Memorial to Wilmot Hyde Bradley 1899–1979

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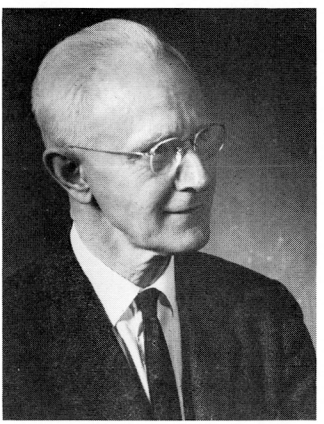

Wilmot Hyde Bradley died of a stroke on April 12, 1979, eight days after his eightieth birthday.

Bill was both an ordinary and extraordinary man. He was ordinary in the sense that he was of average physical build, had plain tastes, was unpretentious, and considered himself to be no better than anyone else. He was, in fact, a superb geologist with extraordinarily broad interests. He was a generalist, not in the sense of one who hasn't specialized in anything or who knows a little bit about a lot of things, but in the sense of one who has demonstrated the ability to probe deeply into diverse subjects, and to contribute new and illuminating knowledge about them. He was extraordinary also in his leadership capabilities, exercised first as Chief of the Branch of Military Geology, which he helped to found in 1943, and then as Chief Geologist of the U.S. Geological Survey from 1944 to 1959. He was extraordinary in the eyes of his associates because of his exceptional warmth and selfless attitude toward others, the personal interest he showed in their work and problems, his good humor and wit, and his ability to make almost any conversation an interesting, stimulating exchange among all the participants.

Bill was born April 4, 1899, in Westville, Connecticut, a suburb of New Haven, the son of Anna Miner Hyde and John Lucius Bradley. He attended grammar school in Westville, high school in New Haven, and college at the Sheffield Scientific School of Yale University. He enlisted in the U.S. Naval Reserves in 1918, and his junior year at Yale was chiefly given to naval-officer training on a two-masted schooner, supplemented with courses in navigation, spherical trigonometry, and related subjects. Although he had majored in engineering in his first years at Yale, he switched to chemistry in his senior year. He soon had doubts about his choice, however, and his friend and later USGS colleague, Arthur A. Baker, then a first-year graduate student, suggested that geology might be more to his liking. After nine weeks of exposure to an introductory course taught by Alan Bateman, he changed his major to geology and was graduated from Yale in 1920 with a Ph.B. That summer he served as field assistant to Frank C. Calkins of the U.S. Geological Survey in the Cottonwood District in the Wasatch Mountains of Utah.

The following two years were spent in graduate studies at Yale, with summers as a geologic aide to Julian D. Sears of the Survey on the north flank of the Uinta Mountains. During the second of these field seasons with "J.D.," in which James G. Gilluly also served as an assistant, he saw for the first time the Eocene Green River Formation and became fascinated with it. He learned that David White, then Chief Geologist, was looking for someone to work full time on the Green River because of its oil-shale potential; he volunteered for the assignment and was taken on full time by the Survey in the fall of 1922 to work on the Green River—for, as it turned out, much of his professional career.

The fall of 1922 thus began Bill's union with two of his lifelong loves—the Green River Formation and the Survey. A third was joined during the same period when, on November 4, he married Catrina van Benschoten, also of New Haven and a friend since childhood. Their marriage—blessed with two daughters, Anne and Penny—was a devoted one, lasting until Bill's death.

Bill's paper on "Shore phases of the Green River Formation in northern Sweetwater County, Wyoming" (U.S. Geological Survey Professional Paper 140) served also as his doctoral dissertation, and he received his Ph.D. from Yale in 1927. His sound academic training laid a solid foundation for the career that followed. He was appreciative of his teachers' stimulating thought—particularly Adolph Knopf at Yale who inspired him to search for causes and dependent relationships among natural phenomena and processes. Bill's broad interests had been stimulated before he reached the college level, however, by his father, a dentist, who was interested in all things mechanical and electrical, and who taught Bill how to wire motors, and to make and experiment with various kinds of wet batteries, Leyden jars, and other electrical devices. His mother and her maiden sister, Carolyn, played strong parts also in arousing Bill's curiosities, for they were intensely interested in birds, flowers, butterflies, and moths and took him on numerous trips to nearby woods and meadows, and to Yale University's Peabody Museum as well.

With this background, it is easy to understand how Bill's interest in the Green River Formation encompassed almost every aspect of its composition and geologic origin. His first scientific paper described "Fossil caddice fly cases from the Green River Formation of Wyoming" and subsequent papers dealt with its mineralogy, plant and animal fossils, physical structures such as varves and mud cracks, stratigraphy and areal geology, and geochemistry, as well as the climate of the Green River Epoch and the paleolimnology of the Green River lakes. In his later years, Bill broadened his study of oil shale to its formation in the modern environment. Motoaki Sato (1979, personal commun.), Bill's colleague in some of these studies, says of them:

> One of Bradley's main scientific concerns was to find a modern lake that was producing rich organic ooze with very little clastic material. He was excited when he heard R.S.A. Beauchamp, an English limnologist, describe a remarkable organic ooze that was forming in the northern part of Lake Victoria. The organic ooze consisted almost wholly of algal matter which would not decay in a warm, wet, and oxidizing environment. Bradley immediately began his search for such lakes and found that only one more lake in equatorial East Africa and two lakes in Florida, one of which is Mud Lake, are known to be accumulating this kind of pure algal ooze. His tireless and all-out effort in understanding the limnology, microbiology, and geochemistry of Mud Lake, Marion County, Florida, began soon afterwards. Bradley's approach was characteristically multidisciplinary. Not only did he examine the algal ooze microscopically to identify microorganisms and the evidence for their activities, he mobilized experts in the nation to identify various organic compounds and microbes existing in the organic sediment, and to develop tools for sampling the ooze and conducting *in situ* measurements of geochemical parameters. His main effort was directed to unraveling the secret of how the algal matter resisted decay in a subtropical to tropical environment and how relatively oxygen-rich algal matter changed with time to the hydrocarbon-rich organic matter of oil shale in an ordinary diagenetic environment. His pioneering efforts in this realm of science have given impetus to many students of organic sedimentation. One of the most thorough documentations of geochemical parameters existing in organic sediments, which Bradley worked on even after his retirement from the U.S. Geological Survey, is expected to be published shortly.

With respect to the significance of Bill's over-all work on the Green River, Erle Kauffman of the U.S. National Museum writes (1979, personal commun.):

> Bill Bradley was the true "father" of non-marine aquatic paleoecology and paleolimnology. He pioneered modern technique by crossing the line between Recent and ancient ecosystems to become a respected limnologist and aquatic biologist, and then to apply that knowledge with great precision to the interpretation of ancient ecosystems. His early work was 20–30 years ahead of its time, and stands today as one of the best examples of fresh water paleoecology on record. A measure of Bradley's perception as a student of paleoecology and paleoenvironments has come to light in the recent "Green River controversy," which seemed to pit Bradley's older stratified fresh water lake model against a newer playa lake model for the origin of Green River oil shale. Bradley reasoned that varved oil shales with their high organic residues and beautifully preserved biota could only have formed in a permanently stratified lake, characterized by a thick, poorly circulated, O_2 depleted and H_2S enriched hypolimnion and a metalimnion and epilimnion with a diverse fresh water biota, high productivity, and seasonal fluctuation producing well defined varves.
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> From the outset, Bill recognized a significant stratigraphic interruption in the middle of the Green River Formation in which the stratified lake model broke down. He termed this the "middle saline facies," or the Wilkins Peak Member of the Green River Formation. He noted paleogeographic restriction of the Wilkins Peak and determined that the lake had shrunk considerably and was without outlet at this time. He reviewed the geochemistry of the unit, and especially the unique suite of authigenic saline minerals. From this he concluded that evaporation greatly exceeded fresh water input, and that a shallow, clear saline lake persisted, with broad episodically exposed brine flats. Bradley was describing a playa; he simply never called it this. Subsequent filling of the Green River lake basins resulted in the redevelopment of a large stratified freshwater lake system, possibly with a saline hypolimnion. Subsequent detailed stratigraphic analyses of the Wilkins Peak Member by others have revealed extensive new evidence in support of the playa lake model for the Wilkins Peak phase of the Green River. Whereas this started out as a sober analysis of a specific unit, it mushroomed into a quiet controversy in which some workers insisted on a playa origin for most of the Green River system. From the outset, Bradley agreed that the Wilkins Peak evidence fit the playa model, and even presented new evidence in support of it. But at the same time he quietly warned of extrapolating to make one depositional system (the playa model) fit the whole Green River. His prediction was correct, the controversy has run its course, and now in the aftermath Bradley's perception and the breadth of his observations have re-emerged. His original stratified lake model, from the standpoint of integrated geochemical, sedimentological, paleogeographic, and paleoecological evidence, is still supported for most of Green River time, and most of the varved oil shale.

Although Bill's interest in the Green River lasted until his death, he had many other assignments. One of the most rewarding was his pioneering work on the C. S. Piggott cores from the deep ocean floor of the North Atlantic between the Grand Banks off Newfoundland and the continental shelf of Ireland. Eleven in all, averaging nearly 8 feet in length, they were the first obtained from the abyssal depths. Bill's careful studies of these cores, made in collaboration with several others, showed for the first time the possibilities of unraveling geologic, oceanographic, and climatic history from analysis of the sedimentary record on and beneath the deep ocean floor. Another series of investigations demonstrating Bill's multidisciplinary interests had to do with the dynamics and history of tidal flats in Maine. It is noteworthy that his principal report on these studies was

published by the U.S. Fish and Wildlife Service because of their bearing on commercial clamming.

Although the Geologic Division of the Geological Survey had been blessed with fine leadership beginning with its first Chief Geologist, Grove Karl Gilbert, none gave it better or more dedicated service than Bill Bradley. Wise in the ways in which a scientific organization can be brought to do its best work, Bill led not by command or directive but by inspiration, by the contagiousness of his own enthusiasm, and by the stimulating effect his interest in other people and their work and problems had in bringing out their best efforts. Bill's 16-year period of service as a branch chief and Chief Geologist spanned a period of great change in the Geologic Division—a several-fold expansion in professional personnel and the beginning or expansion of important new programs, such as military geology, airborne geophysics, the geology of radioactive minerals, and engineering geology. Not only was he able to find solutions to the many difficult problems that he had to face in this expansion, but he found them without affronting or offending those concerned. He won and held the deep respect and affection of his associates.

Through his membership, Bill contributed to the activities of a diverse array of organizations: National Academy of Sciences, American Philosophical Society, American Academy of Arts and Sciences, Geological Society of America, American Society of Limnology and Oceanography, International Limnological Association, American Association for the Advancement of Science, American Association of Petroleum Geologists, Botanical Society of America, Sigma Xi, Society of Economic Paleontologists and Mineralogists, Geological Society of Washington, and the Cosmos Club of Washington. Several organizations honored him with awards and high office—the National Academy with its Award of Merit in 1940, the Philadelphia Academy of Science with the F. V. Hayden Medal and Award in 1971, the Geological Society of America with its Presidency in 1965 and its Penrose Medal in 1972, the Geological Society of Washington with its Presidency in 1946, and the Society of Economic Paleontologists and Mineralogists with Honorary Membership. Bill was awarded an honorary Doctor of Science degree from Yale in 1947. In 1958, Bill received the Distinguished Service Award from the Department of the Interior. His colleagues honored him with the Bradley Volume festschrift, published by the American Journal of Science in 1960.

On the conclusion of his 48-year career with the Geological Survey in 1970, Bill and Catrina moved to the west shore of Pigeon Hill Bay, Maine. There he continued writing his results on the Green River and Mud Lake while enjoying the physical stimulation of outdoor work on their farm. During a visit with him in the fall of 1978, when illness had already begun to overtake him, he was rhapsodic about the enjoyment and satisfaction his life had given him—the love of his family, the excitement of his research, his stimulating and rewarding friendships, and his life with the Geological Survey. His life was a joyous and satisfying one to him and an enriching one for his family, his friends, his scientific organizations, his country and its Geological Survey, and his science.

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