

## In Memory of Lee A. Woodward, 1931–2020

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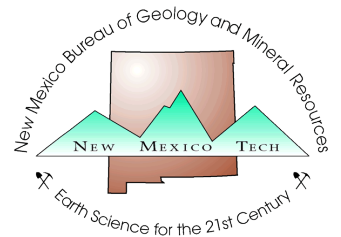
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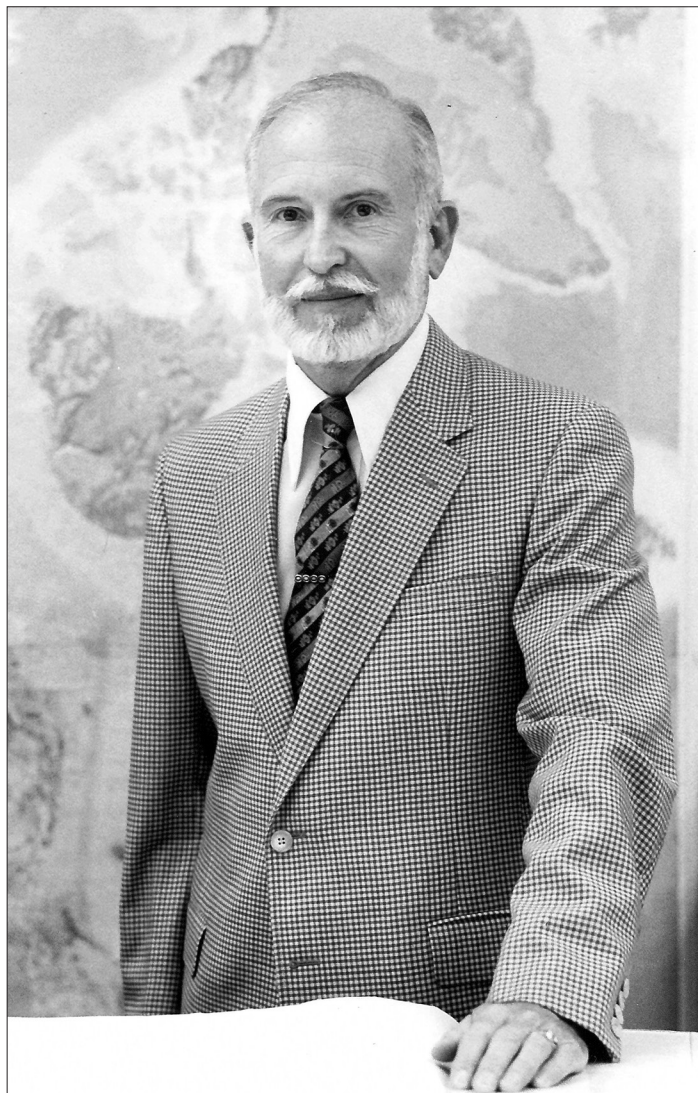
# In Memory of Lee A. Woodward

## 1931–2020

Lee Woodward, long a faculty member (1965–1997) and former chairman (1970–1976) of the Department of Earth and Planetary Sciences at the University of New Mexico (UNM), died on August 16, 2020, at the age of 89. His research contributed significantly to knowledge of New Mexico structural geology and tectonics, and the relationships of the structural history of an area to the occurrence of oil and gas and mineral resources. Lee spent much time studying geology in the field, and involved numerous graduate students in mapping 7.5-minute quadrangles, especially in the Nacimiento Mountains region. As an educator, he trained hundreds of undergraduate students in structural and field geology, as well as teaching introductory geology courses and advanced undergraduate and graduate courses. During his time as chairman the department's faculty expanded rapidly, attaining its highest number (14) to that point in its history, and he oversaw the strengthening of its undergraduate and graduate programs. Lee assumed leadership positions in several professional societies, and was active as an editor and contributor to New Mexico Geological Society field conferences and guidebooks. In addition to his work at UNM and in New Mexico, Lee also pursued research and published on aspects of the geology of his home state, Montana. These contributions are examined in more detail in the following paragraphs.

Lee Woodward was born on April 22, 1931, in Omaha, Nebraska, but his family moved to Montana in 1933, settling in Great Falls in 1935 and by 1940, in Missoula. From early in his life Lee traveled, was exposed to the natural world, and to a great variety of people. His father owned a construction firm, and took Lee along on many projects throughout Montana, often in small towns, during the depression years of the 1930s. Possibly a latent interest in geology was planted by periodic stays at a gold mine his father and others worked for a time. Later (1945), his family bought a ranch in the Bitterroot Valley south of Missoula, and Lee enjoyed fishing, hunting (sometimes for mountain lions), and backpacking through the Montana high country. During summers while in high school in the late 1940s he worked in construction for his father in several locations in Montana. While in college Lee spent the summers of 1950–1952 in Alaska, working on highway construction and as a longshoreman in the port of Valdez. These experiences likely were influential in shaping his personality, approach to life, expectations of others, and a very colorful vocabulary.

An indifferent student in high school, Lee enrolled in the University of Montana (Missoula) in 1950. There he married Katie, who would be his wife for the remainder of his life,



Lee Woodward, 1990.

nearly 68 years, and (less significantly) earned a Bachelor's degree in Business Administration in 1953. ROTC summer camp followed, and he was commissioned into the Army in October of that year. After four months of infantry and airborne training at Ft. Benning, Lee served most of his time in Germany, first as a platoon leader, and then company executive and intelligence officer.

After returning to the U.S. and discharge from the army early in 1956, Lee again enrolled in the University of Montana, this time majoring in Geology, receiving his Bachelor's degree in 1958. He worked for the U.S. Bureau

of Reclamation during the summer of 1958, on a project involving the geology of a potential dam site south of Glacier Park, and used this work as his Master's thesis, earning the Master's degree in 1959. Supported by a three-year NSF fellowship, he entered the Ph.D. program at the University of Washington, and wrote his dissertation on the structure and stratigraphy of the northern Egan Range in east-central Nevada, under Peter Misch. After receiving his doctorate in 1962, Lee worked briefly for Pan-American Petroleum Company in Montana and Wyoming, then taught at Olympic College in Bremerton, Washington from 1963 to 1965. In spring 1965 he interviewed for and was offered a faculty position at UNM.

Lee arrived at UNM in September 1965 with his wife and four children as a new assistant professor, and immediately began a heavy fall teaching load—structural geology, beginning field geology, and a geology-101 section. Knowing nothing of the local geology, he once remarked that in the field course “it was mainly a case of the blind leading the blind. I was however, enthusiastic and this helped to inspire the students.” The roster of courses he taught expanded through the years, to also include advanced field geology, regional tectonics, mineral deposits, and subsurface geology. He immediately attracted graduate students, mentoring nine Master's students from 1967 to 1970. Throughout his career, Lee guided many graduate students, totaling 42 M.S. and five Ph.D. students. He coauthored papers and maps with some of them and many became lifelong friends.

In his first few years at UNM Lee quickly became knowledgeable about New Mexico geology and identified several areas of research interest. In addition to publishing Montana-based research, he initiated studies of spessartine dikes in the Sandia Mountains (*Journal of Geology*, 1970), and the tectonics of the Cordilleran foldbelt in southwestern New Mexico (with Lonnie Corbitt, his first doctoral student; *AAPG Bulletin*, 1973). However, his main focus of research in the 1970s became the geology of the Nacimiento Mountains. With a dozen Master's students Lee published geologic maps of 12 7.5-minute quadrangles, for the New Mexico Bureau of Mines & Mineral Resources (NMBMMR) geologic map series from 1972 to 1982, as well as major journal papers on the Nacimiento and Sierrita faults, a new Pennsylvanian formation, Triassic sandstone copper deposits, and the Morrison Formation of the area. This work was incorporated into Lee's monograph *Geology And Mineral Resources of the Sierra Nacimiento and Vicinity* (NMBMMR Memoir 42, 1987), one of the outstanding works on New Mexico geology of the last part of the 20th century.

During these early years at UNM, Lee also became heavily involved with the New Mexico Geological Society. He edited/coedited Guidebooks 21 (*Tyrone-Big Hatchet Mountains-Florida Mountains Region*, 1970), 25 (*Ghost Ranch*, 1974), and 30 (*Santa Fe Country*, 1979), as well as contributing numerous papers and road logs to these and other guidebooks through the years. With Stu Northrop, he also edited NMGS Special Publication 6 (*Tectonics and Mineral Resources of Southwestern North America*) in 1976, and was a contributor to the first edition of the *New Mexico*

*Highway Geologic Map* (1984). For his contributions to NMGS he was awarded an honorary membership in 1989, and the 50th Guidebook (*Albuquerque Geology*, 1999) was dedicated to him.

Vin Kelley, chairman of the Geology Department since 1962, retired in spring 1970, and the department set about finding a new chairman. The process proved to be tortuous, involving a failed external search and initial selection of one of the current faculty, who proved quickly to be unsuitable. Finally, the Dean asked Lee to become acting chairman for the 1970–1971 academic year. He accepted, and then became the regular chairman from 1971 to 1976. His first year especially was difficult, as departmental programs were disorganized, its finances depleted, and no advice or assistance in understanding the many details of the position was offered by the previous chairman. Further, Lee was editing an NMGS guidebook, was president of the Albuquerque Geological Society, and establishing research programs, publishing, and mentoring nearly a dozen graduate students at this time. To say that this was an incredibly busy year for him would be an understatement.

Lee's time as chairman was extremely beneficial to the department. He led an effort to make the B.S. program more rigorous, and was instrumental in strengthening standards for admission into the Master's program, and in developing procedures for testing and evaluating the thesis research of Master's students, previously a process left principally to thesis advisors with varied results. He also enhanced the department's ties with industry, resulting in more job interviews and job offers for graduates and increased funding for graduate student research.

The six years Lee served as chairman had important consequences for the future of the department. When he became acting chairman, in fall 1970, the department consisted of 10 regular faculty. Lee hired nine new faculty members, some replacements for departing faculty but others in new positions, bringing the total to 14—the most in the department's history to that time—by the time his term as chairman ended. Further, four of the new faculty he hired (Brookins, Ewing, Wells, and Kues) eventually became chairmen of the department themselves. One, Steve Wells, is currently the president of the New Mexico Institute of Mining and Technology. Not all of the men he hired stayed long enough to contribute significantly to the department's growth, and to establish productive and sustained research careers in New Mexico and elsewhere, but most did, and that is an important part of Lee's legacy.

The end of his term as chairman released Lee from many time-consuming administrative duties, allowing more time for research and writing. His work in the Nacimientos continued, as well as studies of the structure, tectonics and Precambrian rocks in other parts of New Mexico and the greater Rocky Mountains region, and he published prolifically through the 1970s and 1980s. For NMGS guidebooks he and coauthors provided broad but detailed and very useful overviews of the structure/tectonics of various parts of the state (e.g., Four Corners region, 1973; central-northern New Mexico, 1974; Raton basin, 1976; San Juan basin, 1977;

Santa Fe area, 1979; Albuquerque area, 1982; northeastern New Mexico and adjacent states, 1987). In the context of early understanding of the new concept of plate tectonics, he collaborated with others to produce tectonic maps of the Rio Grande rift (for the Geological Society of America [GSA] Map and Chart series, 1975; NMGS, 1975; and NMBMMR Circular 163, 1978), as well as a guidebook for the Albuquerque basin part of the rift (NMBMMR Circular 153, 1976). Related journal articles included an early attempt to determine the rate of crustal extension across the Rio Grande rift (Geology, 1977), a comparison of the southwestern New Mexico overthrust belt with that of Utah and Wyoming (AAPG Bulletin, 1981), and a study of the age of the Abiquiu Formation, an early pre-rift sedimentary unit in central New Mexico (GSA Bulletin, 1981).

During this time Lee also worked with extractive industry companies as a consultant. These projects enhanced his interest in the structural/tectonic influences on mineral and oil and gas deposits, and resulted in numerous papers, typically with one or more coauthors, in the late 1970s to early 1990s. Many dealt with oil and gas prospects in New Mexico, including southwestern New Mexico (Oil and Gas Journal, 1980; Rocky Mountain Association of Geologists, 1984), the San Juan basin (AAPG Bulletin, 1979), the Raton basin (AAPG Bulletin, 1984), along the Nacimiento uplift (Rocky Mountain Association of Geologists, 1984), the Albuquerque basin (Oil and Gas Journal, 1985), and in central-western New Mexico (NMGS, 1986). Other papers incorporated studies of mineral deposits, such as gold mineralization in the Manzano Mountains (Mountain Geologist, 1978), Precambrian metallic mineralization in New Mexico (New Mexico Geology, 1981), mineralization associated with Tertiary intrusions along the Tijeras-Cañoncito fault (Geology, 1985), epithermal gold deposits remobilized from Precambrian strata during late Cenozoic continental rifting (Geology, 1990); a study of the tectonics, intrusive rocks and mineralization in the San Pedro–Ortiz porphyry belt east of Albuquerque (NMBMMR Bulletin, 1991), and studies of a copper-gold prospect in Lincoln County, gold mineralization in the Gallinas mining district, and a tectono-metallogenic map of mining districts in Lincoln County (all in the 1991 NMGS Guidebook).

Lee's research and publications concerning New Mexico geology lessened in the 1990s, as his focus shifted to Montana (see below). He continued to contribute overviews of structure, tectonics, and mineral resources to NMGS guidebooks and journals (e.g., on the geometry of the Nacimiento-Gallina fault system, 1992; the geology of the Santa Fe area, 1995; tectonics of the Four Corners region, 1997; tectonics and fracture reservoirs in the Cretaceous of the Raton basin, 1997; the Phanerozoic geologic evolution of the Albuquerque area, 1999; and Jurassic strata in east-central New Mexico, 2001). He collaborated on a tectonostratigraphic map of the Cordilleran orogenic belt in the Geological Society of America's Decade of North American Geology series (1993). And, he contributed to ongoing efforts to work out the movement of the Colorado Plateau during Laramide time, principally by examining stratigraphic constraints on right and

oblique slip faulting on the east side of the plateau relative to its rotation, with papers in Geology (1994, 1997) and the GSA Bulletin (2001).

Lee Woodward retired from the regular faculty at UNM in December, 1997, and became a senior research professor. He was a familiar presence in the department until about 2008. His contributions to our understanding of New Mexico's geologic history were voluminous and significant, contained in more than 100 published papers and maps, and he will be remembered as one of the state's most productive and influential geoscientists of the later 20th and early 21st centuries. This would be a fine scholarly career for any research geologist. His accomplishments, however, do not end there.

Shortly before coming to New Mexico, Lee and Katie purchased a cabin in the Judith Mountains, northeast of Lewistown, in central Montana. They renovated and enlarged it, and returned to it nearly every summer for decades. It became Lee's base for continuing field work and research in Montana. His body of work in Montana is impressive—about 25 papers and maps, mostly published in journals and in various publications of the Montana Bureau of Mines and Geology (MBMG), as well as several books and book-length monographs. Most of these publications are studies of regional tectonics and the relationship of tectonics and structure to the formation of metallic resources. The following account is not exhaustive but is intended to indicate some of his most important and representative contributions that may not be known to his New Mexico colleagues.

An early, major paper on the tectonic framework of the disturbed belt of west-central Montana (AAPG Bulletin, 1981) was followed by a tectonic map of the fold and thrust belt in Montana (MBMG Geologic Map 30, 1982), and later by studies of Proterozoic faulting in central Montana (Mountain Geologist, 1995), and the tectonic evolution and geophysics of central Montana (Northwest Geology, 1997). Numerous studies involving silver and gold deposits are represented by papers on the tectonic origin of fractures for fissure vein emplacement in the Boulder batholith (Economic Geology, 1986), tectonic setting of gold and silver deposits in Proterozoic strata in west-central Montana (International Basement Tectonics Conference, 1992), structural control of lode gold deposits in the Tobacco Root Mountains (Economic Geology, 1993), metallic mineral deposits of the Judith Mountains in central Montana (MBMG Memoir 67, 1995), and a tectono-metallogenic map of the Dillon 1 x 2 minute quadrangle of Montana and Idaho (Tobacco Root Geological Society, 1990). Shortly after retiring Lee received the Distinguished Alumnus Award from the University of Montana, honoring his career contributions to geologic knowledge in both Montana and New Mexico.

After retirement, Lee turned to writing about the geology, history, and natural attractions of the central Montana country he liked so much. He produced four nontechnical books for general readers. The first, with former student Otto Schumacher, was entitled *Magnificent Journey: a Geologic River Trip with Lewis and Clark Through the Upper Missouri Breaks National Monument* (2004), which retraced the route of the Lewis and Clark expedition 200 years previously.

This was followed by *Field Guide to the Judith Mountains, Central Montana* (2009), with his daughter Ann, a guide to the geology, history, hiking, ghost towns, and natural history of the range in which he spent many of his summers. *Montana's Island Ranges* (2010) discussed the isolated mountain ranges that protrude through the surrounding prairie of central Montana. And lastly came *The Yogo Sapphire Mine, Montana* (2013), the geology and history of a world-class gem deposit in central Montana, published when he was 82 years old.

Lee was a man with a remarkable work ethic, a great sense of duty in fulfilling responsibilities he had undertaken, a straightforward, no-nonsense attitude, and strong convictions that included appropriate standards of behavior in people in general and in geology faculty in particular. His opinions were often expressed in unconventional, colorful language, no doubt acquired in his early years and in the military. All of his friends, students, and colleagues probably have their own favorite examples of Lee's distinctive ways of expressing himself. Mine occurred shortly after I arrived as a new faculty member in 1974. During an early faculty meeting, Lee was reporting some edict from the Dean that he disagreed with, and followed with the comment that the Dean "is so dumb that he does not have enough sense to pour warm piss out of his own boots." That was an eye-opener, but I soon learned that such language was a part of his unique persona, and more often than not reflected an accurate assessment of the subject in question. Lee did not suffer fools gladly, but was warm, generous, and supportive to those he found worthy.

One example of how Lee treated a young faculty member is contributed by Rod Ewing, who arrived at UNM at the same time as this writer. "As others do, I have many stories about Lee. For me the story that best captures his approach to life has to do with my teaching of mineralogy. As is true of many beginning faculty, my first mineralogy class was overly ambitious. Also, I had over a hundred students and no TA. The class did not go well. Finally, a delegation of students approached Lee with a long list of complaints. Lee called me into his office, and I sensed impending doom as he ran down the list of my shortcomings. When he came to the end of the list, he handed it to me and advised me to consider each complaint carefully, make adjustments as needed, and then get back to teaching the course. With a few profanities directed at some of the students who he judged to be lazy, he assured me that I had his full support, but he expected me to be successful and not to "f\_\_ up". He could have crushed me at that vulnerable moment, but instead he left me in a good position to improve. I have always appreciated his very direct way of approaching any issue. Fortunately, as a veteran, I was not surprised by Lee's language—or the references to body parts and functions."

Lee expressed his own views on his career as a geology professor simply but eloquently: "As I look back on my career I feel extraordinarily fortunate to have had such good friends, including many of my former students. But perhaps most of all, I had an opportunity to do the kind of work that was both a vocation and an avocation—it was like being paid to have a hobby. Nearly all the research I undertook was a labor of love."

—Barry S. Kues, Emeritus Professor, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM