MILTON NUNN BRAMLETTE
1896 - 1977
BY EDWARD L. WINTERER

I

Professor Milton Nunn "Bram" Bramlette was at Scripps for the last quarter-century of his life, fully engaged in his research until the last painful years, when he became too ill to carry on. Bram was already a renowned geologist when he came to Scripps, but he devoted his years at the institution to perhaps the most important and enduring of his scientific contributions, the study of the biostratigraphy of calcareous nannofossils, which he established as one of the principal means for dating oceanic sediments.

His career was that of the exemplary research scientist, melding exacting standards of scholarship with a great breadth of geological knowledge and field experience. He was one of the brightest of the stars in the Scripps galaxy, earning high academic honors from his colleagues, his university, and his nation and near-reverential awe from his students and post-doctoral visitors. He was by nature an extraordinarily modest man, shy in his dealings with those around him and almost never assertive in public or departmental meetings. Nonetheless, his reputation for clear, logical, and innovative thinking on scientific matters gave him the status of wise counselor amongst his international peers. To this formal portrait must be added a special human dimension, his taste for adventure and for travel to exotic places.

He was born in Bonham, Texas, a small farming town north of Dallas, not far from the Oklahoma border, on February 4, 1896. He lived in Bonham during his boyhood with his parents William Ambrose and Eula Lee Nunn Bramlette, attending public schools there. He left home for a year at Principia School, a private Christian Science academy in St. Louis, Missouri, in preparation for going on in 1914 to the University of Wisconsin, where he began his studies in geology. The Madison department then included such luminaries as C. K. Leith, A. N. Winchell, and W. Mead, and W. H. Twenhofel, without question the leading American sedimentologist of his day.

Bram interrupted his college studies with America's entry into WWI in 1917 to join the air force (then still a part of the Army Signal Corps). He trained as a pursuit pilot and a bit of that flair came through later in his preference for convertibles, which he generally drove top down, in a derring-do style that often alarmed his passengers. After his military service ended in 1919, he returned to Wisconsin to complete work for the bachelor's degree. During summer recesses, he worked for the Wisconsin Geological Survey, making magnetic surveys in the Precambrian iron ranges.

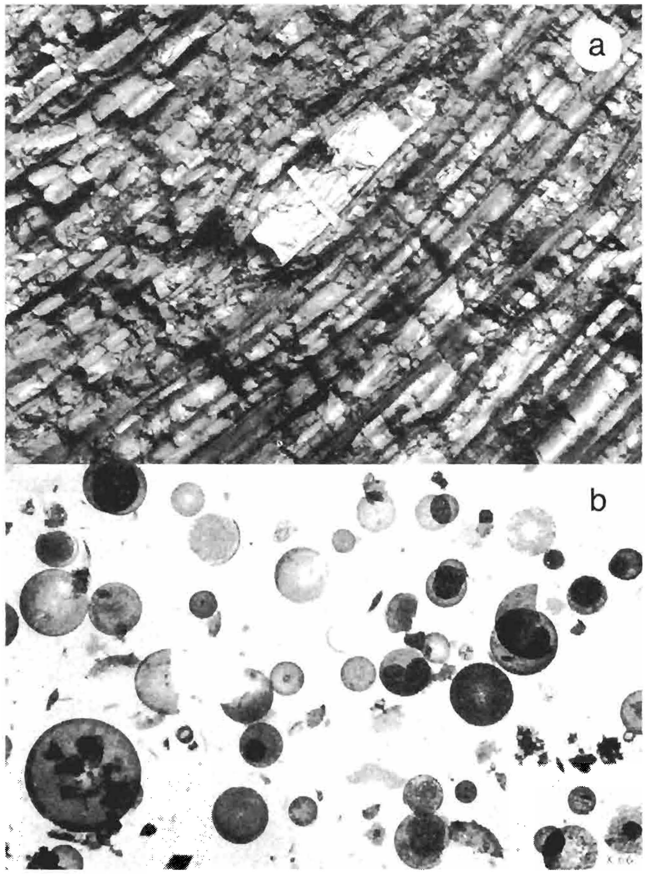
After graduating in 1921, Bram next began a long association with the U.S. Geological Survey, starting in 1921 as an Assistant Geologist doing geologic mapping during the summer field season and returning to the Washington, D.C. survey headquarters in the winter. His first assignments were in the Missouri Breaks country of Montana and in the region around the Black Hills of South Dakota, some of it done from horseback. I still have the special canvas-covered map case he fashioned for this mounted work. He said it was always a temptation to stay in the saddle and not dismount to pick up rocks. Possibly from his early exertions getting on and off his horse and climbing hills, he stayed trim all his life.

The survey, as part of its training program, recognizing that he had already amply demonstrated his extraordinary talents in geological mapping, next sent him to study stratigraphic sections of Paleozoic rocks in Kansas, and then to work on clay deposits of economic importance in Arkansas, Louisiana, and Mississippi. Scientifically, this can be very dull and routine work, but in Bram's hands it became significant. In his work, to which he returned in the 1930s, he related the aluminum (bauxite) ores he studied in Arkansas to certain discrete periods of very intense weathering of the crystalline bedrock land surface about 55 million years ago. We now know from recent stable-isotopic data from oceanic planktonic and benthic foraminifers that this time, at the close of the Paleocene Epoch, was a brief, abnormally warm episode in Earth history. His findings, which were backed by exacting mineralogic work (clay minerals at that time, before the full development of x-ray diffraction techniques, were studied mainly by optical methods) permitted an efficient exploration strategy that uncovered major new sources of ore. This proved especially important during WWII, when America was effectively cut off from sources of overseas bauxite. The findings also established in Bramlette's mind the conceivable global geologic consequences of weathering processes that strip soils of most of their nutrients, a possibility he later advanced as a feasible cause for the mass extinctions of plankton at the end of the Cretaceous Period. Bram did not pass from one project to another, leaving behind what he had learned, but made continuing, innovative use of almost every scrap of knowledge acquired.

Several special aspects of the clay studies drew his attention. One was the problem of the partial or even complete dissolution of many types of minerals that were generally regarded as chemically stable, and hence particularly useful in correlating strata or in determining the crystalline bedrock provenance of sedimentary deposits. His interest in this problem led to a series of influential cautionary papers on the uses and misuses of accessory minerals. He also discovered hitherto undetected volcanic ash beds in the clay successions, some of which were cemented by zeolites.

After three years, he left the survey in 1924 to begin graduate studies at Yale, but his formal education was interrupted barely a year later, when he accepted a job with the Gulf Oil Company, where he worked for three years. He came back to Yale in 1928 to complete his studies. He was awarded the doctoral degree in geology in 1936, following his return to the survey in 1931. Even after joining the faculty at UCLA in 1940, he continued to work intermittently for the survey on bauxite deposits in Jamaica and on correlations of Late Paleozoic rocks in Utah, as well as on the Miocene rocks of California. The friends he made at Yale and in the U.S. Geological Survey during those formative years of his professional career became his close friends for life. They included such distinguished geologists as James Gilluly, William Rubey, and Wilmot Bradley and provide evidence for a kind of Golden Age at Yale, where the faculty in geology at that time included such stars as Charles Schuchert, H. E. Gregory, A. M. Bateman, Chester Longwell, Adolph Knopf, and Carl Dunbar.

The Gulf Oil Company work, from 1925-1928, was mainly in southern Mexico and Venezuela, where he was able to venture to remote and strange places and meet odd people. He liked to recount that he actually became acquainted, in a bar, with the fabled and reclusive B. Traven, the *nom de plume* of the author of *The Treasure of Sierra Madre*. Aside from the adventuring, this was an especially formative period in his professional life. The Gulf Company had hired him for his skills as a physical stratigrapher, correlating strata using mineralogical and lithological criteria, and much of his field work was directed toward establishing correlations of strata using these methods (the Twenhofel effect). Just at this time, in the mid-1920s, the enormous potential of microfossils as tools for dating and correlation began to be exploited in petroleum geology. Mineralogists converted to micropaleontology. Bram was quick to begin teaching himself the new tool, and, on his ensuing return to the survey, to apply it to the vexing problems of California Neogene stratigraphy.



Monterey Formation [14]. (a) Early-formed calcareous concretion in cherty strata (note compactional bending of enclosing strata). (b) Opaline diatoms obtained from digestion with acid of part of the same concretion.

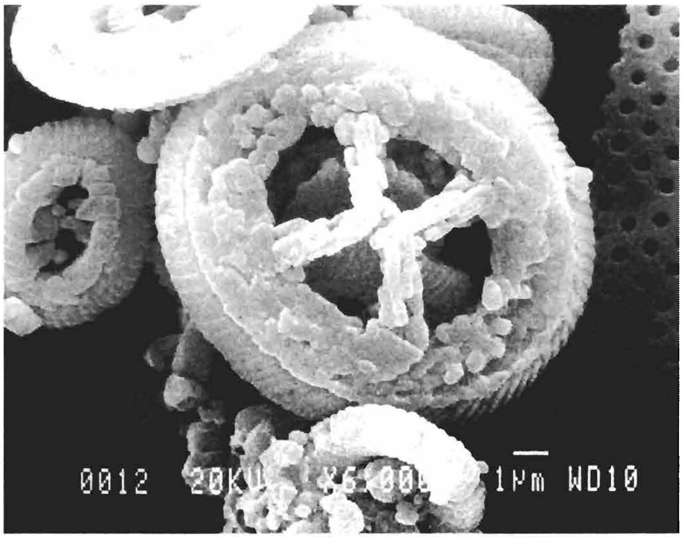
One more adventure offered itself: near the very end of his formal studies at Yale, after his tour with Gulf Oil, he attended a lecture by the British explorer Sir Aurel Stein, who was planning an expedition up the Indus River past Nanga Parbat into Central Asia, notably Tibet. Bram rushed forward to volunteer as expedition geologist, and was accepted. His collection of rocks from this 1931 expedition is at UCLA and shows a classic size gradation, from large specimens taken early in the trek to smaller and smaller bits as his pack grew heavier.

Back again with the survey, his field studies during the 1930s of the geology of two of the Miocene marine basins of coastal California, the Palos Verdes Hills (1933) and the Santa Maria Basin (1938–1940), with his colleague W. P. Woodring, engaged him in a long-term, comprehensive study of the widespread and puzzling siliceous rocks of the Miocene Monterey formation, a study which has become a landmark in sedimentary geology. During the Miocene Epoch, the region of the present-day Coast Ranges of California was occupied by a series of small marine basins, much like those of the modern offshore California Borderland. Highly siliceous strata, composed now partly of laminated diatomite and partly of bedded chert, were deposited in the basins, mainly during a 10-million-year episode. The origin of the diatomite was obviously through deposition of the remains of planktonic diatoms, without much dilution by clay. The source of the silica used by the diatoms was controversial. Hypotheses included emanations from submarine springs and the alteration of volcanic glass from contemporaneous nearby volcanism. The cherts were another matter. Because the cherty strata consisted almost wholly of fine-grained chalcedonic quartz, with no trace of any fossils, the rocks had been widely thought to be the result of inorganic precipitation of dissolved silica on the seabed, in spite of the known strong undersaturation of modern seawater. Bramlette's painstaking field and microscopic studies completely changed our thinking by establishing beyond doubt that the origin of the chert in the Monterey Formation was through dissolution and recrystallization of the remains of opaline diatoms, a diagenetic transformation so thorough that it left almost no trace of the original diatoms. He found the "missing" diatoms inside early-formed dolomitic concretions that had provided a protective shield, preserving the diatoms from further diagenesis. This study altered the conventional view about the origin of cherts in the geologic record, for the California cherts are not unique. Only a few cherts—local spring deposits and a few altered ash beds—were left to essentially inorganic origins and virtually all the rest could now be ascribed to post-burial diagenetic alteration of siliceous biogenous sediments, consisting originally of diatoms, radiolarians or sponge spicules. Bramlette did cling to the notion that the silica was derived from alteration of volcanic ash beds, but he encouraged later studies of modern diatomaceous deposits in the Gulf of California, a modern analogue of the Miocene basins. A Scripps doctoral student, Steve Calvert, showed that no special source was needed for the dissolved silica: it derived from inflow of silica-rich deep waters from the world ocean, upwelling from wind-driven Ekman transport along the sides of the gulf and nourishing rich blooms of diatoms in near-surface waters. Settling of the diatom tests yields the diatom oozes on the gulf floor. Results of mineralogical studies of cherts in oceanic sediments sampled during the multimillion-dollar Deep Sea Drilling Program have confirmed the main features of Bramlette's original model presented three decades earlier.

Although Bram's interest in modern sediments can be traced back to a laboratory study he made of samples from Pago Pago Harbor, Samoa, published in 1926, it was rekindled in the late 1930s when Bram was given an opportunity to study with W. H. Bradley, a noted sedimentologist and one of his colleagues (and later Chief Geologist) in the survey, a suite of piston cores raised by Piggot corer from the floor of the North Atlantic, between Newfoundland and Ireland. Bramlette's careful lithologic studies of these cores set a standard for future work and helped establish the sequence of glacial deposits on the two sides of short-lived climatic events that sent debris-laden ice episodically into the North Atlantic. The core study excited his interest in furthering stratigraphic work on pelagic sediments.

Biostratigraphy had received a dramatic boost in the 1920s and 1930s when the use of fossil foraminifers became the standard means of determining the geologic age of Cretaceous and Cenozoic marine strata. Benthic foraminifers are commonly very abundant in fine-grained marine strata of this time interval, and can be easily extracted from borehole cuttings and cores. Previously, dating had relied mainly on the finding of shells of larger animals, especially molluscs, but these are much less abundant than foraminifers. Stratigraphers could correlate locally, but not over long distances, for example to the type sections in western Europe. They came to realize that the benthic foraminifers were not only primarily of local significance, but that their successions were strongly reflective of changing local environmental conditions, especially of changes associated with water depth, such as temperature and oxygen content. Such faunal changes were commonly engendered by the gradual shallowing of a basin as it filled with sediment, and have little to do with geologic age. Thus, the succession of faunas in two adjacent basins could be nearly the same, but offset in age, reflecting different environmental histories. What was needed were time-significant planktonic microfossils that would be independent of water depth. Serious work on planktonic foraminifers had been launched, especially by people working in the Caribbean region where Cenozoic strata are characteristically calcareous and not highly diluted by clay and sand. Bramlette saw a new way forward, using fossil remains of the planktonic Coccolithophoridae.

In 1941 when he left full-time employment in the survey to accept a post of Professor of Geology at UCLA, he began his pioneering work in this nearly new and virtually undeveloped discipline, the study of the fossil remains of calcareous nannoplankters, the Coccolithophoridae. He had begun to study the tiny coccoliths, which are the complexly constructed individual platelets (typically less than 10 nanometers in diameter) that together make up the orbular tests of these marine algae, with a view to using them for long-range correlations. The work was excruciatingly slow: he assured himself that his material had not been redeposited into younger sediments by using only coccoliths he extracted



Coccolith (*Chiasmolithus expansus*), one of the many new species discovered by Bramlette from the Eocene Lodo Formation, California. Scale bar is one nanometer. A cubic centimeter could contain about one billion coccoliths. Photograph from Wu-chang Wei.

from the interior chambers of dateable planktonic foraminifers, which are themselves only about half a millimeter across. Bram was a master of the optical microscope but was fully aware of the importance of the then-emerging technique of electron microscopy in the study of nannofossils: he often used this method of study. On the other hand, he argued forcefully for the continued use of the polarizing light microscope, fitted with phase-contrast capabilities, for routine study, because this was usually the only means available for most paleontologists.

Coccoliths have several advantages for stratigraphic work. They are generally very abundant in modern calcareous pelagic sediments, but also occur in very muddy sediments. Being constructed of low-magnesium calcite, they are relatively resistant to dissolution. Bramlette's early studies had shown that coccoliths were the most abundant constituent of Tertiary calcareous pelagic sediments in both the Atlantic and Pacific. He now needed good materials for study, from calcareous pelagic sediments containing other microfossils, such as radiolarians and planktonic foraminifers, to provide independent paleontological age control. To establish relative ages, the samples should preferably come from sampling successions of sediment layers, such as those retrieved in the piston cores at that time beginning to be taken almost routinely over most of the world's oceans by oceanographic research vessels. The stage was set.

Spurred by an invitation from Roger Revelle and with the knowledge that Scripps Institution now had ships actually taking cores in the deep oceans, Bramlette left UCLA and came to Scripps in 1951. At Scripps, he seized the chance to obtain the undisturbed, purely pelagic sequences from the seafloor that he wanted. Soon after his arrival in late 1952, he enlisted in an expedition (Capricorn) on R/V *Horizon*, from Kwajelein to Suva. This was to be his only seagoing expedition: he found shipboard life tedious and uncomfortable and decided he could ask others to take cores for his later study ashore.

Another major acceleration in biostratigraphy came with the Deep Sea Drilling Project, launched in 1968, with a specially equipped drilling vessel, D/V *Glomar Challenger* in a program managed by Scripps. The cores raised by this ship provided Bram with a treasure trove of material from most parts of the world ocean, and all arranged in stratigraphic order. With post-doctoral visitors E. Martini, J. Wilcoxon, and D. Bukry, he published a stream of papers setting out the coccolith stratigraphy of the sediments cored on many drilling legs, a sequence that, with others he helped train, became the standard for global correlations. He made many trips abroad (by air, not ship!) during these years, especially to Western Europe where he could sample at the type localities where many of the standard stratigraphic stages were originally defined. He became fast friends there with Georges Deflandre, the great French biostratigrapher, visiting him with his family, discussing stratigraphy, practicing his skills in the French language, and sampling the wines.

From his arrival at Scripps in 1951 and over the next 25 years, almost until his death, he continued to develop the new biostratigraphic tool and to train the stream of students and scholars from all over the world who came to learn from him. His legacy is that a major part of the world community of paleontologists now studying nannofossils are either his former disciples or are his intellectual grandchildren. His discipline has now become an essential part of the larger discipline of paleontology and biostratigraphy, and every expedition of the JOIDES drill ship that expects to encounter sediments has a nannofossil specialist aboard as a key team member.

One special aspect of planktonic stratigraphy held his attention for decades, namely, the abrupt and wholesale extinction of whole groups of planktonic organisms at the end of the Mesozoic. He had himself documented, with Martini, the near-wholesale global extinction of coccolithophorids at that time. Drawing on his experiences with the consequences of deep weathering on soils and combining these with his knowledge of the nutrient requirements for the phytoplankton, he advanced an hypothesis for the mass extinctions that called for a time of unusual global tectonic stability and low relief accompanied by intense weathering that bled the continental soils of the nutrients that ultimately feed the oceanic plankton.

Aboard R/V *Horizon* in the equatorial Pacific, 1952. Bramlette is looking in the sediment core for evidences about the geologic past. With him is Roger Revelle. SIO Archives.

Bramlette did not live to see the revolution in thinking about the Cretaceous-Tertiary boundary that attended the discovery of abnormal concentrations of iridium in boundary clays, now widely accepted as evidence for the collision of a cosmic bolide with Earth, a collision that raised dust that blocked the sun and led to a collapse of food chains. Bramlette's weathering hypothesis was laid aside. Bram was also too late to be able to absorb all the implications of plate tectonics and seafloor spreading, and remained a bit skeptical in his last years that the ocean basins were so young and of such orderly age fabric as the theory would have him believe. But he did this not as a die-hard, but because he was not yet convinced by the proffered evidence, and could cogently argue alternative hypotheses.

As his reputation as a biostratigrapher grew, he was asked to contribute to the workings of the International Commission on Stratigraphic Nomenclature. This commission was organized to bring some logic and consistency to the confusing tangle of schemes that geologists were using in organizing the strata they work with. Practices were radically different from country to country, and even within countries. These differences befogged clear communication of ideas and facts. The problem was not trivial, because the ambiguous and self-contradictory language used by stratigraphers muddied fundamental concepts. Near-anarchy prevailed. At the very base of stratigraphic nomenclature, in a sense as basic as the Linnean system in biology or the basic entities of physics, such as waves and particles, is the need to keep distinct the several basic types of stratigraphic units: 1) "Rock" or lithologic units: the three-dimensional belts of stratified rock defined by the type of rock of which they are composed, like the Navajo sandstone; 2) "time" or purely chronostratigraphic units: divisions of the geologic time scale, like the Devonian Period, and associated with a type locality by an actual succession of strata; and 3) "rock-time" units, consisting of strata deposited during a certain episode of geologic time, like the Devonian system, and finally closely related to 3), 4) Biostratigraphic units, comprising strata deposited during the duration, either local or global, of a species or of a certain biota. Although these basic notions seem transparently simple, unimaginable confusion and misuse reigned during the first half of the 20th century. Bram, called on by his former protege in the Gulf Oil Company, Hollis Hedberg, president of the ICSN Commission, contributed many letters to the commission and helped guide them to the present Code, now almost universally accepted and used.

Bramlette did not take much to formal classroom lecturing, preferring the small, seminar-laboratory format. Even here, as his former students will attest, the emphasis in seminars was on presentation and discussion by the students of assigned topics. Bram would sit alert but nearly silent at the head of the table, chain smoking. Students learned to read the smoke signals: when he puffed a lot of smoke, and especially if he started shuffling his shoes, you were going off the track. Then he would intervene in a kindly and helpful tone to get things moving in a more productive direction. In seminars, he wanted logical and critical thinking; in the laboratory, he wanted close observation and attention to crucial detail.

In fact, the hallmark of Bramlette's scientific style was his attention to significant detail. ("A seeing eye": Roger Revelle) Bram was a superb microscopist, accused by his students of having ten-power eyes, whereas in reality, of course, he noticed what others overlooked. He preferred, rather, to be thought of as a field geologist, for it was there, in the field at the outcrop, where he believed hypotheses must finally be tested. His published reports show his exceptional talents for field mapping and observation, and those who were fortunate enough to have been in the field with him were awed by his uncanny talent for spotting just the layer that contained the perfectly preserved fossils or the revealing sedimentary structures. The clarity of his published papers reflect his habit of constantly reviewing and correcting while he was writing. This habit extended even to the writing of labels for specimens: the teaching collection of sedimentary rocks at Scripps contains many rocks collected by Bram, and most of their labels contain cross-outs and revisions in his hand. The distinguishing feature of his character was his absolute integrity. He was unswervingly faithful to a demanding code of professional and scholarly conduct, a code which he lived but about which he was never preachy.

Bramlette's honors included election to the National Academy of Sciences (1954), and the award of the Academy's Thompson Medal (1964), the Distinguished Service Medal of the Department of the Interior (1963), and the Honorary degree of Doctor of Laws from the University of California, Los Angeles (1965). He himself considered the greatest honor was the enduring friendship of other geologists whom he respected.

In 1931, he married Valerie Jourdan, who died in 1962. She was his perfect complement in life, and her death marked him deeply. Their only child, Emily Assami, lives in Damascus, Syria. Bram died on March 30, 1977, after a long, cruel fight against emphysema.

Acknowledgments

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James Gilluly. I thank D. Day, SIO Library Archivist for help in searching records, and my Scripps colleagues for sharing their recollections.

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