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ARTHUR LOUIS DAY

1869—1960

A Biographical Memoir by

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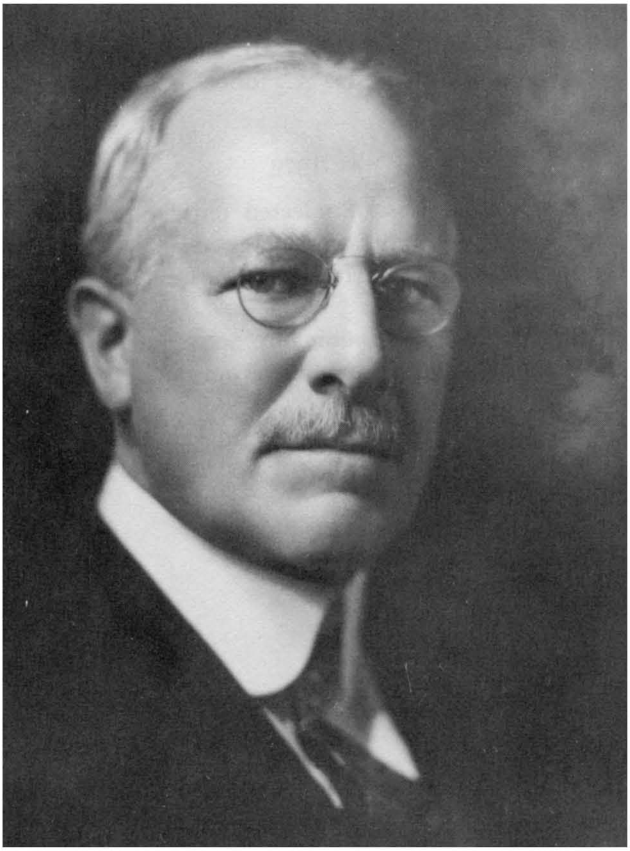
Biographical Memoir



Arthur L. Day

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October 30, 1869—March 2, 1960

BY PHILIP H. ABELSON

ARTHUR L. DAY usually described himself as a "physicist," but this description is too simple for a man whose scientific achievements spanned the fields of physics, geophysical chemistry, volcanology, seismology, and ceramic research.

Dr. Day began his scientific training at the Sheffield Scientific School of Yale University, from which he received his Ph.D. in 1894. He taught physics at Yale until 1897, when he decided that his career should be in the laboratory, not the classroom. He had worked with Friedrich Kohlrausch during the summers of 1894 and 1895 and was convinced that advancement in the field of physics required a foreign, particularly German, postgraduate experience. In 1897 he went to the Physikalisch–Technische Reichsanstalt in Charlottenburg–Berlin, one of the best physics laboratories in the world, and volunteered his services as an unpaid assistant. His offer was accepted, and he soon became a member of the regular staff. It was there that he became interested in high-temperature thermometry, a field that was to be his primary research interest for the next fifteen years.

In 1900, the U.S. Geological Survey established a physical laboratory as part of the Division of Physical and Chemical Research, headed by George F. Becker. A principal aim of the laboratory was to conduct high-temperature research in silicate equilibria. Dr. Day was offered a temporary appointment as physical geologist in the fall of 1900, and he accepted. The appointment was made permanent in 1901.

Dr. Day undertook two major investigations at the U.S. Geological Survey. The first was the investigation of equilibria in mineral systems at high temperatures. He chose to study some of the most common minerals of igneous rock, the plagioclase feldspars. He began this work with a study of their melting relationships and soon enlisted the help of E. T. Allen of the Survey's chemical laboratory. The work was pioneering and productive. C. D. Walcott, Director of the Survey, described the results of their research as " . . . one of the most important contributions to geologic physics ever printed."

The second line of investigation begun by Dr. Day in the physical laboratory of the Survey was an extension of the gas thermometer scale to high temperatures. At that time no reliable gas thermometer measurements had been made at temperatures around 1150° C. Temperatures in that region were usually estimated by extrapolating the temperature–resistance relationship of platinum resistance thermometers or by rather inaccurate radiation methods. Since it was evident that much of the projected work on mineral relationships would lie in the temperature regions above 1150° C, Dr. Day undertook to extend the nitrogen thermometer scale.

While this work was under way at the Survey, in 1902 Andrew Carnegie created the Carnegie Institution of Washington "to encourage, in the broadest and most liberal manner, investigation, research and discovery, and the application of knowledge to the improvement of mankind." As soon as an Executive Committee was formed, an investigation was begun to determine what work should be undertaken in the near future by the new institution. Eighteen advisory committees were appointed to help make the decisions. T. C. Chamberlin, C. R. Van Hise, and Charles D. Walcott formed the Advisory Committee on Geology; they, together with R. S. Woodward, Carl Barus, and A. A. Michelson (the members of the Advisory

Committee on Physics) formed an Advisory Committee on Geophysics. This committee invited advice from many other distinguished scientists and recommended that the Carnegie Institution establish a Geophysical Laboratory.

The Institution did not immediately establish the laboratory as recommended. Instead, it made grants to Becker and to Day to increase and extend the work that they were doing in the physics laboratory of the Survey: to Becker for experiments on the elasticity and plasticity of solids and to Day for his investigation of mineral fusion and solution at high temperatures and pressures. Space was provided by the Survey to conduct these experiments as of July 1904. Each year following, the Carnegie Institution made larger grants to Dr. Day, who was able to assemble a capable staff of workers to vigorously pursue his investigations.

In December 1905, the Carnegie Institution, seeing that the work was bringing results, appropriated money for the creation of a geophysical laboratory in Washington to house the work. Dr. Day, by virtue of his broad experience and practical nature, was the logical choice for the directorship of the laboratory, and he held this position from 1906 until 1936.

At first the Geophysical Laboratory was concerned mainly with phase-equilibrium studies of the oxides and sulfides of the earth's crust. Dr. Day, continuing the work he had begun years before in Germany, extended the standard gas thermometer scale from 1200° C to 1600° C in a series of experiments that he completed in 1911. By extrapolating from this temperature, a value was assigned to the melting point of platinum. This work established a practical temperature scale, defined in terms of closely spaced melting points of pure substances.

After completing this work, Dr. Day turned his attention to the geophysics and geochemistry of volcanoes, which provided accessible "laboratories" to test the theories of high-temperature geological phenomena. A prevailing theory that particularly interested him was that volcanic emanations are completely anhydrous. In 1912 he and E. S. Shepherd went to the active volcano region of Kilauea, Hawaii, to collect gas samples directly from liquid lava. The development of gas-collecting equipment to avoid contamination by air was an important by-product of these studies. Dr. Day not only found water vapor to be the principal volcanic gas, but he also discovered unexpected variation in the nature and volume of the gases; the amount and proportion changed with every escaping bubble. The methodology and results constituted an important advance in volcanological studies. Dr. Day's interest in volcanoes led him to the study of hot springs, and he collaborated with E. T. Allen in a series of monographs on the hot springs of Yellowstone National Park and the Lassen Peak and Geyserville regions of California.

In its early years the Geophysical Laboratory was considered by many to be of little practical significance. Dr. Day often told the story of the Senator's wife who could see no reason for trying to find out how rocks were formed as long as they could be bought more cheaply than they could be made. The usefulness of the laboratory was demonstrated in 1917, when it was called into war service to ease a critical shortage of optical glass.

Optical glass of high quality was urgently needed by the armed forces for use in gunsights, periscopes, rangefinders, field glasses and the like. Before the war optical glass was obtained almost exclusively from Germany, and by 1917 the United States had exhausted its own small supply in filling orders from Great Britain and Canada. To make the situation worse, European methods of manufacture had been kept secret and there were no American glassmakers experienced in optical glass production.

A few days after the declaration of war, the National Research Council delegated Dr. Day to make a personal canvass of the possible resources for the manufacture of satisfactory optical glass in this country. He presented an informal history of his activities in a talk at a joint meeting of the Section of Physics and Chemistry of the Philadelphia Section, American Chemical Society, which was published in the *Journal of the Franklin Institute,* in October 1920. In this report he said that he discovered in the canvass to which he had been assigned that optical glass had been made in small quantities in this country long before the year 1917.

When his canvass was completed, Dr. Day reported to the National Research Council that one firm in the United States was regularly producing glass of fair optical quality at the rate of perhaps 2,000 pounds per month; that there was another plant of much larger capacity that might be deemed available but which had never produced glass of strictly optical quality; and that four others, including the Bureau of Standards Laboratory, were very small and still in the experimental stage.

In 1915, the Bureau of Standards Laboratory in Pittsburgh had erected a small furnace in which a number of pioneer essays were attempted. One type of optical glass (a borosilicate crown) had been produced at the Bureau of Standards Laboratory by March 1917, when the situation was most critical, and their experimental work was continuing.

As forecast by the General Munitions Board in 1917, the estimated requirements of the army and navy amounted to 2,000 pounds of optical glass per day. Following this revelation, there were earnest conferences in the National Research Council before a course of action was determined upon, which was to ask the President of the Carnegie Institution of Washington to allow the resources of the Geophysical Laboratory, both in men and apparatus, to be applied to this overwhelming task, not that optical glass had ever been made there, but that at the Geophysical Laboratory there was available a larger and more experienced group of silicate chemists than perhaps could be found elsewhere.

On April 19, 1917, thirteen days after the United States entered World War I, the Executive Committee of the Carnegie Institution authorized Day, "upon application from the United States Government or any of its agents, to undertake an investigation of the properties and technique in production of optical glass, and to secure cooperation in so far as practicable and essential with governmental and private agencies engaged in the study or production of this material."

About the end of April 1917, members of the Geophysical Laboratory staff were detailed by Dr. Day to the Bausch & Lomb Optical Company at Rochester, New York. The silicate chemists pursued the usual research methods to discover what they could about optical glass. They analyzed existing samples and assembled the indicated raw materials; they calculated the evaporation of alkali during the melting process and the kind and amount of material likely to be dissolved out of the containing vessel; and they estimated what the initial composition would be that would yield the required product. Then they made up two other samples differing from the first by a few percent in the most critical ingredient, melted the three samples under like conditions, and plotted the curve representing their relationship to one another and to the prescribed sample. In almost every case the exact specifications for the glass desired fell within that row of three observations, and it became possible to write the formulas for any of the typical glasses required for war service without the advice from a "glass expert." In the days of rule-of-thumb glassmaking, as many as 150 essays had been necessary before a glass of predetermined optical constants resulted. The knowledge attained by the Geophysical Laboratory scientists commanded for them the immediate respect and confidence of the workmen who had hitherto believed these things to be shrouded in impenetrable mystery, and rapid progress and wholehearted cooperation were obtained.

In May 1917, the General Munitions Board (later replaced by the War Industries Board) appointed Day a member of a committee to give continuous attention to the task of developing an adequate supply of optical glass, and he was designated "In Charge of Optical Glass Production, War Industries Board."

It appeared that all of the sources of optical glass available in May 1917 could together produce only about half the quantity required by the General Munitions Board, assuming that all glass produced was of quality suitable for war equipment. It was estimated that Bausch & Lomb Company, by extending their plant, could carry approximately one-half of the war load. To maintain the other half, it was decided to make the Charleroi plant of the Pittsburgh Plate Glass Company available and to place someone in charge of it who should have sufficient knowledge of the requirements and techniques to raise the quality of glass produced there to the standard that the government required and that they had not hitherto attained alone.

After several conferences, Dr. Day reported, "a plan was agreed upon whereby the Pittsburgh Company should undertake to perfect their glass under the direction of the Bureau of Standards Laboratory, located nearby. It appeared to the committee that such an arrangement might work out advantageously, for the chemists of the Geophysical Laboratory were already in charge at Rochester [Bausch & Lomb] and a gentle rivalry between the two institutions might prove an incentive to each, of a kind which might bring results more rapidly than without such an arrangement. . . ."

By the time of the armistice, in 1918, Dr. Day had supervised the production of over 90 percent of the optical glass produced in the United States, and a crisis had been averted.

In 1918, Dr. Day took a leave of absence from the Geophysical Laboratory to become Vice President in Charge of Manufacturing at the Corning Glass Works in New York, for which he had been a research consultant since 1905. He remained there until 1920, when he resumed directorship of the

Geophysical Laboratory in Washington. Although no longer in charge of any research activities at Corning, he continued as consultant until his retirement from Carnegie Institution in 1936.

Dr. Day's ability and experience as a laboratory and field investigator, his widespread and intimate acquaintance with scientific workers, and his outstanding qualities as an organizer made him particularly suited for the next major activity of the Geophysical Laboratory, which was the study of earthquakes. From 1921 until 1936 he served as chairman of the Institution's Advisory Committee in Seismology.

The idea for such a committee arose from H. O. Wood's publication in 1916 of a detailed plan for cooperative seismological research in California. This called for the active guidance and financial support of some organization that could enlist the cooperation of the appropriate organizations and individuals. Shortly after John Merriam was elected president of the Carnegie Institution in 1921, it was proposed that the Institution enter the field of seismology and the Advisory Committee in Seismology was formed. This committee, composed of J. A. Anderson, Ralph Arnold, W. W. Campbell, A. C. Lawson, R. A. Millikan, Harry Fielding Reid, Bailey Willis, and Dr. Day, was asked to investigate the matter and advise the Institution.

After a careful examination the committee recommended that the Institution enter this field, beginning in Southern California. After surveying problems in that area, it pointed out the need for four principal studies: geology along the fault zone, surface displacement, continuous seismological observation at selected stations and the development of suitable instrumentation for such observations, and gravity determinations. These four studies together would constitute a comprehensive approach to a discussion of crustal movement of a magnitude and scope beyond anything previously attempted.

Dr. Day was chosen chairman of the committee and proceeded to organize what was then the largest cooperative effort in the history of American science. Among the agencies involved in the joint endeavor were the Seismological Society of America, the U.S. Coast and Geodetic Survey, the California Institute of Technology, the Hydrographic Office of the Navy, the U.S. Geological Survey, the University of California, Stanford University, the observatories at Mount Hamilton, Ukiah, and Mount Wilson, the U.S. Bureau of Standards, and the Geophysical Laboratory of the Carnegie Institution of Washington.

The Advisory Committee in Seismology continued to guide the work of the Carnegie Institution in this field until the retirement of Dr. Day in the fall of 1936. The various projects of the committee were energetically pursued, and the work resulted in several comprehensive reports on seismological problems in the western United States. Dr. Day can properly be given credit for stimulating seismology in the United States and raising it to a level of sophistication that it had not previously known.

In the later years of his directorship, Dr. Day became involved in still other areas of research. With the advance in knowledge of radioactivity and the realization that radioactive disintegration must supply an enormous amount of heat to the earth, it became evident that more work was needed in this field, and in 1925 the Geophysical Laboratory entered this research. In an investigation of the radioactive content of ocean samples, it became evident that better samples were desirable. The work done at the laboratory under the direction of Dr. Day led to the development of Dr. Charles Piggott's gun for obtaining core samples of the ocean bottom. The Geophysical Laboratory also advanced the study of methods of age determination based on radioactive disintegration.

Dr. Day continued to pursue his many fields of interest even after his formal retirement in 1936. He remained especially interested in seismology and hot springs and made extensive studies of the volcanic areas of New Zealand. A severe physical breakdown forced him to give up such activities after 1946, and he died suddenly of a coronary thrombosis on March 2, 1960.

The esteem in which Dr. Day was held by his fellow scientists is evident by the memberships and high offices to which he was elected and the honors that were bestowed upon him. He was elected to membership in the National Academy of Sciences in 1911 and served as Home Secretary from 1913 to 1918 and Vice President from 1933 to 1941. He became a Fellow of the Geological Society of America in 1909, and served as Vice President in 1934 and President in 1938. Dr. Day was also elected President of the Philosophical Society of Washington in 1911 and of the Washington Academy of Sciences in 1924.

His memberships also included the Accademia dei Lincei of Rome, the American Academy of Arts and Sciences, the American Philosophical Society, the American Chemical Society, the American Physical Society, the American Geophysical Union, the Franklin Institute, the Turin Academy, the Geological Society of London, the Society of Glass Technology, the Société Hollandaise des Sciences of Haarlem, and the academies of sciences of Sweden, Norway, and the U.S.S.R.

Dr. Day was the recipient of four honorary degrees in recognition of his scientific achievements: from Groningen (1912), Columbia (1915), Princeton (1918), and the University of Pennsylvania (1938).

Among his scientific honors, he received the John Scott Award of the City of Philadelphia (1923), the Bakhuis Roozeboom Medal of the Royal Academy of Amsterdam (1939), the William Bowie Medal of the American Geophysical Union (1940), the Wollaston Medal of the Geological Society of London (1941), and the Penrose Medal of the Geological Society of America (1947). Dr. Day was chosen as Orton Lecturer of the American Ceramic Society in 1934 and as Edgar Marburg Lecturer of the American Society for Testing Materials in 1936.

In 1948, Dr. Day created a fund for an Arthur L. Day Medal, under the auspices of the Geological Society of America, to be presented annually in recognition of "distinction in the application of physics and chemistry to the solution of geological problems." He hoped that such recognition of achievement in the geophysical sciences would lead to more and better research in the laboratory and in the field.

Dr. Day is eminent for his personal research, for his leadership in the establishment of the Geophysical Laboratory to investigate numerous geophysical and geochemical problems, and for the part he played in promoting cooperative effort in several fields of geophysical research. This eminence was recognized by the dedication to him in 1938 of an entire volume of the *American Journal of Science* (number 35-A in the fifth series of the *Journal*). The "Arthur L. Day Volume" contains twenty-three scientific papers on geophysical and geochemical topics, contributed by twenty-four active or former members of the Geophysical Laboratory staff.

Dr. Day was born in Brookfield, Massachusetts, on October 30, 1869, the son of Daniel P. and Fannie Hobbs Day. In 1900 he married Helene Kohlrausch, daughter of Friedrich Kohlrausch, President of the Reichsanstalt. He had three daughters by that marriage: Margaret, Dorothy, and Helen; and one son, Dr. Ralph K. Day, who pursued a career in glass science and technology at Maumee (Toledo), Ohio. In 1933 Dr. Day married Ruth Sarah Easling of Corning, New York. At the time of his death, in March 1960, he was survived by his wife, by his four children, and by five grandchildren.

THE FOLLOWING ORGANIZATIONS provided source material for this biographical sketch: The American Ceramic Society, Inc., American Philosophical Society, American Society for Testing Materials, Carnegie Institution of Washington, Corning Glass Works, The Franklin Institute, The Geological Society of America, Geological Society of London, University of Pennsylvania, Princeton University, and the Royal Academy of Sciences of Amsterdam. I am indebted also to a summary of Dr. Day's work prepared by J. W. Greig of the Geophysical Laboratory in 1940 and to research by Richard T. Rook.

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KEY TO ABBREVIATIONS

Am. J. Sci. = American Journal of Science
Ann. Phys. = Annalen der Physik
Carnegie Inst. Wash. Publ. = Carnegie Institution of Washington Publication
Carnegie Inst. Wash. Year Book = *Carnegie Institution of Washington Year Book*
Centralbl. Mineral. = Centralblatt für Mineralogie
Geol. Soc. Am. Bull. = Geological Society of America Bulletin
J. Franklin Inst. = Journal of the Franklin Institute
J. Geol. = Journal of Geology
J. Ind. Eng. Chem. = Journal of Industrial and Engineering Chemistry
J. Wash. Acad. Sci. = Journal of the Washington Academy of Sciences
Proc. Wash. Acad. Sci. = *Proceedings of the Washington Academy of Sciences*
Sitzungsber. Akad. Wiss. Berlin = Sitzungsberichte der Akademie der Wissenschaften zu Berlin
Smithson. Inst. Annu. Rep. = Smithsonian Institution Annual Report

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