes of evolution of physiographic features, continental or marine sediments, and the development of organisms, including man and his civilization. In this last-named relation Pumpelly long afterward showed the importance of the climatic factor in his investigations of the ancient cities of central Asia.

OFFICIAL SURVEYS, 1879 TO 1890

Pumpelly was now forty years of age. He had behind him the experience and observations of an ordinarily full life. Although at times hard pressed for immediate moneys, for he was a generous and care-free spender, he had from his student days up been accustomed to alternating fullness and emptiness of purse, and its condition never long affected his habit of living. He was happily married; he had hosts of friends with whom he shared a variety of interests. Science, literature, history, art, development of national resources, farming, social opportunities—all drew out his abundant interest, gave outlet to his exuberant vitality.

Under these circumstances he was naturally invited to take part in the

larger enterprises in which geology was a factor, not as an investigator, but as an organizer.

The consolidation of the Government surveys of the Far West under the leadership of Clarence King and the plans which the Survey developed in connection with the taking of the Tenth Census gave Pumpelly an opportunity. He accepted the responsibility for the census of the mineral industries, exclusive of the precious metals and petroleum, and directed the forces at his disposal toward a complete investigation of the geology and chemical nature of the iron ores of the country, at least in the more settled regions. This purpose was a natural outcome of his world-wide knowledge of the bases of civilization and his intimate studies of the iron deposits of Lake Superior and Missouri. He fully realized that the future of American industries was involved in the production of iron and steel in competition with the world. He appreciated the need of more thorough knowledge of the distribution of good ores. His mind daringly hurdled the difficulties of so great a task and he confidently organized his division, with very inadequate resources in men and money, it must be confessed.

Four young geologists were sent into the field equipped with the title of "special expert," the humor of which the writer, at least, who was of the number, was too inexperienced to appreciate. A group of chemists was gathered at headquarters, in Newport, Rhode Island. During two years, 1879 to 1881, the field men diligently sought out the iron ore occurrences of the States east of the Great Plains, many of them known only through the tradition of a colonial charcoal furnace. Each occurrence was described as found and any available ore was sampled as carefully as the circumstances permitted. In the case of working mines or stock piles, the method of quartering down large samples composed of many bits of ore taken at random was employed; in the case of an abandoned ore bank, such material as was on the surface was taken. There was no excavating. The observation of geologic associations had to be superficial. Nevertheless, the amount of information gathered, comprising the description of localities and the chemical analyses of more than a thousand ore deposits, constitutes an important contribution to our knowledge of the national resources in this important metal. Pumpelly's share in it lies in the initiative, in the working out of a practical plan within the limited appropriation, and particularly in the inspiration he gave to his assistants. In his "Reminiscences" he refers appreciatively to the *esprit de corps* which ruled throughout the organization. The thrill of it persists after more than forty years. Its source was in his

own abounding enthusiasm and generous confidence in the loyalty and capacity of the young men whom he drew about him.

In 1881, before the Census work was completed, Pumpelly was offered an opportunity than which none could have been better suited to his tastes and abilities. Mr. Henry Villard, president of the newly reorganized Northern Pacific Railway, with rare foresight, realized that the exploitation of the vast empire across which the road was being built would proceed far more advantageously if guided by knowledge of the resources of the region. He appreciated, furthermore, the need of basing that knowledge on facts rather than on hearsay, and he understood that facts can best be assembled by trained observers. He proposed, therefore, the organization of an economic survey, which was to cover the freight resources tributary to his road and which should rest upon studies of the geology, soils, and timber lands. He invited Pumpelly to become its director.

With what enthusiasm that invitation was accepted can be understood only by one who knew Pumpelly's interest in great, beneficent enterprises of a practical character. He was a man of very broad, far-seeing vision. So was Henry Villard, though from another angle. Their two minds worked sympathetically. Here was a vast realm of great potentialities; here were almost limitless plains and mountains, under varied climates, to be opened to human settlement; here were resources of all kinds to be exploited in the building up of new communities; the railway, stretching out under Villard's direction, was to be the instrument and Pumpelly's survey the guiding intelligence of this illimitable enterprise.

It was born too big to live long. The Northern Transcontinental Survey, as it was called, demanded expenditures commensurate with its scope. Mr. Villard supported it most liberally while his power lasted; but when, after three years of intense activity, he failed, just as the rails were linked from terminus to terminus, the Survey fell with him.

We are not here concerned with the causes of the failure, which are to be sought in the rivalries of kings of finance for the control of empires; but it is but doing justice to two able, practical men to record the fact that the Transcontinental Survey far more than paid for itself. It may fairly be estimated that it saved its cost in checking the extortion which was being practiced by officials of the road upon the company (through the reselling of lands privately purchased by them or their friends) and in coal lands that were discovered by the geologists of the Survey and acquired by the Land Department of the railway it has paid for itself many times over, with compound interest on the investment.

Pumpelly threw himself into the work with optimistic energy. In his "Reminiscences" he states that he divided his personal supervision between administrative work and reconnaissance expeditions, to get the broad conceptions of the problems necessary to blocking out plans. His capacity in administration was shown chiefly in selecting his assistants, nearly all of them young men, to whom he gave generously of confidence and freedom of action—an excellent method when the initial choice has been wisely made. His personal direction of the work was limited to brief instructions, commonly given orally, and to occasional visits of a day or two, devoted to rapid reconnaissances of the fields under survey. He trusted us (I speak for my comrades, most of whom have preceded their great chief on the long trail) and he received the response which youth ever gives to faith associated with enthusiasm.

The winters of 1882, 1883, and 1884 were spent by the entire technical force at headquarters, at Newport, Rhode Island, where the younger members enjoyed frequent contact with the director and learned much from his world-wide experience. Pumpelly spent the summers of 1882 and 1883 in Montana and the Rocky Mountains of Idaho. He made two attempts to cross the latter, from the Plains to the Flathead Valley, by way of Two Medicine Pass, from which he had to turn back on account of deep snow, and more successfully by the Cutbank Pass. The latter trip led him across what is now the southern part of Glacier National Park and he first saw the glaciers at the head of Thompson Creek. It does not appear that he made any notable geological observations on any of these excursions. His contributions to science were made through his assistants, who were encouraged to prepare their results for publication over their own names, even after the failure of the Northern Pacific had cut off all support from that source. How the staff was kept at work and paid during the winter of 1884 has never been divulged, but it is a fair assumption that Pumpelly backed his determination to get out the results without regard to the cost to himself. The geology of the coal fields, which had been studied in Montana and Washington, was published in the volume issued by the Tenth Census, Number XV, containing the results of the Census studies, also made under Pumpelly's direction.

GREEN MOUNTAIN STUDIES

Detailed investigations, requiring painstaking application in field or laboratory, were foreign to Pumpelly's free, roving nature, yet his German training had taught him the value of intensive studies and he showed himself capable of executing them, as in the examination of the

Lake Superior copper deposits. Accident rather than design threw some of the most difficult of American geologic problems in his path. In association with Irving and Van Hise, he studied the pre-Cambrian, and later, as geologist in charge of the New England Division of the United States Geological Survey, he directed the surveys of the Green Mountains of New England, more particularly with reference to Hoosac and Greylock Mountains.

His contributions to the solution of the pre-Cambrian problems, involving the metamorphism, structure, and original character of the ancient crystalline rocks, were made in conversation in the field face to face with the facts or in talks of an evening between days' work. They were not recorded, but his colleagues, notably Van Hise, have borne witness to the value of his penetrating insight into the intricate relations and processes.

Pumpelly greatly enjoyed his association with Van Hise, especially in excursions which he made with him in conference on pre-Cambrian studies of the Appalachian Mountains. This brings to mind a day on the French Broad River, in North Carolina, where the two geologists invited the writer to accompany them, it being at the time his immediate field of work. The section examined comprised the base of the quartzites, which Keith has since determined to be Cambrian, and the underlying granites. There is a stretch of perhaps two hundred yards in which the obvious granite grades into the distinctly stratified quartzite, but in which no plane of contact can be recognized. After passing carefully over the section a couple of times together, the two separated.

Van Hise had begun to collect a series of specimens which should show the mineralogical character of the crystalline and sedimentary rocks and of the transition zone. He was thinking of the metamorphism, which according to hypothesis had altered an arkose sediment into something closely resembling the parent granite, and was considering the distinctive criteria which might be looked for under the microscope. He afterwards published papers on the secondary enlargement of crystals, in which these specimens played a part.

Pumpelly had turned to look at the tossing river and the beauties of the gorge. He spoke of the exhilaration of the scene, contrasted it with a desert landscape of granite hills and enveloping sands, which he made very real by a few graphic touches, outlined the process of disintegration which granite suffers under those conditions, and left it rather to be understood than stated, that the relations we had just been observing, in reminding him of the deserts of Arizona or central Asia, had suggested the aspects of the Appalachian region in a long past geologic age.

Each thinker followed his inherited lines of reasoning. Van Hise was adding a few precisely observed facts to that enormous mass of details upon which he based his thorough analysis of the most difficult problems of American geology, those of the pre-Cambrian. Pumpelly saw the facts, readily interpreted them in terms of known processes, drew an analogy with scenes he knew, and swept up on the wings of imagination to heights from which he could cast a glance down the long vista of the past.

It was with a penetrating understanding of the relation between sediments and the geographic or climatic conditions which govern their character and distribution that Pumpelly directed the investigation of the Green Mountains of New England. The general facts of stratigraphy and structure had been observed by the two Hitchcocks, Ebenezer, Emmons, Hall, J. D. Dana, and other contributors to the Taconic controversy. Each had espoused an idea and advocated it, but of precise observation and rational interpretation the very controversy itself had proved the need. Pumpelly took but little account of all that had been written. He went back to Nature's record. Having selected a critical area comprising Hoosac Mountain, an anticlinal ridge with a granitoid core, and Greylock Mountain, a synclorium, he with his assistants, Wolff and Putnam, Dale and Hobbs, traced out in great detail the areal and structural relations of the granite, gneisses, schists, and limestones of which the geologic column is composed. Any careful observer might have done as much, but there remained several outstanding riddles that could be solved only by that use of the imagination which with Pumpelly was intuitive rather than deliberate.

Running through the sediments and gneisses and fading out into the granitoid rocks was an appearance of bedding which had been interpreted as such and had led to the opinion that the different rocks all belonged to a conformable series. Wolff and Dale, guided by Pumpelly, proved it to be a secondary schistosity, and thus disposed of the apparent conformity. The actual unconformity of the Cambrian sediments on the pre-Cambrian was then demonstrated by evidence of weathering of the older rocks in pre-Cambrian time, especially where a dike occurred in the granite, and the deposition of clastic sediments in the irregularities of the old land surface. Metamorphism had greatly obscured the original character of the sediments, some of which had been altered to gneisses, and Pumpelly credits Wolff with having carried out the tedious field and laboratory investigations required to establish the true relations. It may be noted that both chief and assistant were trained in exact

German methods, the one in mineralogy and structure, the other as a modern petrographer.

In the study of the Cambrian stratigraphy, which was obscured by schistosity, the true sequence of the strata could be ascertained only by the identification of obscure anticlinal or synclinal folds, where the dips are closely or actually isoclinal. Here the application of principles published by Heim in his "Mechanics of Mountain Building" was of critical value and Dale worked out a group of American examples of the laws originally recognized in Switzerland. These are today classical illustrations of the structures to be looked for in metamorphosed sediments.

A further problem presented itself in the differences of sequences of sedimentary beds in Mount Greylock and in Hoosac Mountain. In the former the Cambrian strata comprise both limestones and schists; in the latter there is only a great thickness of schists, both sections rising from the basal quartzite. The lack of agreement across the short span between the two ranges had been explained by the assumption of a fault, but Pumpelly and his assistants proved that there was no fault and solved the riddle by demonstrating that the strata in Hoosac Mountain are the near-shore equivalents of the offshore deposits which form Greylock.

It is the old story of Columbus's egg. The monograph on the Green Mountains has taken its place among the accepted results of geological research. The hypotheses have become part of the rationale of working geologists. We take for granted the penetrating insight into past geographic conditions, the understanding of obscure processes, the capacity for patient, conclusive investigation, those qualities which enabled Pumpelly to open a new era in the geology of New England and to settle a controversy which had lasted for half a century. It is as it should be. The perfect stone has found its place in the great structure of geologic science.

The elucidation of the problems of the Green Mountains was Pumpelly's last contribution to his adopted science, geology. In 1890, after six years of Government service, during which he had perforce given up the remunerative practice of his profession, he shared the lot of the scientists who work under official limitations. He was poor. The owner of large areas of iron lands, he saw their potential value being eaten up by taxes. Business conditions were such that there was little opportunity to recoup his fortunes through expert examinations of mining properties. He had a considerable family, led by himself in habits of lavish liberality. Under these adverse conditions, in 1893, he took his family abroad and during two years set his children an example of economy (so he says in

his "Reminiscences"). They traveled much in Italy, France, and Switzerland. One can imagine the mutual delight of their companionship among the scenes of the father's youth. Returning home in 1895, Pumpelly once more took up the practice of his profession, but, finding the opportunities few, he renewed his explorations of the Lake Superior iron ore districts. These efforts were, however, not particularly successful in the discovery of valuable ore deposits.

The years passed in home life among his growing children and in excursions to the Far West or to Mexico to make mine examinations, but in 1903, at the age of 66, he was once more seized with the desire to explore distant lands.

EXPLORATIONS IN CENTRAL ASIA, 1903 TO 1904

For forty years there had lain in Pumpelly's mind a spark, originally lighted by his imagination, which required but a breath to kindle it into flame. The central thought was the relation of climatic changes in central Asia to the migrations of peoples and the evolution of civilizations. In it were combined the fragmentary suggestions of Chinese history regarding ancient cities and peoples and the deductions from geographic and geologic evidence, which sufficed to give color to the hypothesis of a changing climate.

The spark was kindled by a fact recorded by an ancient Chinese map-maker, who inscribed the words "Here dwell the U^{sun}, a people with red hair and blue eyes," on a map of the Tarim basin, in Chinese Turkestan, at a point apparently north of Kashgar. Another record mentioned the fact that many cities had been buried by advancing sand nearly two thousand years ago. These notes were brought to the attention of Pumpelly by the Chinese scholars employed by him during his stay in China in 1862-1863. He then felt that he was on the track of the ancestors of the European races (one can not help thinking how accurately the description fitted him, himself), and, pursuing a line of reasoning suggested by the diminishing inland lakes without outlets, he attributed the migrations of these peoples to a desiccation of the climate of central Asia. This hypothesis, since elaborated by Huntington, who was one of his assistants in 1903, lay for forty years in its author's mind, withheld from development by that scientific caution which had prevented him, when but a boy, from publishing his idea of an inland sea covering the Sahara.

The Chinese records and the facts he observed in his journey across Siberia in 1863 had suggested the idea of the former existence of an

inland sea in the now desert regions of Asia, and subsequent speculation had connected the sea with the Glacial Period, while its shrinkage would naturally follow from the waning of the conditions that had caused glaciation. But this logical chain of ideas lacked confirmatory evidence until Pumpelly was told by the Russian geologist, Tchernysheff, that strata containing shells of the Glacial Period had been found in a position that seemed to indicate an inland sea of that time. The "dream," as he called it, then assumed the form of legitimate hypothesis, worthy of being tested. It had previously seemed to him through all those years, during which he had discussed it with scientific friends, too subjective in character.

Furnished with a grant of funds by the Carnegie Institution of Washington, Pumpelly carried out two expeditions to Turkestan, one in 1903, to reconnoiter the country and seek for the evidences of geologic changes in association with those of ancient civilizations; the other in 1904, to excavate old dwelling sites. In the organization of these expeditions he was guided by the experience of a lifetime of travel and aided by the prestige of the Institution he represented, as well as by his own great reputation. He chose as assistants specialists distinguished in physiography and archeology and, as was his custom, gave them free rein in their investigations, together with the fullest possible opportunity to publish their results as their own.

The purpose of the expeditions was chiefly ethnological, as the dream had been. In his youth Pumpelly had been divided in his interest between history and geology. Chance had directed the emphasis of his training to geology, but he had always shown a profound, if not a preferential, interest in his fellow-men and their development. Now the earth-science stepped into the background. He assigned to W. M. Davis, Ellsworth Huntington, and his son, Raphael W. Pumpelly, the studies of the physical basis of the human history, and, after giving them the outline of his hypothesis to prove or disprove, as the facts might decide, he turned to the archeological investigations with enthusiasm. In 1905, when he was entering upon the four years of preparation which intervened between the close of the field-work and the completion of his brief summary of results attained, he said to the writer: "I never could read books on geology; I had to see the facts to become interested, but I can read this by the hour," and he held up "Ripley's Races of Europe."

Very important contributions to our knowledge of the glacial and postglacial conditions which have obtained in central Asia were made by Davis, Huntington, and R. W. Pumpelly as a result of the expeditions.

They are fully set forth in the volume entitled "Explorations in Turkestan," issued by the Carnegie Institution of Washington, in 1905, as Publication Number 26. The archeological results of the second expedition appeared in 1908, under the same general title, as Publication Number 73.

Elected President of the Geological Society of America for 1905, Pumpelly chose for his address a subject drawn from his Asiatic investigations, "Interdependent evolution of oases and civilizations," and presented it at Ottawa in 1906.

Reviewing the field of study in central Asia after his return from the first reconnaissance, in 1904, Pumpelly wrote:

"Judging from our observations and from those of others, especially of the Arabian writers and of the later Russian explorers, it would seem that the country has long been an interior region, dependent for its life mainly on the snows and glaciers of the mountains; that there have been within the present geological period great fluctuations in the amount of water derived from the mountains, as recorded in the high and low shorelines of the seas and in the strata containing living forms left by different expansions of the united waters of the Aral and Caspian, and that man already existed within the region during at least the last great maximum of moisture. . . .

"While we have been surprised at the abundance of the data in natural and artificial records offered by the region, . . . we are impressed with a realization of the intimate relation in which this region stands to the Quaternary and prehistoric history of the whole continent. Physically it forms part of the great interior region extending from the Mediterranean to Manchuria, whose history had been one of progressive desiccation, but in Russian Turkestan the effects of this have been mitigated by the snows of the lofty ranges and the lower altitude of the plains.

"Archeologically this region has, through a long period, been a center of production and commerce, connecting the eastern, western, and southern nations, and its accumulating wealth has made it repeatedly the prey of invading armies. It has been from remote time the field of contact and contest between the Turanian and Aryan stocks; but its problems, both physical and archeological, are parts of the greater problem underlying the study of the development of man and his civilization on the great continent and of the environment conditioning that development."

Allowing Pumpelly to speak further regarding the last scientific work of his long and varied activities, we may quote from the preface to his final report on the work in Turkestan those paragraphs which show his attitude of mind toward his subject, toward his fellow-workers, and in regard to the realization of his dream. He says:

"While each of the investigators was expected to work up his material, there devolved upon me, as initiator and director of the expeditions, the duty of presenting an independent discussion of the results as a whole. I found

myself confronted with the task of translating and editing the contributions of the experts, and of drawing my own conclusions from these and from my own observations. To do this, I surrounded myself with a library of six hundred or more volumes related to our work and problems, besides many borrowed from libraries. Literally living in this problem for nearly four years, my whole time, reading, and thought have been devoted to acquiring such a general survey of the field as would enable me to discuss the subject of our results and of their wider bearing in the light of the present condition of archeological and ethnological knowledge.

"Besides incidental inspection of the museums of Tiflis and Tashkent, numerous visits for study were made to those of Moscow, Saint Petersburg, Berlin, Vienna, Zurich, Schaffhausen, Cairo, Athens, London, Naples, and Rome, and to those of Paris, including M. de Morgan's systematically collected finds from Susiana—to me, perhaps the most important of all—and in connection with my chapter on chronology a special journey was made to Egypt to study the rate of growth of Egyptian village mounds in comparison with those of Anau.

"Of the two alternatives, confining the reports, my own included, to a record of observations and finds, or having each contributor go further and, treating his subject from the comparative point of view, draw his conclusions as to the bearing of his results on the general question of Eurasian problems, the latter seemed preferable; for, with the whole chain of observation and thought fresh in mind, it would seem to be the province of the individual investigator to state his inferences, even if only as working hypotheses.

"I confess to having written a chapter on the Aryan problem in the light of an extended study of the whole field and of our own results; but this I have suppressed, because it seemed a premature as well as a hazardous venture for one not already an authority on the subject . . .

"And now, what relation do the results bear to the dream that gave rise to the expeditions? On the physical side, Messrs. Davis, Huntington, and R. W. Pumpelly have traced in high Asia the records of several great glacial expansions during the Glacial Period. The climatic conditions, which during that period so greatly expanded these glaciers and buried Russia under thousands of feet of ice, presumably produced also the inland sea whose shorelines are still visible.

"The evolution of civilization has been traced backward to a time when, before its datings in Babylon and Egypt, man at Anau already lived in cities, cultivated wheat and barley, began the domestication of the useful animals which are our inheritance, and possessed the fundamental industrial arts, including a certain amount of metallurgical knowledge. Evidence has been traced of a progressive desiccation throughout long climatic cycles in whose favorable extremes civilizations flourished, which disappeared in the arid extremes. And that the climatic conditions under which these civilizations vanished gave rise to very early migrations and to a constructive reaction upon the outside world would seem to follow from the early appearance, in Babylonia and Egypt and in the late Stone Age in Europe, of wheat and barley and of breeds of domestic animals which Dr. Duerst identifies with those first established on the Transcaspian oases. . . .

"The reader will see that in tracing back to central Asia the source of the fundamental elements of western civilization, in finding the traces and causes of the inland sea, in discovering evidence of progressive desiccation (and in this the cause of the migrations that revolutionized the world), the dream has to this extent been realized."

This was written at his summer home in Dublin, New Hampshire, in 1908. Might not the old man, who had cherished that dream for forty-four years, have with justice put his statement of its realization more strongly? Might not one who knew his exuberant vitality, his optimism, have expected that he would? But no, his was fundamentally a scientific mind, adhering above all things to the truth as he understood it, and no impulse of self-gratulation could urge him to surpass its limits. In the suppression of his own chapter on the Aryan problem, the ultimate speculation to which he had given years of thought, we see the expression of that supreme loyalty to his ideal of truth which made him truly great.

DUBLIN, NEW HAMPSHIRE

The last dozen years of Pumpelly's long life were passed at his homes in Newport, Rhode Island, and Dublin, New Hampshire, alternating summer and winter, except when making journeys abroad or in this country for the pleasure and education of his children. Mrs. Pumpelly died in 1915, after forty-six years of married life in a relation more complete in its harmony than falls to the lot of but few. In his loneliness, Pumpelly drew even nearer, if possible, to his children and with them turned to the desert, where "Blessed are the realms of Silence, for in them is the nearness of God." He revisited the scenes of his labors and marvelous escape from Apaches and Mexicans and again plunged into the waterless wastes in search of the Old Yuma Trail, along which he had ridden fifty-four years before. The Ford cars proving less able to cope with the sand than horses had been and the water giving out, the desert almost claimed him permanently as its own; but, with his habitual resourcefulness and the guidance of an Indian as old as he himself, he once more escaped.

Of his life and influence at Dublin, his old classmate and intimate friend, Henry Holt, has written:

"It was most exceptional and it was all unconscious—simply the action and reaction between his character and that of his neighbors. Probably never elsewhere was such a community. He was incomparably the most influential person in the place—ruled it without knowing that he did—unconsciously attracted there all forms of excellence and unconsciously repelled any form

of pettiness. The circle he drew around him blended the highest aristocracy with the simplest democracy. A visitor once described it to a stranger: 'One night you'll go to as lovely a ball as you ever saw, and the next night you'll dine with people you met there who do their own work.' That realization of Utopia those who shared and marveled at it knew was the involuntary work of Pumpelly. He loved all people worth loving and had no other standards; and all people worth loving loved him."

There is nothing to add to this statement of the humanity of this remarkable man. His great soul possessed the magnet of love for his fellow-men, without distinction of creed or race, excluding only the false. His penetrating intellect threw the searchlight beams of his imagination into the unknown realms of knowledge in search of Truth. To her he was ever absolutely loyal, never allowing even a suspicion of egotism to color a statement of fact or to influence his estimate of the validity of an hypothesis. To the Truth he was true. Therefore his contributions to his adopted science, geology, stand unchallenged, monuments to its progress, while he himself takes his place outside the circle of specialists, in the group of great explorers of the physical and intellectual worlds. His thought is being handed down, a living, growing influence, by many who are as unconscious as its author often was of its intense vitality. It lives on because its author invariably put Truth before self.

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