NATIONAL ACADEMY OF SCIENCES

FREDERICK EUGENE WRIGHT

1877—1953

A Biographical Memoir by

JOHN A. FLEMING AND CHARLES A. PIGGOT

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INTRODUCTION

"WITH THE SCIENTIST, to wonder is a chronic state. In that respect he is like the young boy named Boots in the old Norse tale who set out with his two brothers to make his way in the world."

In this whimsical way Frederick Eugene Wright began a talk which must have surprised some of the more stolid members of the august Literary Society of Washington. To him this fairy story, his favorite of all the fairy stories he loved so well, exemplified the scientific spirit better than anything else he knew.

To the end of his life, Fred Wright never lost that spirit of wonder which he admired in the legendary Boots, who, moved by curiosity, pursued the unknown with the comment, "I think I shall go and see." This spirit led him to seek the answers to unsolved questions from the depths of the sea to the heights of the moon.

Fred Wright was a member of the National Academy of Sciences from 1923, serving as Vice-President for four years, then as Home Secretary for twenty consecutive years. Much of what he was and did in his long life culminated in his work for the Academy. His preeminence as a geologist in the field and laboratory, his capabilities in related fields of science, his wide intellectual interests, his ability as a writer of disciplined thought, and perhaps above all his firm sense of responsibility brought to his Academy work unmatched authority and vigor.

EARLY LIFE AND TRAINING

Heritage and environment overlap in their influence on a man's life. Fred Wright's lineage was in great part scientific. He wrote of inheriting a "liking for engineering, physical, and chemical problems . . . a trait that has characterized our family for generations."

In these days of narrow specialization in science the truly educated man of wide intellectual interests and thorough training is becoming rare. Wright was such a person. He inherited his superior qualities from an ancestry of significant forebears. From John Wright, Esq., Lord of Kelvedon Manor, Essex, England, in 1538, each in his generation was a man of significance in his community. Thomas Wright, Esq., of Essex, brought the family to America in 1635 and settled at Wethersfield, Connecticut. Four subsequent generations were born at Wethersfield, including Lieutenant John Wright (1709-1784) who served during the French and Indian War at Lake George, Ticonderoga, and Crown Point, with his son a drummer-boy of the same regiment. Captain Charles Wright (1739-1830) marched to the "Lexington Alarm" in April 1775 and with his three brothers fought in the battle of Bunker Hill.

The family moved progressively westward. Charles Wright (1774-1827) presided as moderator at the first meeting of the township of Denmark, New York, and served in the War of 1812.

Fred's boyhood environment also played its part. He was born on October 16, 1877, in the lovely port town of Marquette on the Upper Peninsula of Michigan, a town noted at that time for "the magnificent prospect which the outlook over the great lake affords; while everywhere abound the unbroken forest, the rugged hills and the impenetrable glens to afford to the lover of nature the enjoyment which he seeks." This wild country was also mining country, a land of opportunity where the emphasis was on the search for what lies beneath the earth's surface. Its beauty and promise exerted a lasting influence on the developing boy as they had on his father, Charles Eugene Wright, pioneer geologist of Michigan, of whom Charles

Lawton wrote: "His great love in scientific inquiry was for rocks . . . he loved them for the lessons they could teach, and his mind glowed with enthusiasm in his labors to force them to reveal their mysteries. He had been far and wide into the mineral regions of Europe and this country but found no part so congenial to him as here amid the rocks, the hills, the mines of Lake Superior."

Like many other settlers of the Upper Peninsula, Charles Wright had migrated to Michigan from New York State. There, at the age of eighteen, he had completed an engineering course and was City Engineer of Auburn where he had spent his boyhood. Six years later, after mining and engineering experience in Michigan and Kentucky, he went abroad for three years, studying geology and mining. On his return from Europe in 1872, he settled in Marquette and practiced as a mining expert. In Europe he had studied the determination of rocks under the petrographic microscope and brought this method to the United States. He became Commissioner of Mineral Statistics and later, State Geologist.

In 1888, while engaged on a monumental survey of the geologic formations of the State, Charles Wright died suddenly of pneumonia at the age of 45. Fred was only 10; the further molding of his interests and that of his two younger brothers was carried on by his mother, Carolyn Wright. Mrs. Wright was a courageous person—a woman of spirit—as later events proved.

In 1895 when Fred was graduated from the Ann Arbor High School, Carolyn Wright made an important decision. She had frequently heard her husband speak of the universities in Germany as the best scientific schools in the world, and she decided to take her sons there. She moved her family to Weimar, Germany, where Fred had one year in the Real Gymnasium to improve his German before going on to Heidelberg University. At the time of Mrs. Wright's move, President Angell of the University of Michigan tried to dissuade her, feeling she was making a serious mistake. How vindicated she must have felt five years later when Fred received his Ph.D. *summa cum laude.*

The chains of strong family ties and affection were unusually good in Fred's family and in the families of his ancestors. His esteem and love of his mother were illustrated by his casting aside his research duties promptly each day at 4:30 in the afternoon in order that he might share tea with her. Almost daily when he was on field duty he wrote long letters telling of his experiences.

The European education provided the ideal environment for a youth of Fred's scientific talents. It was the catalyst for many of the ideas and skills which led to his international renown in later years. From his work with Rosenbusch in mineralogy and with Goldschmidt in crystallography, Fred soon became fascinated with the problems of light, its nature and its effects. This interest, which remained with him throughout his life, became the basis for nearly everything he did in the next fifty years; his pioneer work on the petrographic microscope and related fields; his fundamental work on the manufacture of optical glass; and later, his study of the moon's surface.

His intense concentration and determined mastery of each undertaking produced as broadly educated and thoroughly trained a Doctor of Philosophy as ever entered the geologic profession in the United States. Recognition of his training brought offers of excellent positions in colleges and universities from Pennsylvania to California. Despite these offers he returned to his native state. His first job was as instructor in petrology and mineralogy at the Michigan College of Mines at Houghton. His classes were largely attended but demanded so much of his time that he could find no opportunity for the research he was eager to do. After two years of teaching at Houghton he accepted a position in Washington, D.C., as Assistant Geologist with the United States Geological Survey.

During the summer of 1903 Wright worked on the Michigan Survey in the Porcupine Mountains, a wild and harsh region of the Upper Peninsula. In 1904 his position on the United States Geological Survey took him to an even wilder region.

His first assignment instructed him "to study the geologic section through the Alexander Archipelago from Sitka to Juneau, Alaska, and to accomplish reconnaissance mapping of the mainland belt lying between Port Huron and the Ketchikan District." Also, "to make a reconnaissance survey of the coal-bearing rocks of the southern part of the Admiralty Islands." This was to include geologic mapping and to be in sufficient detail that a "definite statement can be made in regard to the extent and possible commercial importance of this field." He was instructed to visit all the "coal openings" and "to obtain commercial samples including fossils from all the seams." He was allowed one assistant, his brother Will, and $3,000 for all field expenses. Quite a first assignment for a young geologist! He was engaged on it for three years and mapped and studied an area of more than 40,000 square miles of unsurveyed territory.

Fred noted not only the geologic features but was emotionally appreciative of the beauty and grandeur of the country. He wrote, in words reminiscent of Ruskin: "Occasionally in the early morning sun the cold icy peaks appear to be enveloped in a veil of deep, fiery red which seems fairly to glow and to include even the snowfields and glaciers. Everything is radiant and the whole atmosphere is charged with superb color tints far finer than those of the Alpine glow of Switzerland."

One summer, Will Wright recalls, they "got a blamed old steam engine boat . . . went up Taku Inlet . . . but the boat was no good, and we got nowhere fast . . . finally got a 60-foot gasoline boat—much better . . . a lot of our work was spyglass geology . . . we could always go ashore and get grouse or deer . . . along the shore were clams and crabs . . . also huckleberries in abundance from which our Chinese cook made stew . . . once we got into an inlet and left the boat . . . when we returned the high tide had reached far back and left the boat high and dry . . . in 1906 in the Glacier-Bay Region Fred had his morning plunge and once came up against an iceberg and scratched his shoulder."

During this Alaskan work Fred and his brother improvised a panoramic camera for topographic surveying, the first such camera ever made. This proved to be an important pioneer step in modern photogrammetry.

SCIENTIFIC WORK FROM 1906

On January 1, 1906, Wright joined the staff of the recently established Geophysical Laboratory of the Carnegie Institution of Washington as Petrologist, where he continued research and a variety of other tasks until his retirement in 1944. He retained a close association with the Survey and throughout his life never lost his enthusiasm for field work. He completed his work in Alaska during the summer of 1906, and during the summers of 1907 and 1908 returned to the Upper Peninsula of Michigan to carry on the survey which his father had begun and which he himself had continued while teaching at Houghton. His letters tell of heavy packs, vicious mosquitoes, slippery trails, black flies, and sodden clothes, but always there is a cheerful and whimsical allusion—a chipmunk scolding while Fred cooks at a smoky fire, and even sympathy with a porcupine who had chewed a boot. Such camping journeys, where each day a new camp is made after a tiring tramp, show up the real camp man from the fake. Letters from A. C. Lane, who certainly knew his camp ethics and was a competent judge of character, contain many references to Wright's generosity, helpfulness, and good spirits. One refers to coming upon a miner and sharing supper with him, whereupon Wright volunteered to wash up and to cook the next day's meal. Despite the subsequent arrival of two hungry friends of the miner, Wright cooked for the whole party for several days without comment.

Later when other tasks absorbed him, Wright longed for those early days in Alaska and Michigan. "Yes, there is a great big longing . . . in me which comes to the surface once in a while, for Alaska and the field work there. Can't help it, any more than a lot of other things, but the Fates have ruled otherwise and there you are."

In 1908 Wright published a report on "The Intrusive Rocks of

Mount Bohemia, Michigan," the result of his field work in that region in the summer of 1907, as well as in 1902 and 1905.

After his months in the field, he returned to the Geophysical Laboratory where he pursued with enthusiasm the fundamental research for which he had laid the foundation in Germany. From this time on, laboratory work increasingly absorbed his interest. His letters of this period show his interest in the mathematics of optics and his concern with the design and improvement of optical instruments. He was at heart a born experimentalist with a strong belief in the value of new methods and instruments for the solution of problems still unsolved. With his innate and inherited inventive ability, he went ahead to develop new methods for the solution of vexing problems in mineralogical and particularly crystallographic fields.

"Have been drawing most of the day," he wrote, "on a new instrument design and have really enjoyed myself. It is one of the keenest pleasures I know of to block out an idea or scheme and then work out the details on paper, give it to the mechanics and watch its growth until it is put into commission. The most intense moments are those when the idea raps at one's brain for entrance, but it is good fun afterwards to become thoroughly acquainted with the new friend, for our tools are good friends, and without them we should have a hard time."

"You will think it queer," he remarked as he surveyed his work, "that a fellow who has been trained as a geologist should take such pleasure in fooling with instruments, but the fact is . . . that the optics in microscopic work cover pretty much the entire field, and most of the instruments I play with are optical instruments."

Among the significant papers Wright published in these years were those on "Quartz as a Geologic Thermometer," published jointly with E. S. Larsen, and on "The Change in the Crystal Angles of Quartz with Rise in Temperature." These grew out of the type of investigation which was one of the primary reasons for the establishment of the Geophysical Laboratory, that is, the study of high pressures and temperatures and their application to geophysical problems.

In 1911 his first full-scale book appeared: "*The Methods of Petrographic-Microscopic Research: Their Relative Accuracy and Range of Application*. L. V. Pirrsson reviewed the book in the *American Journal of Science:* "It is probably the most serious, scholarly and generally comprehensive investigation of the optical methods employed in petrographic research to the extent indicated in the subtitle which has yet appeared and it cannot fail to have a great influence in promoting more careful work along these lines."

Letters of appreciation came from all parts of the world. One of these from A. W. Gibb, his classmate at Heidelberg, was in a less serious vein: "Thanks very much, it is the highest flight your genius has yet taken. I am not at all sure that *my* genius will be equal to understanding it all, but, as we say here, 'They're far ahin' that darna' follow.' I have only glanced through it yet, but it seems full of valuable matter. It must have given you a lot of work. Rosenbusch will be beginning to tremble in his shoes."

A few years later, in an article in the *Journal of the Optical Society of America* on "The Petrographic Microscope—a Useful Tool in Applied Optics" Wright summarized his ideas briefly. This "tool" proved so useful that years later E. H. Kraus, Head of the Department of Mineralogy at the University of Michigan, wrote: "Indeed the present wide use of the petrographic microscope in research not only in our sciences but also in related fields is due in large measure to Dr. Wright's early and persistent advocacy of its value."

During the last years of his life Wright partially revised and enlarged the text for a second edition of his classic book. It is hoped that this work will be completed and published for the benefit of all who work with the petrographic microscope.

In the years that followed as well as those that preceded publication of his book, Wright offered numerous suggestions for improvement in the methods as well as in the applications of the microscope. He was constantly suggesting new and better devices for the solution of the problems that continued to turn up as his microscope was more and more widely used, in the chemical as well as in the mineralogical field. In 1916, in an article on "The Petrographic Microscope in Analysis" published in the *Journal of the American Chemical Society,* he wrote:

"Long experience has convinced the writer that the field of its application is a large one and full of possibilities both from the viewpoint of pure research and of practical application in the technical world. In many instances information can be obtained by means of the petrographic microscope, in a few moments, which it would take several days to get by the usual methods, this means an appreciable amount of time and money saved. To know at each step in a process of investigation just what is taking place is essential to effective work and such knowledge is obtainable in many problems only with the aid of the petrographic microscope."

In Wright's hands, the petrographic microscope yielded important commercial results, particularly in the analysis of Portland Cement. The paper by Rankin and Wright, "The Ternary System CaO-Al_2O_3-SiO_2" is considered a classic.

Recently Dr. George Tunnell at the University of California at Los Angeles has written of Wright's contribution to the crystallographic field: "So far as I am aware, Dr. Wright was the first investigator to properly emphasize the facts that wave-front normals, wave-velocities, and refractive indices are of much greater importance in petrographic work than rays, ray-velocities and ray-indices.

"It is my understanding that Dr. Wright was responsible for the introduction of the immersion method for the determination of refractive indices and other optical properties of natural and artificial minerals at the Geophysical Laboratory. It is certain that without the use of the immersion method, the long series of investigations at the Geophysical Laboratory of systems fundamental in petrogenesis and ore formation could not have been carried through successfully.

"Dr. Wright's accomplishments in establishing the limits of accuracy attainable in the measurement of various optical properties of crystalline materials was also of very great importance in giving other investigators a better understanding of the degree of certainty of their determinations of the phases encountered in the various systems and of naturally occurring minerals.

"Dr. Wright had a greater knowledge of the theory of optical crystallography than anyone else in America, and, in my opinion, his works on this subject rank with those of the greatest European masters, such as F. Pockels, G. Szivessy, and M. Berek."

Wright's interest in optics, as Tunnell shows, was not confined to the development of the petrographic microscope and its applications. In 1914 he published a brief article on "A Simple Method for the Accurate Measurement of Relative Strain in Glass." This led in an unexpected way to his work on the manufacture of optical glass which was necessitated by World War I.

In 1916, as the shadow of war approached nearer, Wright, true to his patriotic ancestry, sought to prepare himself for military duty. He joined those other patriotic Americans (often scoffed at for their pains) who assembled at the Civilian Military Training Camps at Plattsburg and paid to be taught the discipline and duties of the soldier. Later he sought admission to the Artillery, Engineers, or Signal Corps, but his technical reputation had reached the Army, and he was commissioned Captain (1917) in the Ordnance Reserve Corps and became a Major in the following year. He soon advanced to Lieutenant Colonel (1919) and finally to Colonel (1928). When he reached the statutory retiring age, he remained in the Reserve Corps and did his requisite tour of duty at regular intervals.

Wright's contribution to the military effort and success of the United States in World War I was of the utmost significance. As no optical glass suitable for range-finders, gun-sights, telescopes, cameras, and other military necessities was then being produced in this country, it soon became evident that this was one of the country's most vital needs.

The Geophysical Laboratory, because of its long experience with silicate melts, was the one organization in the United States competent to render effective aid in the manufacture of optical glass. Wright was assigned the duty of co-ordinating for the War Department the effort of conserving the local stock and developing the technique of manufacturing high-grade optical glass. In association with his colleagues at the Geophysical Laboratory and with the co-operation of selected glass manufacturers he supervised the removal of mystery and alchemy and introduced science and control into the production of more than 600,000 pounds of optical glass that met the most exacting requirements.

During the war, Wright could say little of what he was doing. When it was over he was asked to write an account of the developments in the manufacture of optical glass in the United States. In 1921 he published the comprehensive book, *The Manufacture of Optical Glass and of Optical Systems,* the standard treatise on the subject; it was republished at the beginning of World War II.

In World War II the Government again turned to Wright. At the request of Dr. James B. Conant he was appointed special advisor to the National Defense Research Committee. Here, as Dr. Theodore Dunham wrote at the war's end, his contribution was of great importance because of his "amazing and detailed theoretical knowledge in almost every field in optics, familiarity with the needs of the Services for optical equipment, and extensive experience with the application of scientific methods to military problems."

The military also sought the services of Colonel Wright (now beyond retirement age) and appointed him to the Joint Optics Committee, where his task was to co-ordinate optical supply-problems for the Army, Navy and Air Forces. His services were so appreciated that he was awarded the Army Gold Medal for exceptional civilian services—a rare distinction. The citation reads: "In recognition of his exceptional service to the Committee in establishing an effective expansion program for the production of critically needed optical glass and optical elements. His expert guidance and assistance in the direction of this program were responsible for the solution to a major problem of military supply."

Soon after his return to the Geophysical Laboratory after World War I, Wright published a series of significant papers on the examination of ores and metals in polarized light. In the period between 1918 and 1941 his interest in new and better methods of solving problems was closely related to his chosen field of mineralogy. Sometimes, as in the case of Portland Cement, that interest took him into the commercial field. For Tiffany and Company he devised a pearl-tester which distinguished cultivated pearls from the natural ones. Besides this tester his extracurricular activities produced fourteen or more independent inventions, several of which had military significance, while at least one possessed domestic appeal for it reduced the scratching proclivities of the Bon Ami chick.

One invention, however, took him from his regular line of interest and eventually led him far afield. This was the invention of a gravity apparatus.

He wrote:

"My interest was aroused in 1921 by Major Bowie of the Coast and Geodetic Survey under whose direction gravity-measurements by the pendulum-method, have been carried on for many years past. By this method only three stations a month could be occupied, a rate which seems slow to geodesists and geologists keenly interested in the shape of the earth and the theory of isostasy."

In September, 1954, Wright's colleague, Joseph L. England, at the Geophysical Laboratory supplied the following account of Wright's developing interest in gravity-measurements.

"About 1922, Dr. Arthur L. Day, then Director of the Geophysical Laboratory, suggested that gravity-measurements in the vicinity of volcanoes and hot springs might yield information of geologic importance. . . . Doctors F. E. Wright and E. D. Williamson were asked to look into the possibility of developing a portable gravity-meter capable of rapid determination and high accuracy.

"They began a series of experiments but Williamson died in 1924 and Wright then carried on alone. Wright in 1925 designed and built the first torsion gravity-meter using a tungsten spring, patterned after one built by Sir Richard Threlfall in 1898. . . . A new principle is the use of an elastic medium as a measuring device which required the material to be maintained in a constant state of no strain and the load to be applied for only short periods of time. . . .

"In 1929 Wright and Joseph L. England designed and built the first field gravity-meter. This instrument proved successful, as shown by measurements in the laboratory and field, the validity of the principle of construction of the meter, and yielded valuable data on the formation of certain materials when subjected to strains well within their elastic limit." An improved instrument was designed and used from 1940; field work in the Atlantic Coast region was done by it but stopped during World War II.

Wright's new gravity-instrument provided accuracy to one part in a million and required only four minutes to make a measurement, thereby making it possible to occupy as many as twenty-five stations a day.

In 1928 the Holland Geodetic Commission, the Carnegie Institution of Washington, the National Academy of Sciences, and the United States Navy co-operated to make gravity-measurements in the Caribbean Area. Dr. Vening Meinesz, with Wright's assistance, installed and operated Meinesz' unique apparatus in a United States submarine.

The Caribbean Area selected fitted in with Wright's interest in the relation between gravity-anomalies and vulcanism. The expedition, as it turned out, was highly successful from the human as well as the scientific viewpoint. A close friendship developed between Wright and Meinesz. In a long letter at the time of Wright's death, Meinesz wrote: "It was Wright's purpose in taking part in this expedition to study the multiple-pendulum method and apparatus for determining gravity at sea. . . . He wrote the report of our expedition and his long introduction on method and apparatus is one of the best treatises on the subject. A better compliment can hardly be paid to him than that in the short time he studied it, he mastered it so completely that he could write the most difficult thing there is—a good and exhaustive summary of it."

Meinesz recalls in 1954 discussions about Wright's successful attempt to make a reliable elastic gravimeter and says it can in fact be safely intimated that he was "the first who succeeded in getting accurate and reproducible results along these lines . . . to eliminate the disturbing effects of elastic afterwork. Wright introduced the notion that readings should be made at every station at certain fixed times . . . after the instrument was put into action."

Meinesz concludes "a second noteworthy feat was the way he adapted himself to the somewhat difficult life on board a submarine, notwithstanding the fact that he was no longer young at the time. Officers and crew liked him for his good comradeship; his noble personality impressed everybody. . . . I may summarize my recollections of his remarkable personality by saying that he showed himself a noble, simple, and very great scientist."

The year following the Caribbean Expedition, Wright installed a Meinesz gravity-apparatus on the non-magnetic vessel *Carnegie.* This apparatus was operated by S. E. Forbush during the *Carnegie*'s last ill-fated cruise before she was lost by explosion and fire at Apia, Samoa, on November 29, 1929.

In the spring of 1940, Wright journeyed to Guatemala with his gravity-instrument in an effort to gain knowledge of the extent and depth of the great pumiceous deposits of low density which cover the Pacific slope and highlands of Central America.

Meanwhile, in the 1920s, Wright followed still other interests. After his optical-glass work in World War I, it was with a feeling of relief that he wrote in 1921, to Dr. R. S. Woodward, President of the Carnegie Institution of Washington: "The preparation of the [optical-glass] report took me away for a long time from my own work, and it is partly for the purpose of swinging my mind again into the channels of thinking along geological lines that I undertake the long trip to South Africa."

This trip was a joint undertaking of the Shaler Memorial Fund of Harvard and the Carnegie Institution of Washington; in 1922, with Daly and Palache from Harvard and Molengraaff from Delft, Wright spent some eight months in South Africa. The objectives of the expedition were: To study the great intrusive area known as the Bushveld Igneous Complex; to gain knowledge of the formation of kimberlite and diamonds; and to study the great Stromberg Plateau basalts. Wright's particular interest was in the last of these. He traversed a vast area from Capetown to the Zambezi and back through Natal, with the native areas of Zululand, Pondoland, Griqualand, and Basutoland included. Considerable time was spent at the headquarters of the South African Geological Survey in Pretoria—where the party was welcomed by General Smuts, and where they established a laboratory equipped with their own instruments and demonstrated the newer techniques and procedures, particularly the use of the petrographic microscope. The letters of appreciation from Doctors Hall, Rogers, Dutoit, Wagner, and many other scientists and engineers in South Africa with whom Wright came in contact, indicate sincere gratitude and a real feeling of comradeship developed from many days and nights spent on trek in the bushveld and mountains as well as in the laboratory.

The fall of 1922 found Wright again settled in Washington with his family. Yet, less than a year later, he was on his way to Oregon and the region of the Columbia River basalts to follow up the investigation of lava flows begun in South Africa.

One of the first regions he visited was "The Craters of the Moon." When he returned home he recommended to the Director of the National Park Service the establishment of this region as a National Park, commenting, "The area is extraordinarily interesting and an ideal place to study the surface phenomena of vulcanism of basalt lavas."

Wright's studies of the earth's surface in South Africa and Oregon as well as in Iceland proved a prelude to an even more interesting study of the surface features of the moon. In 1921 he wrote to Dr. Walter S. Adams, Director of Mount Wilson Observatory, "Dr. Day showed me a short time ago four prints illustrating different sections of the moon and copied from plates at the Mount Wilson Observatory. These are by far the finest photographs of the moon that I have seen, and I should like to buy or beg similar prints for myself. Is there any arrangement by which I can have your photographer make these prints for me?"

This was the beginning of Wright's active interest in the moon. The arrival of the beautiful photographs, taken by Francis G. Pease with the 100-inch telescope, piqued his curiosity and roused his interest in the strange pock-marked face of our satellite. Four years later he was appointed by the Carnegie Institution of Washington to the Committee on the Study of the Moon's Surface; he wrote to W. M. Gilbert of the Institution that he hoped "this piece of cooperative research will result in the real advance of our knowledge of the genesis of the moon and its surface."

From this time on Wright was to devote more and more time to the solution of this fascinating problem. The Committee could not visit the moon but the great telescopes at Mount Wilson could bring it close to the Committee, which proceeded to study its surface features in detail, utilizing the various specialties of the geologist, petrologist, physicist, chemist, mathematician, and artist. Since Wright was qualified in all these areas he soon became Chairman and acknowledged leader of the group.

"When one thinks of it," he wrote in 1927, as he approached the problem from his own viewpoint, "it is natural for a petrologist to tackle the rocks of the moon. He has learned to determine minerals under the microscope by the effects they produce on light rays on transmission. Similarly on the moon the problem is to determine the materials by the effects they produce on light rays on reflection as observed through a telescope under proper conditions. The chief problem is to devise methods by which the optimum conditions are attained. Interchange microscope for telescope, transmitted light for reflected light, and thin sections for the moon's surface and you have the difference in a nutshell."

Wright began his studies of the moon's surface at the Naval Observatory in Washington. From 1928 on he continued them at Mount Wilson Observatory where he spent part of every summer, until the coming of World War II prevented this annual jaunt to which he always looked forward with the greatest anticipation. He delighted in the beauty of the natural surroundings as much as he reveled in his work and the companionship of the astronomers.

He devised plans for making a photographic map of the moon in the plane of mean libration and erected a "Moon-house" on Mount Wilson where his plans could be carried out. He also worked out methods for making a topographic map of the moon which would aid the geologist as well as the astronomer in the interpretation of the moon's surface features. He made a series of illuminated globes which for the first time represented the moon's craters and other features free from distortion.

The Moon Committee was only one of many on which Wright served in the Institution as well as in the Academy, the National Research Council, the American Geophysical Union, and other organizations to which he belonged. His wide range of interests, his belief in the importance of co-operation and the value of interpretation in science led him to many fields where his knowledge and judgment proved invaluable. They led him from the 200-inch telescope and cosmic rays to the Grand Canyon.

Everything he did was guided by a philosophy of life and of science which is revealed again and again in his work and in his writings. Everything was pervaded by his unfailing enthusiasm and humor, his modesty, his generosity of spirit. Through everything ran his belief in the obligation of the individual to help his fellow men to the full extent of his powers.

Often by concrete suggestion of new methods and instruments he contributed to the solution of individual problems as well as to those of the diverse groups in which he was interested. Often by his ability to express ideas clearly and vividly, to make the complicated simple, he revealed the possibility of new approaches to old problems. Above all, through his concern with the place of the research scientist in our modern world he contributed to increased understanding of the broader more difficult problem of human relations.

Some of his ideas on this important problem which, in its application absorbed so much of his energies, are illustrated in his reports. One of these was on the Public Relations Problem of the Carnegie Institution of Washington which was founded "to promote research in different fields of science and to interpret and apply the results of research to the betterment of mankind. These two objects are intimately linked and actually represent different phases of the same problem. The ultimate worth of research is determined by its contribution to human progress.

"In his own research work the scientist is thrilled by the results he obtains, by the solution of new and difficult problems. To him this is the chief interest, the difficulties which arise in the attack on a given problem spur him to greater activity and to more exacting observations with improved instrumental technique. His pleasure is derived from the game of solving problems which he has formulated in order to satisfy his curiosity regarding certain phenomena in nature.

"He is prone to consider research as an end in itself and to be impatient with efforts to interpret the results of research in language understandable to men outside his special field. He believes in 'science for Science's sake' just as certain painters a generation ago stressed 'art for Art's sake.' These are the catch phrases of enthusiasts of limited outlook and perhaps exaggerated group-loyalty. The scientist has an innate curiosity regarding natural phenomena and seeks to find out about them, chiefly by experiment and by observations made under controlled conditions. It is this trait of the human mind that makes for progress. The scientist explores new fields, adds to our knowledge of nature and its forces and processes, thereby teaching us how to control them to the end that living conditions may be bettered and men may have a happier, fuller life, not concerned wholly with making a living. At the same time science enlarges our outlook on life and enables us to understand better its meaning and man's place in the universe. It extends our horizon and increases our perspective, it suppresses narrow, subjective views and leads us outside and beyond our immediate surroundings."

To open such vistas is the scientist's obligation not only to the public, but also to his fellow scientists working in other fields. This view that the scientist "should not live unto himself alone," in which Wright believed firmly, was given imaginative expression in the arranging of lectures, the editing of papers, the designing of exhibits. He believed that while such activities must help the audience at which they are aimed, they will contribute also to the development of the scientist. Lectures which help the layman to understand the meaning of science will train the scientist in the art of presentation and help him to "take stock of the general bearing of his results and to obtain a correct perspective of their significance."

"Although the scientist works constantly with details, it is in his moments of inspiration that he visualizes their relative significance and realizes that this detail, and not that one, is really important; thus he brings order into a series of observations and is led to discoveries and new laws. If he emphasizes the essential elements of his problem, the steps taken to solve it, and the results thereby obtained, he presents to the audience a unified picture of why and how he did the task and what he found. . . . Nonessential details like by-paths from a forest trail, divert the attention and confuse those not in a position to evaluate them."

In the same way the designing of an exhibit to bring out simply and graphically the essential nature of the subject portrayed may illuminate the scientist's own problems, while it provides to the visitor "the same sort of stimulus that travel offers to the student of geography and of human affairs. He may become fascinated with one of the exhibits and learn from it, directly and in a few minutes, a lesson that could not be conveyed by many hours of study of the printed page."

The arranging of such exhibits both in the Institution and the Academy was only one of many tasks in which Wright demonstrated his belief that it is the scientist's obligation to contribute to general scientific progress and understanding. In the Academy the major part of his time was given to administrative work, first as Vice-President, then as Home Secretary. "Election to membership," he wrote, "besides being a great scientific honor, includes the acceptance of some liability to service." He willingly gave such service at the cost of his own research.

Throughout his twenty years as Home Secretary from 1931 to 1951 he made this office a particularly significant one in helping to mold and to guide the policies and activities of the Academy. The letters of sincere appreciation sent him by each of the Presidents with whom he served reveal that he not only pulled his load, as always, but that he had more to do with the success of the Academy than can be mentioned here.

When Wright died, former President A. N. Richards wrote: "As you know, he and I worked closely together during the three years of my presidency. That association gave me the privileges of his friendship . . . many opportunities of recognizing and relying upon his wisdom and the integrity of his character. He never hesitated to let me know when he thought I was off on the wrong foot and those discussions—frank as they were—always left me with increased feelings of respect and affection for him. He managed the duties of his secretaryship with such quiet, unassuming skill, tact, and devotion that neither officers nor the members were fully aware of the volume and difficulties of the tasks he performed. His departure deepens my sense of loneliness, as I know it will for many others of the members for whom time is running out."

PERSONAL LIFE AND OUTSIDE INTERESTS

Some mention should be made of the happy family life that Wright lived in Washington and of the outside interests which roused his broad sympathies and boundless enthusiasm.

In 1906 Fred Wright journeyed from Alaska to Mexico City for a meeting of the International Geological Congress. There he met the gracious and talented Kathleen Finley, who on graduation from McGill, had received the Governor General's Medal for highest honors in modern language and history.

Fred Wright and Kathleen Finley were married in June, 1909, and decided to spend their honeymoon on a pack-horse camping trip across Iceland. Such was the buoyant and confident attitude of these two exceptional people at the beginning of the life they were to live together happily and productively.

The Wrights built and established a home in Washington. The family grew to three sons and a daughter (their first daughter, Kathleen Margaret, died at age eight months) and included two violins, a piano, a dog, and lots of fun. All the children were taught to use their hands, and constructive projects were constantly under way. Each child built his own radio receiver. "We see what we are trained to see," Fred Wright said, and on the long hikes which were his chief relaxation he taught his children to see many things besides the rocks with which he was so familiar. Sunday morning the whole family was roused at dawn to go out and look for birds. In summer on their island among the Thousand Islands of the St. Lawrence, the children learned to identify flowers and trees, rocks and stars. With such training it is not surprising, perhaps, that all of them have entered in one way or another into different fields of science.

An element in the joy of living was the close association Wright and his wife maintained with their many friends and the hospitality they extended so generously to those who came to visit them from near and far. They had also a deep sense of duty toward their community and served on numerous boards and committees concerned with social welfare. Both maintained an active interest in the arts, particularly in music. Wright, a fine violinist, often accompanied Mrs. Wright, an accomplished pianist, in duets.

Wright was deeply and sincerely religious, but he did not proselytize. He sought to live his religion and be rational about it. His belief in God was strong and he could not understand how a research scientist could be without faith. He wrote: "We go to the Bible for Religion, not for science."

It may be recalled that Wright was left-handed but he was proud of being ambidextrous. He admired people with skillful fingers—an admiration resulting from his period, while in Germany, spent with the well-known instrument-maker Peter Stöe—this was advantageous in Wright's later developments of optical instruments and other instrumental equipment in the manipulation of which he was so adept.

Before his marriage Wright wrote: "I know I am not destined to become the self-centered scientist which I know you fear at times, who has no interest in life outside his own little domain. I have only this life to live, and although I do not want to spread it out so thin over everything that when it draws to a close its effects will nowhere be visible, I do want it rounded out and evenly balanced and not limited to one particular branch of geology. For there are so many things more important than science and the mere accumulation and orderly arrangement of facts. These are interesting, even fascinating, but surely not the end and ultimate purpose in life." It is likely that Fred Wright's wish was realized in greater degree than is given to most scientists or even to most men.

Colonel (now General) W. K. Rutherford, of the United States Army, prepared in 1954 an account of a campaign with Fred Wright at Fort Monroe in May 1919, from which we quote in part. "It is not necessary for me to enumerate the contributions which Fred Wright made to the Industrial Mobilization of the War and Navy Departments during the two World Wars in which he and I were closely associated. His additions to the knowledge of the Departments on the science of optics and its practical application in the fields of optical glass and optical instruments form an important factor in our historical progress. . . .

"Several personal experiences illustrating the character of the man may, however, bring back recollections of his kindliness and consideration for others that would never appear in his records or official reports of his work.

"During the First World War, the problem of locating a distant target so accurately on a map that it could be brought under artillery fire was an important one as yet unsolved and to which Fred and I were assigned. We decided that there might be possibilities of obtaining the data necessary to a solution by observations on the target from a captive balloon, which could then be translated into range and direction from the firing battery. This required an instrument for use in the balloon, and Fred undertook the job of producing such a device. He went to the Instrument-Shop at the Geophysical Laboratory of the Carnegie Institution of Washington and in a few days returned with what was needed, practically all of the quite complicated optical system and mechanical parts having been made by his own hands.

"We then proceeded to Fort Monroe where there was a captive balloon for testing the instruments. The balloon was ready, the weather was almost perfect for a flight. We got aboard and, as we ascended, the leash was paid out a couple of hundred feet, while the telephone and other controls were adjusted. Our captive began to behave like a bucking broncho at a rodeo or a small boat on a stormy ocean. It was here that my breakfast and I decided to part company. My attitude was anything but scientific but to Fred's eternal credit it may be said that he preserved his scientific objectivity (and breakfast) and did not even smile at my shortcoming.

"We had to conclude that a gyroscopic stabilizer both for the instrument and the observer's head would be needed.

"One of Fred's outstanding characteristics was consideration for the feelings of his associates, however much at variance with his own. This helped to make him such a delightful companion in the many activities in which we were mutually engaged, and his quiet appreciation of a joke made him good company."

Wright on first meeting appeared to be perhaps austere but, as friendship grew, his splendid character and sterling integrity and the charm of Mrs. Wright made their friendships more and more coveted as the years passed.

In 1944, at the age of 67, Wright retired from the Research Staff of the Carnegie Institution of Washington at the Geophysical Laboratory but he occupied an office at the Administration Building of the Institution, where he kept the usual hours until his death, engaged in his extensive correspondence, and the revision of his book on the petrographic microscope.

Wright died on August 25, 1953, at his island home (Sagastaweka), Ganaoque, Canada.

His many friends will miss this man of sensitive kindness, of high sense of duty, and of productive investigation, whose life was rich in contact with others, to each of whom he gave inspiration and guidance.

CHRONOLOGY

1877	Born at Marquette, Michigan, October 16. Son of Charles Eugene and Carolyn Alice (Dox) Wright.
1882–1895	Educated in private and public schools in Marquette and Ann Arbor.
1895–1896	Student at Real Gymnasium in Weimar, Germany.
1896–1900	Student at University of Heidelberg, Germany.
1900	Received Ph.D. from University of Heidelberg, *summa cum laude*.
1901	Returned to the United States.
1901–1904	Instructor in Petrology and Mineralogy at Michigan College of Mines, Houghton, Michigan.
1901–1902	Assistant Geologist on Michigan Geological Survey.
1902–1904	Assistant State Geologist of Michigan.
1904	Published "Rocks and Minerals of Michigan."
1904–1905	Assistant Geologist on United States Geological Survey.
1904–1906	Summer field work in Alaska for United States Geological Survey.
1905–1917	Geologist on United States Geological Survey (summer work only from 1906).
1906	Attended International Geological Congress in Mexico where he met his future wife, Kathleen Finley.
1906–1944	Petrologist, Geophysical Laboratory, Carnegie Institution of Washington.
1909	Married Kathleen Finley of Montreal, Canada.
1911	Publication of "The Methods of Petrographic Microscopic Research: Their Relative Accuracy and Range of Application.
1917–1918	Army Ordnance Reserve Corps. Captain, 1917; Major, 1918; Lieutenant Colonel, 1919; Colonel, 1928. (On inactive status with Reserve Corps of United States Army from 1941.)
1917–1918	As Captain, Ordnance Department, in charge of Geophysical-Laboratory group engaged in direction of manufacture of optical glass in the United States with headquarters at Bausch and Lomb in New York.
1917–1919	President of Optical Society of America.
1921	"The Manufacture of Optical Glass and of Optical Systems," published by War Department.

1922 Eight months in South Africa on joint geological expedition of Harvard University (Shaler Memorial Fund) and Carnegie Institution of Washington to study Bushveld Igneous Complex, Stromberg Plateau basalts, and formation of kimberlite and diamonds.

1923 Summer field work in Washington and Oregon in area of Columbia River basaltic-lava flows.

1925 Study of the moon begun. Chairman of Committee on Study of Surface Features of the Moon.

1927–1931 Vice-President of the National Academy of Sciences.

1928 International gravity-expedition to West Indies with Dr. Vening Meinesz.

1931–1951 Home Secretary of the National Academy of Sciences.

1940 Received Honorary Sc. D. from University of Michigan. Expedition to Guatemala for gravity-survey.

1941 Vice-President of Geological Society of America and President of Mineralogical Society of America.

1942-1946 Technical Advisor to Joint Optics Committee of the Army and Navy Munitions Board and the War Production Board. Chief Physicist, ASF, War Department. Special Advisor to Division A of the National Defense Research Committee.

1943 Special expedition to Guatemala for further study of gravity.

1945 Awarded Army Gold Medal "for exceptional civilian services."

1951 Second diploma of the University of Heidelberg given after 50 years. (Personally, Wright felt this to be a token of friendliness and co-operation in spite of World Wars I and II).

1952 Awarded Washington A. Roebling Medal of Mineralogical Society of America.

1953 Died August 25, at his island home (Sagastaweka), Ganaoque, Canada.

MEMBERSHIP IN PRINCIPAL LEARNED SOCIETIES AND CLUBS

American Academy of Arts and Sciences, 1915
American Association for the Advancement of Science, 1902
American Astronomical Society
American Geographic Society, 1904

American Geophysical Union, 1924
American Institute of Mining and Metallurgical Engineers, 1909
American Mathematical Society (President), 1915
American Philosophical Society, 1913
American Physical Society, 1911
American Radio Relay League, 1927
Army Ordnance Association, 1919
Cosmos Club of Washington, D. C., 1904
Geological Society of America (Vice-President, Councillor), 1904 (Life)
Geological Society of London (Foreign Fellow)
Geological Society of Washington (President, Secretary, Councillor), 1905
Mineralogical Society of America (President, Councillor), 1920
Mineralogical Society of London (Foreign Member)
Miscowaubit Club (Calumet, Michigan), 1904
National Academy of Sciences (Vice-President, Home Secretary), 1923
National Research Council, 1928
Optical Society of America (President, Councillor), 1916
Optical Society of London
Petrologists' Club (Washington, D. C.)
Philosophical Society of Washington (Councillor), 1905
Pick and Hammer Club (Washington, D. C.)
Physical Society, London
Seismological Society of America, 1926
Sigma Rho (Michigan College of Mines), 1901
Sigma Xi (Washington Branch)
Washington Academy of Sciences, 1906
Washington Literary Society, 1933
Washington Society of Engineers (Charter Member), 1905
Washington Society of Fine Arts (Secretary), 1905
The Carnegie Institution of Washington, 1924–1940

The second President, Doctor John C. Merriam, assigned Wright to be chairman of many special committees of the Institution, among which were the following:

Consideration of Questions Relative to Future Exhibits of work of the Institution (with the two-fold purpose to acquaint (1) the Trustees and (2) the general public with the current scientific results and activities of the several departments of the Institution), 1924;

Plan of Program for Exhibit of Carnegie Institution of Washington at

the Carnegie Memorial Building in Scotland, 1927–1928;
Advisory Committee on Public-Progress Reports, 1932;
Editorial Committee and Present Functions and Status, 1932;
Preparation of News for Publication by the Institution, 1933;
Instrumental Techniques and Methods within the Institution, 1935;
Public-Relations Problem of the Institution, 1937;
Advisory Committee on Physical Science, 1938.

Reports for these Committees cover over a hundred pages of typed matter including "Suggestions for Writers of Popular Lectures and on Science."

KEY TO ABBREVIATIONS

Acad. = Academy
allg. = allgemeine
Am. = America, American
Ann. = Annual
anorg. = anorganisch
App. = Appendix
Beil. = Beilage
Biol. = Biological, Biology
Bull. = Bulletin
Bur. = Bureau
Centralbl. = Centralblatt
Ceram. = Ceramic
Chap. = Chapter
Chem. = Chemical, Chemistry
Coll. = Collection(s)
Cong. = Congress
Coun. = Council
Dep. = Department
Dir. = Director
Doc. = Document
Eng. = Engineers, Engineering
Ethnol. = Ethnology
Frank. = Franklin
Geol. = Geological, Geologie, Geology
Geophys. = Geophysical, Geophysics
Ill. = Illustration
Ind. = Industrial
Inst. = Institute
Inst'n. = Institution
Inter. = International
J. = Journal
Jahrb. = Jahrbuch
Kryst. = Krystallographie
Mag. = Magazine
Met. = Metallurgical, Metallurgy
Min. = Mining
Mineral. = Mineralogical, Mineralogist
Mitt. = Mitteilungen
Mo. = Monthly
Nat. = National
No. = Number
Obser. = Observatory
Opt. = Optical
Ord. = Ordnance
Paleon. = Paleontologie
Petro. = Petrological Petrology
Phil. = Philosophical
Proc. = Proceedings
Pub. = Publication(s)
Rep. = Report(s)
Repr. = Reprint
Res. = Research
Rev. = Review
Sci. = Science(s)
Sec. = Section
Ser. = Series
Sess. = Session
Smith. = Smithsonian
Soc. = Society
Supp. = Supplementary
Surv. = Survey
Terr. = Terrestrial
Terr. Mag. = Journal of Terrestrial Magnetism and Atmospheric Electricity
Trans. = Transactions
Zs. = Zeitschrift

BIBLIOGRAPHY

INTRODUCTORY NOTE. In the preparation of the following bibliography, aid was given by the Geophysical Laboratory of the Carnegie Institution of Washington, where Wright was so many years a member of the staff, and by his daughter, Helen. It is arranged chronologically and gives a picture of the many fields of scientific and administrative activity in which he was engaged.

Some of his publications are doubtless omitted from the list, but such omissions are probably few. During his later years, his publications are fewer than in earlier years because of his duties as (1) an active officer of the United States Army during World Wars I and II and (2) his administrative responsibilities (*a*) during more than twenty years as Home Secretary of the National Academy of Sciences, (*b*) during the regime of President J. C. Merriam of the Carnegie Institution of Washington, when he was assigned responsibility as Chairman of many committees set up by President Merriam, and (*c*) because at the Administration Building of the Institution, he took over the arduous task of Chairman of the Committee on the Construction of the Elihu Root Memorial Hall and additional offices and storage facilities to the original Administration Building. All of these were important and called for much thought and organization on Wright's part. These assignments made unusually heavy demands on his time at the sacrifice of his scientific research—accounting for fewer publications over his name in later years. The result of these duties was of great value to the Institution and especially so during World War II, when the enlarged structure of the Institution's Administration Building was made the headquarters of the National Defense Research Committee under Doctor Merriam's successor, Dr. Vannevar Bush.

Wright was frequently called upon to address meetings of scientific societies. He was most generous in accepting these invitations and gave careful preparation to each address. Unfortunately, because of the press of war matters, not many of these were published. Had they been, another 50 or 60 titles would have been added to the bibliography.

A chronological review of the list following, also shows his continued devotion, throughout his scientific life, to the development and application of the petrographic microscope. This was recognized by his colleagues in the Mineralogical Society of America as shown by the award of its Roebling Medal. His speech of acceptance of that Medal is the last of the many publications listed in this section.

1898

Ueber einen Orthoklaszwilling. With V. Goldschmidt. Zs. Kryst. Min., 30: 300-301, with 1 pl.

1900

Der Alkalisyenit von Beverly, Massachusetts, U.S.A. Tschermak's Min. Petro. Mitt., 19: 308-320.

1901

Die feyaitisch-theralitischen Eruptivgesteine der Insel Cabo Frio, Rio de Janeiro, Brazilien. Tschermak's Min. Petro. Mitt., 20: 233-306.

1902

A New Combination Wedge for Use with the Petrographical Microscope. J. Geol., 10: 33-35.

1903

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Report on the Progress Made by the Porcupine Mountain Party during the Summer of 1903. Mich. Geol. Surv. Ann. Rep., 35-44.

Ueber Actzfiguren, Lichtfiguren und Lösungskörper, mit Beobachtungen am Calcit. With V. Goldschmidt. Jahrb. Beil., 17: 355-390, with 11 pl.

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1904

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1905

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1906

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1907

Recent Changes in the Glaciers of Glacier Bay, Alaska. With C. W. Wright. Science, n.s., 25:770

Artificial Magnesium-Pyroxenes and Amphiboles. Science, n.s., 25:389-390.

Die Kalkkieselreihe der Minerale. With Arthur L. Day, E. T. Allen, E. S. Shepherd, and W. P. White. Tschermak's Min. Petro. Mitt., 26:169–232.

The Measurement of the Optic Axial Angle of Minerals in the Thin Section. Am. J. Sci., 24(4):317–369, with 2 pl.

1908

Die Justierung des Abbe-Pulfrichschen Kristallrefraktometers. Zs. Instrumentenkunde, 28:201–206.

Quartz as a Geologic Thermometer. With E. S. Larsen. Bull. Geol. Soc. Am., 20:671.

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1910

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