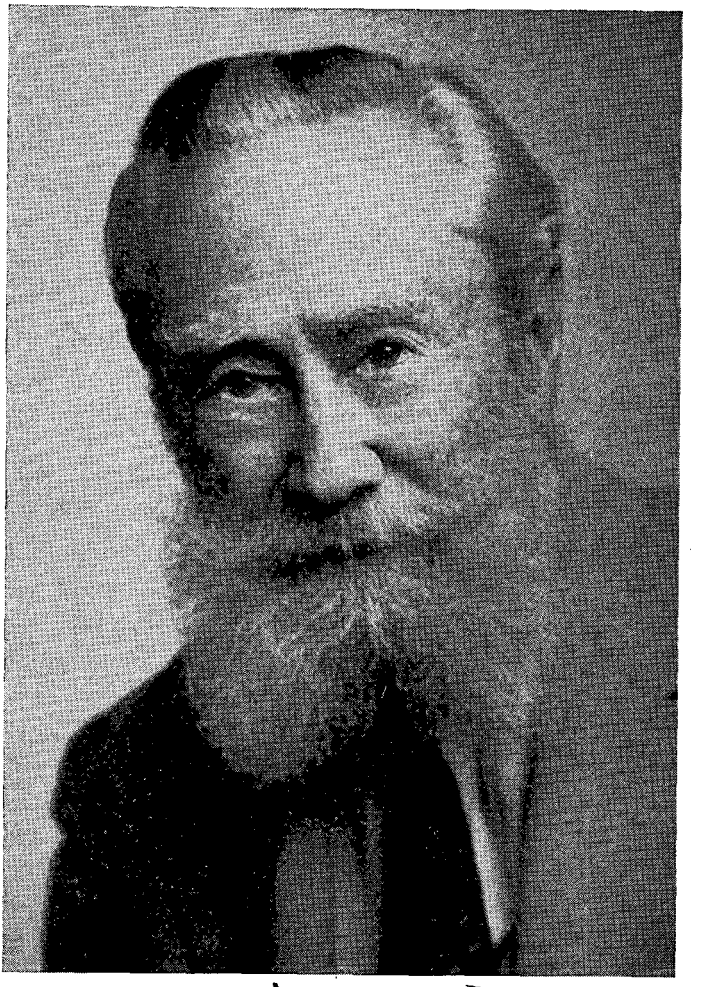

Bailey Willis

BAILEY WILLIS

May 31, 1857–February 19, 1949

BY ELIOT BLACKWELDER

WHILE it is not easy to classify as versatile a man as Bailey Willis, the word explorer fits him best. Although he came too late for the early period of geologic exploration of the western states, he was associated with many of those who had taken part in it, and he grew up with its later stage.

The son of a noted poet, it is not strange that he displayed much of the temperament of an artist and that his scientific work should have leaned toward the imaginative and speculative side rather than the rigorously factual.

Willis was born on a country estate at Idlewild-on-Hudson in New York, on May 31, 1857. His father, Nathaniel Parker Willis, whose Puritan ancestors settled in Boston in 1630, was well known as a journalist, poet and writer of essays and commentaries; but he died when Bailey was only ten years old. His mother, Cornelia Grinnell Willis, of Quaker ancestry, seems to have been his principal mentor in his youth, inspiring his interest in travel, adventure and exploration.

At the age of thirteen he was taken to England and Germany for four years of schooling. A ready command of the German language which he thus acquired was of great value to him in an epoch when German science and culture led the world. Returning to New York, he entered Columbia University and in five years completed his studies with the degrees of mechanical (1878) and civil (1879) engineer.

Thereby his interests were given a bent toward the physical rather than the biological aspects of geology.

His geologic work began in 1879 under fortunate circumstances that had much to do with shaping his later career. Having met Clarence King, who was then organizing the new U. S. Geological Survey, he was recommended by him to Raphael Pumpelly, one of the earliest and most active economic geologists in the United States, recently returned from several adventurous years in China and then in charge of the survey for the projected Northern Pacific Railroad. In Pumpelly's employ, Willis spent the next few years in estimating deposits of coal and iron ore in remote parts of the southern Appalachian mountains, northern Minnesota, Montana, and particularly Washington. Much of the time he was alone, except for native helpers, traveling by canoes, on horseback, or on snowshoes, and living the strenuous life of the wilderness. It was difficult work, which called forth all the stamina and ingenuity at his command. In 1882 he visited the slopes of Mount Rainier with a distinguished party which included General Miles and General Sherman. In the following year he led another party of notables, among whom were Sir James Bryce and Baron Karl von Zittel, to the same locality. Fourteen years later, in company with I. C. Russell, he made one of the first ascents of the great volcano. Out of this episode later developed the Rainier National Park, for which Willis had the pleasure of writing the memorial to Congress.

When the railroad company went bankrupt in 1884 he joined the U. S. Geological Survey under Major Powell, and for the next dozen years devoted his time largely to the study of the southern Appalachian mountains and other parts of eastern United States. During that interval he had an inspiring association with G. K. Gilbert, noted explorer of the Great Basin, who was then Chief Geologist. He also credited Powell with an important influence on his development as a young scientist.

Willis first earned widespread recognition as a geologist as a result of early studies in eastern Tennessee and adjacent parts of the Ap-

palachian mountains. The region was forested, only sparsely inhabited and the geologic structure complex. In spite of these heavy obstacles, he mapped in detail the folds and overthrusts and brought out a new interpretation of the geologic history of the region. With the encouragement of Major Powell, he made a series of laboratory experiments on the deformation of strata under load. Using layers of colored wax he reproduced in realistic fashion the folds and faults typical of the compressed area of the Appalachians. The results of these experiments, as well as his field surveys, were published in his first book, *The Mechanics of Appalachian Structure,* a work which aroused immediate interest in Switzerland and other parts of Europe where similar conditions were being studied by others. This led to his presenting a paper on overthrusts, at the International Geological Congress, in Vienna, in 1903.

Structural geology continued to be one of his major interests for many years, and in 1923 he published under the title *Geologic Structures* a general book on the subject. In preparing the second edition of this work in 1929 he was aided by his son Robin as junior author. In the preface he says that he owed his introduction to the subject to G. K. Gilbert.

In connection with his study of the Appalachian region he helped to develop the system of folio reports which were soon extended to all parts of the United States. Meanwhile he had served as editor of geologic maps and for a time as assistant to the director; but administrative work was never to his liking and the unknown wilderness continued to beckon to him. He therefore resumed work in the northwestern states, studying parts of the Cascade Range in Washington and the region of Glacier Park in Montana. On part of this work he was assisted by George Otis Smith, who later became director of the Geological Survey.

In 1903 he readily accepted the invitation of the newly established Carnegie Institution of Washington to lead an expedition to northern China, for the exploration of the very region about which he had heard much from Pumpelly in his earlier years. This journey around

the world, which lasted more than a year, enabled him to attend the International Geological Congress in Vienna and also to confer in London, Paris and Berlin with several geologists who had some knowledge of the geology of northeastern Asia. The most important of these was Baron von Richthofen, who had spent several years exploring China and in 1882 published the most extensive geological report and atlas of that little-known country. After visiting Karpinski in St. Petersburg, the party continued on via Moscow over the new Siberian railroad into Manchuria. In the course of the long journey he conferred with the Asiatic explorer Obrutchev in Tomsk.

The trip across northern China and eventually down the Yangtze River, made partly during the winter, was through a country largely unknown to geologists and one which had only recently been supposedly hostile to Westerners. It is a tribute to Willis' previous experience in exploration, to his foresight in preparing for the trip and to his skill in adapting himself to novel situations and strange people, that the expedition met with no serious mishaps and was carried through as planned. It might easily have ended in failure if not disaster. The four-volume report and folio of maps are recognized as one of the important early contributions to the knowledge of Chinese geology and paleontology. Part of this was the work of his assistants, Blackwelder and Sargent, and such collaborators as Charles D. Walcott. Willis himself devoted most of his attention to the geologic history and the physiographic development not only of that part of China visited by the expedition but a large part of Asia in general. He interpreted what he saw in terms of the current theories about planation, warping and cycles of erosion. In his final report on the expedition, he even included a summary of his ideas on the dynamics of the earth.

In his last book, *Friendly China,* which was in press at the time of his death, he gives a popular account of his experiences and observations in China. In this he reveals his strong interest in the people of the country, their lives and customs. Ironically, as the book was going through the press (1949), the people of China were helplessly

passing under the domination of a new tyrannical regime that proved to be anything but friendly to Americans.

In the years 1896 to 1902, although much of his time was occupied with administrative work in Washington, partly as Chief Geologist of the Geological Survey, he carried on extensive field work in the region of Puget Sound and later in the central part of the Cascade range of Washington state. Although the primary object of the survey was a study of the coal beds, Willis devoted much of his attention to the Pleistocene glacial deposits and the physiographic history of the region. He interpreted the area as one which had been reduced to a lowland by erosion, had afterward been gently warped and then carved by stream and glacial erosion into its present detailed forms. In later years he applied the same theory to other areas in California, China and elsewhere.

Early in 1905 he and Mrs. Willis went to Europe partly for the purpose of studying at the Geographical Institute in Berlin, conferring again with Baron von Richthofen on the geology of central Asia. Thence they proceeded down the Danube and on into Turkey, where Willis examined features of geologic interest.

A trip to Argentina in 1910, in company with the noted anthropologist Alês Hrdlicka, brought him an invitation from the Argentine government to help them to organize a geological survey primarily for the purpose of planning the development of water and power in the semi-arid lands of southern Argentina and along the eastern slope of the Andes. This project engaged his attention for the next four years and enabled him to study some of the most interesting parts of Patagonia and the southern Andes. His reports to the government covered projects for cities, roads, industries and much else besides geology. Water-supply and hydroelectric power were important considerations. His early training as an engineer served him well in this phase of the enterprise.

Dealing with high officials of the Argentine government required of him, at times, unusual tact and skill in handling relations that were partly personal and largely political. Except for two papers on

the physiography of the Andes, and a book in both English and Spanish, *Northern Patagonia, Character and Resources,* the scientific reports of these expeditions, prepared for the use of the Argentine government, appear to have remained unpublished.

Willis left Argentina in 1914, and the fruition of this work was delayed for thirty years by the vicissitudes of Argentine politics and the outbreak of the First World War in Europe. Eventually he presented the remaining data to the Argentine government. Much later in life, he wrote a popular book on his Argentine experiences, under the title *A Yanqui in Patagonia.*

While working in the Appalachian mountains during the nineties Willis' attention was necessarily drawn to problems of stratigraphy and sedimentation as a basis for interpreting the ancient history of the region. These led to a series of papers between 1893 and 1912, in which he made important contributions to geologic thinking on these subjects. The results of these studies prompted him to publish, in collaboration with R. D. Salisbury, a symposium on paleogeography and other aspects of the geologic history of North America. His widely used geologic map of North America, in the compilation of which he was ably assisted by his artistic wife, was in some respects a byproduct of his work on stratigraphy. It was prepared initially for the International Geological Congress of 1906.

Willis lectured on geology at Johns Hopkins University at intervals from 1895 to 1902 and later also at the University of Chicago (1909). In 1915 he was invited by President Branner to go to Stanford University as head of its Department of Geology. By accepting this he became a resident of the Pacific coast for the remainder of his life, and devoted most of his attention to the geology of California and other parts of the Pacific Basin. Among his students at Stanford he aroused interest not only in the local geology of the region but especially in the principles of structural geology and physiography.

His retirement from active service as a professor in 1922 left him free for many years of activity on his own initiative. In California

his studies were concerned largely with various parts of the Coast Ranges. Some of this work was connected with problems of municipal water-supply for San Francisco and other cities, the foundation for the Golden Gate Bridge, earthquake damage to buildings, and geological problems of military importance in relation to the First and Second World Wars. As these structural studies involved not only ancient but recently active faults, such as the San Andreas Rift, he became progressively more interested in seismology and problems of the earth's interior. A large fault map of California, which he prepared in collaboration with H. O. Wood, was published by the Seismological Society of America in 1923.

While living in California he found time for an expedition to Northern Chile, in the capacity of seismologist for the Carnegie Institution of Washington (1923), and for a second trip to Japan, China and the Philippines in 1926–1927. In Tokyo he was a delegate to the Pacific Science Congress. Continuing southward he visited New Zealand and then Palestine and Europe while returning homeward.

After attending the International Geological Congress in South Africa in 1929 he utilized the return journey northward to Egypt to examine for the Carnegie Institution the physiographic features of the great East African rift valleys and lakes,—a study which had begun in Palestine two years earlier. His interpretation of these features as being due to compression and shearing along inclined thrust-planes represents a notable departure from earlier opinions. The results of this journey were published in the form of two books: *East African Plateaus and Rift Valleys,* which contains the scientific results, and *Living Africa,* a popular narrative.

His last foreign journey, in 1936–1937, took him to Japan, Formosa, the Philippines, Indonesia and India. Some of the results of this trip are embodied in a geological report on the Philippines, presented to the Pacific Science Congress, in Berkeley in 1939.

In order to keep in touch with his fellow geologists over the world, he managed to attend most of the International Geological Con-

gresses between 1891 and 1933, as well as the Pacific Science Congresses in 1926 and 1939. He also took part frequently in the meetings of the Geological Society of America—of which he was president in 1929,—the American Philosophical Society, the National Academy of Sciences (to which he was elected in 1920) and other organizations in which he had membership. He also carried on extensive correspondence with many foreign geologists, such as de Margerie, Penck, Gregory, Heim and Suess.

Although in his early years Willis did some notable experimental work on rock deformation, he was not a laboratory scientist; the microscope was not one of his tools. As a confirmed explorer he loved reconnaissance, and was content to leave the filling in of details and the determination of niceties to those who were to come after him. The breadth of his interests included such diverse subjects as archeology, the origin of petroleum, cosmogony and geophysics. In dealing with broad and complex problems, his lively imagination often contributed hypotheses to explain the phenomena; while some of these could not, for lack of evidence, be tested at the time, he continued to revise them as more data became available.

In his later years he found time to elaborate certain ideas about the conditions and processes in the interior of the Earth, which had been stimulated in part by his earlier association with G. K. Gilbert and T. C. Chamberlin. One of the first was his discoidal theory of the earth's crust, which was presented in 1919.

Ten years later, in his presidential address to the Geological Society of America, he offered a theory to account for the formation of continents by the amalgamation of certain fluid masses which he named *asthenoliths*. In connection therewith he found an explanation for the crustal pressure which is the cause of rock folding and faulting, ascribing it to the mineral changes in the course of rock metamorphism under the influence of gravity and heat, in the interior of the earth. He suggested that radioactive minerals generated heat faster than it could be conducted away.

The subjects of isostasy, orogeny and epeirogeny had engaged his

mind for more than half a century and were dealt with in a notable address which he made before the Geological Society of America in 1948 only a few months before his death. On that occasion he offered hypotheses to explain such things as uplift and subsidence, curved island arcs, the origin of batholiths, the genesis of granite and the cause of the forces involved in orogeny. Always a lover of theory, Willis was often ready with an explanation long before he had the facts necessary to establish his opinion. His ideas on isostasy differed somewhat from those of Dutton and Hayford, agreeing better with the views of his old friend Gilbert. Apparently he regarded isostasy as merely a guide to movements which were actually caused by the generation of internal heat. In a paper published in 1944 Willis rejected the theory of continental drift, which at one time had many adherents, especially in Europe.

At the time of the First World War he prepared local reports for the use of the United States government; and even in World War II he contributed useful information to the military authorities, especially regarding southeast Asia and the adjacent islands. At the close of World War I, in 1918, Willis was called to New York for several months as head of the Latin-American division of the Col. E. M. House Inquiry in connection with the Peace Conference in Paris. In later years he often used his scientific talents in the service of the community, in connection with problems of water-supply, the construction of dams and the prevention of damage by earthquakes.

Among the numerous honors which came to Willis during his long life, one may note an honorary Ph.D. degree from the University of Berlin and the Gold Medal of the Geographical Society of France in 1910, the Legion of Honor, Belgium, in 1936, and the Penrose Medal of the Geological Society of America in 1944.

In times of relaxation, his principal hobby was painting, especially in water colors. He was also a skilled photographer even in the early days of that art. His notebooks and scientific reports contain many admirable pencil sketches—often more useful than photographs.

Willis married Miss Altona Grinnell in 1882, but she died in 1896,

leaving one child, Hope, later Mrs. Seward H. Rathbun. In 1898 he married Margaret Baker, daughter of Dr. Frank Baker of Georgetown University, who was also superintendent of the National Zoological Park. The children of his second marriage are Cornelius G. Willis, Robin Willis and Margaret (Mrs. Donald F.) Smith. The family lived for many years on the Stanford University campus. Mrs. Willis died in 1941 and her husband on February 19, 1949.

Willis was a slender man, of short stature, but wiry and noted for his endurance as a walker and mountain climber. For many years he was a familiar figure on the Stanford campus, walking briskly along, distinguished from all others by the bushy beard which he continued to wear. To the local public, who understood little about his geological researches, he was best known as "the earthquake expert." One of the numerous myths about him was that he predicted the Santa Barbara earthquake of 1925. This story grew out of the coincidence that he happened to be in Santa Barbara on the very night the earthquake took place.

By supplying facts and helpful suggestions, several of Willis' children aided the writer in preparing this memorial. Special thanks are due to Dr. Robin Willis for providing the bibliography which follows. The list does not include numerous reviews, abstracts and brief notices.

KEY TO ABBREVIATIONS

Am. Jour. Sci.=American Journal of Science
Am. Phil. Soc. Bull.=American Philosophical Society, Bulletin
Bull. A.A.P.G.=Bulletin of the American Association of Petroleum Geologists
Bull. Am. Geog. Soc.=Bulletin of the American Geographical Society
Bull. G.S.A.=Bulletin of the Geological Society of America
Bull. Seis. Soc. Am.=Bulletin of the Seismological Society of America
C.R. Congrès Géol. Int.=Comptes Rendus, Congrès Géologique International
Carnegie Inst. Wash. Pub.=Carnegie Institution of Washington, Publication
Carnegie Inst. Wash. Yr. Bk.=Carnegie Institution of Washington Year Book
Ec. Geol.=Economic Geology
J. G.=Journal of Geology
Jour. Race Development=Journal of Race Development
Maryland Geol. Surv. Sp. Pub.=Maryland Geological Survey, Special Publication
Nat. Ac. Sci. Bio. Mem.=National Academy of Sciences, Biographical Memoirs
Nat. Assoc. Builders, 19th An. Conven. Proc.=Proceedings of the National Association of Builders 19th Annual Convention
Nat. Geog. Mag.=National Geographic Magazine
Nat. Geog. Soc. Mon.=National Geographic Society Monograph
Pac. Sci. Congress, Proc.=Pacific Scientific Congress, Proceedings
Pop. Sci. Mo.=Popular Science Monthly
Science, n.s.=Science, New Series
Sci. Monthly=Scientific Monthly
Smithsonian Inst. An. Rept.=Smithsonian Institution, Annual Report
Trans. A.I.M.E.=Transactions of the American Institute of Mining and Metallurgical Engineers
U.S.G.S., An. Rept.=United States Geological Survey, Annual Report
U.S.G.S., Bull.=United States Geological Survey, Bulletin
U.S.G.S., Prof. Paper=United States Geological Survey, Professional Paper
U.S.G.S., W.S.P.=United States Geological Survey, Water Supply Paper

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