

Allan R. Sanford (1927–2016)

Allan (Al) R. Sanford, professor of geophysics, emeritus, at New Mexico Tech (NMT) passed away quietly at his home in Woodinville, Washington, on 9 August 2016. He was 89. Al was a pioneer in the recording and interpretation of micro-earthquake seismograms. For decades, he was the leading authority concerning seismicity across New Mexico and within the Rio Grande rift (RGR). He published numerous papers with graduate students and colleagues on the unique, high-amplitude reflected phases seen on Socorro-area microearthquake records. Al and his students eventually attributed these phases to the presence of an extensive midcrustal magmatic sill now known as the Socorro Magma Body (SMB).

Al was born in Pasadena, California. He attended Pomona College, but then entered the Navy to train as a radar specialist during the final 18 months of World War II. Back at Pomona following the war, he completed a B.S. degree in physics in 1949. He then spent time as the “computer” on a seismic crew prospecting for oil across the western United States. This experience led him to graduate school at California Institute of Technology where he gained knowledge in seismology while working for C. F. Richter and he completed his doctorate in geophysics under the guidance of C. H. Dix in 1958. Al was employed as a professor at NMT in Socorro from 1957 to 1997 where he taught courses in exploration geophysics and earthquake seismology, and supervised the research projects of about 50 masters students and about one dozen doctoral students. He joined Seismological Society of America in 1957, and he was a Fellow of the American Association for the Advancement of Science.

During his earliest years at NMT, Al teamed with another young professor, C. R. Holmes, to begin recording microearthquakes near Socorro. In 1959, Merle Tuve of the Carnegie Institute loaned Sanford and Holmes a high-magnification seismograph, with which they recorded 49 very small earthquakes over three days. These were the first microearthquakes recorded in New Mexico. By 1960, they were operating their own recording system, and their 1961 *Bulletin of Seismological Society of America* paper, “Note on the July 1960 Earthquakes in Central New Mexico,” documented felt earthquakes from near Bernardo (about 40 km north of Socorro), and also attributed observations of anomalous high-amplitude secondary phases seen on the seismograms of tiny aftershocks to reflections from a midcrustal discontinuity. Their 1962 *Journal of Geophysical Research* paper, “Microearthquakes Near Socorro,

New Mexico,” described their high-amplification recording system and noted the swarm-style seismicity that became so familiar to NMT geophysics students. Although recording and interpretation of tiny earthquakes has now long been routine, during the late 1950s and early 1960s, seismic observatories in the United States were designed to record large teleseismic events while a few networks (with relatively sparse station spacing) typically recorded local and regional events down to magnitudes near 2.0–3.0. Al was a leader in what became a new field of earthquake studies, and his pioneering accomplishments are acknowledged in the introductory chapter of *Principles and Applications of Micro-earthquake Networks* (1981) where W. H. K. Lee and S. W. Stewart note: “The first reported microearthquake study in the United States was made by Sanford and Holmes (1962) near Socorro, New Mexico...”

Between 1965 and 1977, Al and his students published a series of papers describing and analyzing the Socorro-area reflected phases. Their papers first focused on the unusually high amplitudes of the reflections and ruled out many possible scenarios for such strong signals. By the early 1970s, their publications presented the idea of “a zone of very low rigidity” as the cause of the reflections. Finally in 1977, in an American Geophysical Union Geophysical Monograph Series (*The Earth’s Crust*), they published their interpretation that the interface must be a broad magmatic sill at 18–20 km depth, and they presented a map of the areal extent of the reflector. This cautious approach was classic Al Sanford. He was from an era when researchers thoughtfully ruled out alternate scenarios before declaring a final interpretation. I suspect that sometime in the 1960s, Al and his students realized the reflections must be related to midcrustal magma emplacement, but I do not know exactly when the SMB hypothesis was first proposed. Because NMT researchers had documented and interpreted midcrustal reflections on earthquake seismograms, the Consortium for Continental Reflection Profiling (COCORP) program chose the Socorro area of the RGR to record one of its first Vibroseis surveys, conducted in 1975 and 1976. Al and his students assisted in that survey and are coauthors of papers interpreting those seismic lines. Although the SMB is a truly unique geophysical feature, Al was always modest regarding his association with its discovery. He often told me it was simply good fortune that he took a position at NMT in 1957 and was therefore present to record and interpret the previously unknown SMB reflections.



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Although SMB studies were most common within the NMT seismology research program, Al also advised students on many other geophysics projects. Over the years, students working under Al conducted heat flow studies, gravity surveys and interpretations, magneto-telluric surveys, geomorphological fault studies, microseism investigations, seismic attenuation studies, magnitude scale calibrations, seismic analyses of mining explosions, and seismic-hazard analyses of New Mexico. Al collaborated with seismologists from Los Alamos National Laboratory and the U.S. Geological Survey Albuquerque Seismic Laboratory to produce statewide studies of New Mexico seismicity. His students found employment with oil companies, state government agencies, federal government agencies, national and international universities, and national labs. Following retirement, he continued to be active in research. Just as his first New Mexico seismicity paper from 1961 focused on felt earthquakes from the Bernardo area, his final paper, published by the New Mexico Geological Society in 2016, is a summary of the 1989–1991 Bernardo earthquake swarm that produced several felt events greater than magnitude 4.

As an advisor and teacher, Al was always a gentleman. He listened carefully to his students, quietly offering practical advice and guidance without criticism. His cautious approach to science meant nearly all students were required to complete a masters project prior to beginning Ph.D. research. If acceptance into the Ph.D. program was not to be forthcoming, he would volunteer to write letters of recommendation to programs at other universities. To make certain they completed their degrees, he would pick up graduate students that were “orphaned” when other professors left NMT. He always encouraged his best undergraduate students to apply to graduate schools.

Al was curious regarding all of natural science. Sometimes during lectures, or in more informal conversation, he would

become temporarily sidetracked wondering about phenomena well beyond geophysics. I recall one spring when an excited graduate student returned to campus from servicing a seismic station inside a mining adit where he had encountered a rattlesnake. Al immediately began to wonder how snakes knew when spring had arrived, and it was therefore time to exit the mine, because high heat flow at the back of that adit kept the tunnel at a warm and constant temperature year round.

As a teacher and a researcher, Al’s greatest gift was his ability to find clear, clever solutions to complex problems. His approach to science positively influenced many generations of scientists who had the pleasure of collaborating on projects with him. A tribute to Al and his long career at NMT was held at Socorro in October. A video of that tribute can be viewed at <https://mediasite.nmt.edu/Mediasite/Play/7fa22045790941eb974e485d3d4513641d> (last accessed November 2016). The “Dr. Allan R. Sanford Memorial Endowed Fellowship” has been established at NMT, with contribution opportunity accessed through the “Designation” list at <https://advancement.nmt.edu/nmt-pages/donate-ees> (last accessed November 2016).

Al is survived by his wife Alice, sister Marguerite Sanford, daughter Colleen Marzluff, son Rob Sanford, son-in-law John Marzluff, daughter-in-law Joanne Chee-Sanford, and five grandchildren. ✉

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