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MEMORIAL OF LOUIS CARYL GRATON

June 10, 1880–July 22, 1970

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Louis Caryl Graton died on July 22, 1970 in New Haven, Connecticut following an illness that lasted over two years. His life was devoted to the study of ore deposits as assayer, prospector, geologist, consultant, and director of mining companies. As a teacher he brought his wide experience to the classroom and laboratory.

Graton, an only child, was born in Parma, Monroe County, New York on June 10, 1880. Because the family moved frequently he was taught at home until the age of nine when he entered the fifth grade at the school in Friendship, New York. He attended high school in Hornell, New York from which he graduated at the age of sixteen as valdictorian of his class. As a winner of the annual State Regents' Examination, he was awarded a four-year scholarship at Cornell. He entered Cornell in 1896 where he followed a program which, in addition to geology and mineralogy, included chemistry, physics, and mathematics. He received his B. S. degree in the spring of 1900 and that fall became a teaching assistant in chemistry at McGill University. While there he continued his studies in geology and mineralogy and actively participated in explorations of mining districts of Ontario. Awarded another scholarship at Cornell, he returned there in 1902

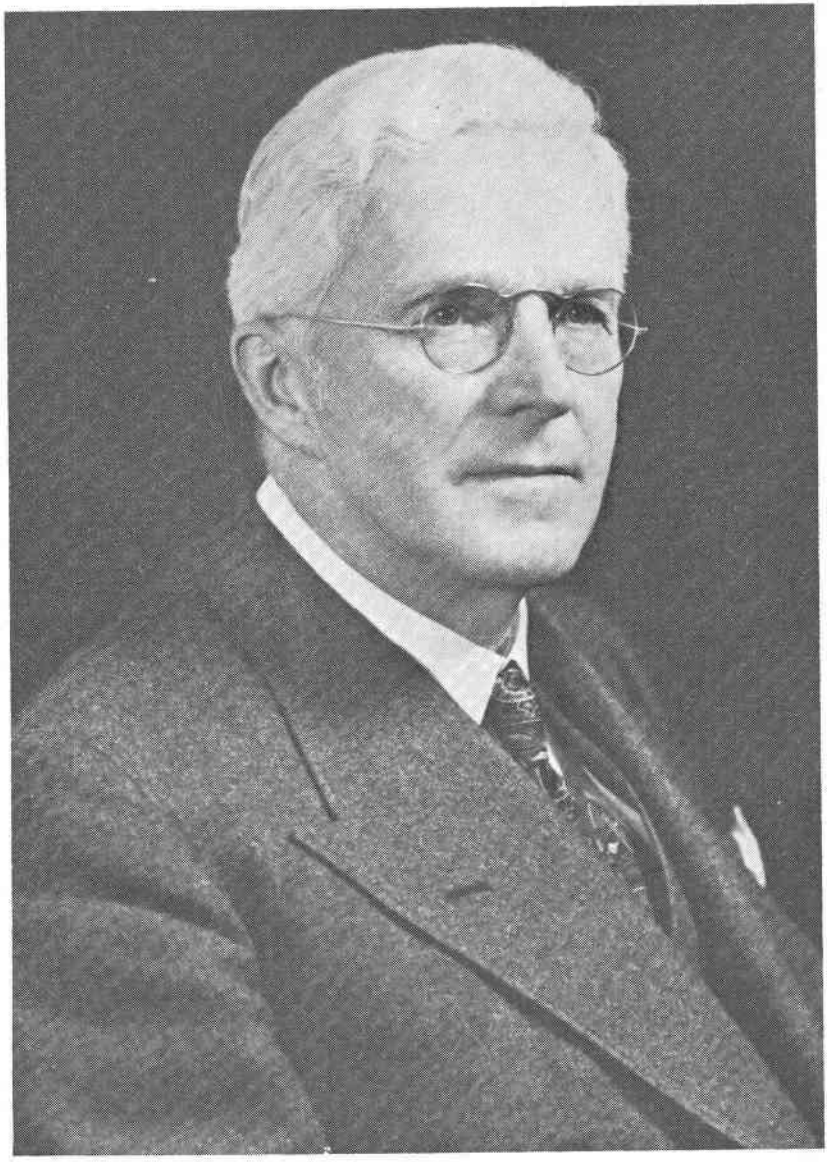
where he completed, with the exception of a thesis, all the necessary requirements for the Ph.D.

On leaving Cornell in 1903, Graton joined the U. S. Geological Survey to assist Waldemar Lindgren in a restudy of Cripple Creek district of Colorado. His intimate association with Lindgren had a profound influence on Graton's scientific thought; his last paper, in 1968, was a defense of Lindgren's classification of ore deposits. For six years Graton worked with the Geological Survey, studying ore deposits, first in Cripple Creek, then in the southern Applachians, New Mexico, and California. During this time he wrote the annual reviews of copper for *Mineral Resources of the United States.* As a result of his articles which, in addition to the usual figures on production and prices, included observations on the geological occurrence of the metal, he was asked to make the first estimate of the copper reserves in the United States.

In 1909, Graton left the Geological Survey to become Director of the newly-formed Copper Producers' Association in New York City. He had scarcely assumed his new duties when he was invited to become instructor in mining geology at Harvard. The offer, which was especially attractive since Lindgren had already joined the faculty at the Massachusetts Institute of Technology, was accepted. However, he continued his work with the Copper Producers' Association on a part time basis and for a while commuted to Cambridge from New York. He was appointed Assistant Professor in 1910 and full Professor in 1912.

Graton's knowledge of and interest in copper deposits brought him in 1913 a new assignment, as Director of the Secondary Enrichment Investigation. In the course of this project, sponsored by the Geophysical Laboratory of the Carnegie Institution and several American copper companies, all the major copper districts of the United States were studied. A large number of eminent scientists took part in the investigation including Augustus Locke, Alan M. Bateman, E. H. Perry, E. T. Allen, and H. E. Merwin. Also a number of Graton's students were involved, among them D. H. McLaughlin, who later became Graton's associate in mining geology at Harvard.

On entry of the United States into World War I, Graton obtained leave from Harvard and served as Secretary of the Copper Producers' Committee for War service until April 1919. At that time, at the request of the Internal Revenue Service, he took part in an effort to develop an acceptable method of valuation as a basis for taxing the extractive industries. The concept of depletion allowance resulted and was adopted largely through Graton's influence.



L. C. GRATON

The years between 1919 and 1949 were productive for mining geology at Harvard. Two of his former students joined Graton on the staff; Donald H. McLaughlin in 1925 and Russel Gibson two years later. On the resignation of McLaughlin in 1941, the vacancy was filled by another former student, Hugh E. McKinstry. This group attracted an extraordinary number of able students, many of whose names will be recognized today as presidents of mining companies, chief geologists, and professors of mining geology.

All Professor Graton's students will remember his course as an exercise in logic. The underlying theme running through his lectures was emphasis on hydrothermal magmatic waters as a source of ore deposits. One former student recalls, "First he would set up straw men: meteoric waters, vein-dikes, etc. and examine each possibility with care and detail. Finally he brought hydrothermal solutions to front and center stage—and by this time the class was ready to shout, 'What else!'" The composition of these solutions was long one of his chief concerns, a problem on which he expended much time and thought. His ideas on the subject, presented to his students for many years, were summarized in 1940 in his paper, *Nature of the ore-forming fluid.* No student could pass through Graton's course without knowing that he was completely convinced that all chalcocite at Butte, Montana was the product of secondary enrichment. I recall hearing him say more than once "I hope I live long enough and Butte goes deep enough to run out of chalcocite." Not all the students agreed, but with Graton's persuasive arguments and presentation one had to think to disagree.

Graton never temporized, one knew exactly where he stood no matter how controversial the issue or formidable the opposition. This was particularly true of the position he took in his 1930 paper, *Hydrothermal origin of the Rand gold deposits.* It is interesting to note that it was this paper which he presented to Cornell University as a thesis, 28 years after completing the other requirements for the Ph.D.

From the beginning of his professional career as a field geologist Graton was convinced that the answers to ore genesis were to be found largely in field relations. In his search for them he traveled widely visiting, he believed, every major mining district in the world and every mine 5,000 feet deep or deeper. He also visited all the major thermal areas of the world in the hope that in hot springs, geysers, and fumaroles lay some of the clues to the nature of ore-forming solutions.

Without minimizing field aspects of mining geology, Graton recog-

nized the importance of laboratory studies in the understanding of an ore deposit. Mineralogy has profited by his interests, for in collaboration with students he developed equipment and techniques for the microscopic study of polished sections. With J. W. Vanderwilt the Graton-Vanderwilt polishing machine was perfected. In contrast to earlier equipment which produced a high relief on the polished surface, from this machine came polished surfaces of no relief, even between minerals with such contrasting hardness as quartz and gold. Under Graton's guidance, G. A. Harcourt so improved the Haycock microdrill that a grain as little as 20 microns in diameter could be removed from a polished section for X-ray or spectrographic analysis. With S. B. Talmage and E. B. Dane, Graton developed a precision method for quantitatively determining the hardness of minerals in polished sections. Also with the collaboration of E. B. Dane the instrument known at Harvard as the "Graton camera" was developed. Of massive construction and precision design, the instrument was used to obtain photographs in either transmitted or reflected light with enlargements up to 4-6000 diameters.

At Graton's suggestion, one of his students, Joseph Murdoch, undertook in 1911 a systematic study of the opaque minerals, which resulted in the publication in 1916 of the book, *Microscopical Investigation of the Opaque Minerals*. Murdoch's book was the first comprehensive work on opaque mineral identification. Later two other Graton students, C. M. Farnham and M. N. Short, improved and elaborated on Murdoch's work in the book, *Microscopic Examination of the Ore Minerals*, by W. M. Davy and C. M. Farnham; and in U.S.G.S. Bull. 825, *Microscopic Determination of the Ore Minerals*, by M. N. Short.

Graton was a consultant for many mining companies, including Calumet and Helca, Noranda Copper, International Nickel, Hercules Mining, Hollinger Consolidated Gold Mines, and New Jersey Zinc, as well as the U. S. Bureau of Mines. However, it is the Cerro de Pasco Corporation with which he had the longest and perhaps the closest ties. Constulting with them began in 1920 and continued until 1950, and he served on their Board of Directors from 1945 to 1967. Many of his students received their practical training in Cerro's mines in Peru and not a small number of these he saw rise to high positions in the company, including that of President.

During his many visits to Cerro's mining properties in Peru, Graton became convinced of the practicality of driving a tunnel over seven miles long to intersect the ore veins of the Casapalca mine more than 1000 feet below the existing mine workings. The tunnel would serve a triple purpose: removal of hot waters, ventilation of the mines, and

haulage. This bold venture began in 1961 and completed in 1969 is known as the Graton Tunnel, the longest mine tunnel in the world.

In 1938 crystals of an unidentified lead-gray mineral found at the Cerro de Pasco mine were received at both Harvard University and the University of Chicago. The mineral proved to be a new sulfosalt, $Pb_9As_4S_{15}$, and was appropriately named *gratonite* by Palache and Fisher in 1940.

Graton's scientific contributions were widely recognized. He was president of the Society of Economic Geologists in 1931 and received their Penrose Medal in 1950. Societies of which he was member or fellow, besides the professional societies of this country, included the American Academy of Arts and Sciences, Geological Association of Canada, Canadian Institute of Mining and Metallurgy, Mexican National Academy, Geological Societies of London, Belgium, Peru, and South Africa. He was awarded an honorary doctorate by the University of California (Berkeley) in 1964, and after retirement from Harvard, and a move to New Haven, was appointed Honorary Fellow in Geology at Yale.

In 1906 Graton married Josephine Edith Bowman, a girl he had known for many years. They attended Hornell, New York high school together, and both graduated from Cornell University in 1900. At their home in Cambridge the door was always open to students, for Graton had a continuing concern in their welfare. He counseled them on personal problems, helped them through financial difficulties, and found them employment through his many mining contacts. The Gratons had one son, Bowman Graton, an architect of Duxbury, Massachusetts, and one daughter, Josephine (Mrs. Philip W. Chase), of Bend, Oregon. Mrs. Graton died in 1952. In 1953 Graton married Mrs. Marion Petitpain and shortly thereafter they moved from Cambridge to Orange, Connecticut, a suburb of New Haven. They moved again in 1964 to an apartment in New Haven where Mrs. Graton continues to live.

In 1968 the American Institute of Mining, Metallurgical and Petroleum Engineers published the Graton-Sales volume, *Ore Deposits of the United States, 1933–1967*. This collection of 82 papers, dedicated to L. C. Graton and Reno H. Sales, attests to the high regard in which Graton was held by his colleagues in economic geology. The bibliography given in that volume, but not repeated here, lists papers published over a span of 70 years and gives eloquent testimony of the breath of Graton's scientific thought and geological contributions.