Memorial to Alfred O. C. Nier
1911–1994

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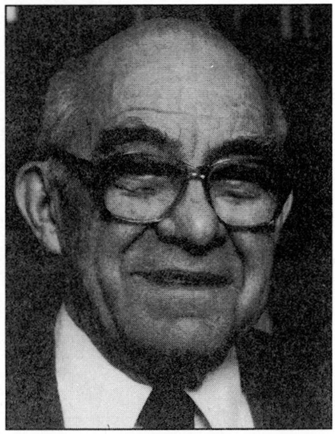

Al Nier spent May 2, 1994, in his laboratory at the University of Minnesota working with his friend and assistant Dennis Schlutter on the interpretation of mass spectrometric data on individual 10–20 micrometer interplanetary dust particles. While returning home at the end of the day, he suffered a spinal fracture when he blacked out and his car struck a tree. Although paralyzed, he communicated with family and friends with eye contact and a spelling board until his death on May 16, 1994. A memorial service was held at St. Anthony Park Lutheran Church on May 18, and a special colloquium to honor his life was held at the University of Minnesota on November 2. "Great" was an oft-heard adjective in the eulogies at these commemorations and in the expressions of loss and nostalgia shared among his many friends and colleagues. In the full sense of the word, Al Nier was a great scientist and a great person. His life evokes lines from Shakespeare's *Twelfth Night*: "Some are born to greatness, some achieve greatness, and others have greatness thrust upon them...."

Al Nier was born in St. Paul, Minnesota, on May 28, 1911. He attended public school and worked in his father's dry-cleaning business. He also delivered newspapers to support his early interest in "tinkering with radios." Although he was always justly proud of his background, it does not make Shakespeare's first category of greatness particularly appropriate. It is a different matter, however, with regard to the category of achievement. The year Al Nier was born, J. J. Thomson, using Aston's mass spectrograph, identified the first isotope, ^{22}Ne. By the 1930s, when Al began designing and constructing his own mass spectrometers in the course of his Ph.D. research at the University of Minnesota, some 200 isotopes had been identified. However, the discovery of additional isotopes, the accurate determination of isotopic masses and abundances and the myriad new insights into nature that isotopic studies would make possible, all awaited the development of ever more sophisticated instrumentation, the intuitive grasp of new problems that could be addressed, and the careful acquisition and interpretation of data. As it turned out, Al Nier was exceptionally gifted in all of these areas, and the enthusiastic, persistent, and unselfish dedication of his talents to significant research has earned him a place among the great scientists of his time.

Al Nier initiated his long career in 1935 with two publications: an instrumental publication entitled "A device to compensate for magnetic field fluctuations in a mass spectrograph" and a scientific paper entitled "Evidence for the existence of an isotope of potassium of mass 40." These communications are characteristic of his more than 200 subsequent publications which consist of a duality of timely communication of his many instrumental innovations and seminal publications that eventually led to collaborative research in previously unexplored areas of biology, chemistry, geology, medicine, and physics.

Al Nier often referred to himself as a "gadgeteer," but what gadgets! The double-focusing spectrometer, the He leak detector, the 60° magnetic sector spectrometer, and an array of miniaturized spectrometers made possible the transformation from the early glass-tube mass spectrographs to the sophisticated instruments found in today's mass spectrometer laboratories. Al's instrumental contributions were all a natural outgrowth of the breadth of the research on the frontiers of science conducted by him and his students. The pace and ingenuity of his instrumental innovations were neither tainted nor diverted by mercenary preoccupations but flowed from an unflagging drive and energy to solve significant scientific problems. One of his students, Walter Johnson, confessed to hoping for an equipment failure to break the pace of data collection—until he learned that such events were only met with a rush to get the equipment running again!

Well into the 1930s, charting the nuclides was the principal use of improved mass spectrographic instrumentation, but Al Nier, from the beginning of his career, had an intuitive grasp of other problems to which better instrumentation could be applied. He played a major role in establishing and advancing the modern disciplines of geochronology, stable and radiogenic isotope geochemistry, the use of isotopic tracers in biology and medicine, gas analysis, the characterization of planetary atmospheres, and a field still in its infancy: micrometer-sized particle analysis. Many of his contributions to science are discussed in another memorial (Pepin and Signer, 1994, *Meteoritics*, v. 29, p. 747-749). Those that relate to geology and planetary science are highlighted here.

After completing his Ph.D. in 1936, Al spent the next two years as a National Research Fellow under K. T. Bainbridge at Harvard. During this time he discovered four new isotopes (^{36}S, ^{46}Ca, ^{48}Ca, and ^{184}Os), determined the isotopic composition of 19 elements (including the unknown $^{238}U/^{235}U$ abundance ratio), and found a 5% difference in the $^{13}C/^{12}C$ abundance ratio in limestone- and plant-derived C (with E. A. Gulbranson at Tufts). Thus, only two years beyond the completion of his Ph.D., Al had advanced the accurate determination of atomic weights, had elevated geochronology to a new plane of quantization, and had laid the groundwork for a new field: the use of isotopic tracers in chemical and biological systems! Fortunately for geology, he also began at this time what turned out to be a lifelong interaction with Arthur Holmes, who termed Nier's work brilliant and encouraged Al at every turn.

Following up on a demonstration by J. L. Rose and R. K. Stranathan in 1936 that $^{207}Pb/^{206}Pb$ ratios could be used to determine geologic time, Nier published, in 1939 and 1941, three important papers on U, Th, and Pb systematics. His new data, the equation he derived to relate $^{207}Pb/^{206}Pb$ ratios in galena samples to their age, and his thoughts on analytical errors, alteration, and "primeval" Pb were pivotal in the subsequent contributions of Gehrling, Holmes, and Houtermans that led eventually to C. C. Patterson's determination of the age of meteorites in 1956 and the subsequent refinement of the age of the Earth by V. Rama Murthy and Patterson in 1962.

Two years after Al Nier was born, Arthur Holmes published, in 1913, a small book entitled *The Age of the Earth* (London and New York, Harper and Brothers, 196 p.). In 1991, just three years before Al Nier's death, Brent Dalrymple published his benchmark book on geochronology, also entitled *The Age of the Earth* (Stanford University Press, Stanford, California, 474 p.). Holmes's book eloquently hints at the wealth of new insights that could be wrested from studies of the Earth with the new-found knowledge of radioactivity, and Dalrymple's book comprehensively chronicles the amazing and exciting results of the intervening 80 years of research. What a great time for all the practitioners of isotopic studies in geology! Over the years, they have all unreservedly acknowledged the fact that Al Nier contributed directly or indirectly to all the advances in their field from 1935 to the present.

Al Nier's attention to the emerging field of isotope geochemistry was interrupted by World War II. With his usual scientific and instrumental acumen he supplied a key element of success to the Manhattan Project: the mass spectrometric separation of ^{235}U and ^{238}U, which led, in

1940, to the recognition that ^{235}U was the fissioning isotope. (The glass-tube mass spectograph used in this discovery is at the Smithsonian Institution in Washington, D.C.) His work in gaseous diffusion and He leak detection made further contributions to the Manhattan Project and the postwar nuclear power industry.

After the war, Nier, along with his many students and collaborators, continued to make contributions to carbon isotope geochemistry and uranium-thorium lead geochronology. New initiatives into the 1960s included the establishment of the K-Ar chronometer with L. T. Aldrich in 1949 (following a suggestion by von Weizsaecher in 1937 (*Physikalischer Zeitschrift*, v. 38, p. 623) that excess Ar in natural minerals could be due to K capture); in 1946, the first measurements of $^3He/^4He$ in natural sources (including in 1958, with J. H. Hoffman, production of ^3He in iron meteorites by cosmic rays); in 1958, high-accuracy atomic mass measurements with W. H. Johnson, Jr., K. S. Quisenberry, and T. T. Scolman; in 1961, the first and still the most extensive geochronological characterization of the Precambrian rocks of Minnesota with S. S. Goldich, H. Baadsgaard, J. H. Hoffman, and H. W. Krueger; and in 1962, the distribution of rare gases in meteorites with P. Signer which led to the Signer-Nier model for the production of cosmogenic nuclides in iron meteorites. An outgrowth of Al's interaction with the scientific community at large at this time was the adoption of his and J. Mautach's recommendation that ^{12}C be assigned the mass of exactly 12 in a new unified scale for atomic masses. The new scale was adopted by the International Union of Pure and Applied Chemistry and the International Union of Pure and Applied Physics in 1961.

In the 1960s, Al Nier turned his gadgeteering instincts from building large mass spectrometers, built to obtain high mass resolution, to problems of miniaturization. Fortunately for planetary science, he and his students foresaw and championed the use of rocket technology for scientific purposes. Together they provided the first reliable data on the Earth's upper atmosphere from miniaturized spectrometers flown on balloons and sounding rockets. Al was the right person at the right time in the 1970s when the Viking and Pioneer Venus missions materialized within NASA. He served as leader of the Viking Entry Science team, as a member of the Molecular Analysis team, and as a co-investigator on Pioneer Venus. He designed and supervised the construction of the Viking mass spectrometers that successfully obtained isotopic data on C, N, and the noble gases in the Martian atmosphere. The data constrain current models of the atmosphere of Mars and provide an important datum for planning future missions to Mars. The discovery of the ~75% enrichment in ^{15}N in the Martian atmosphere relative to that of the Earth remains the hard evidence for identifying the Shergotty-Nakhla-Chassisgny-type meteorites from Mars.

In the 1980s, undaunted by the decline in new NASA missions (particularly a mission to Comet Halley) he refocused his attention on the Earth. He, along with his colleague Konrad Mauersberger and their students, placed new constraints on the composition and structure of the Earth's atmosphere, and he collaborated with Rama Murthy on developing a small double-focusing mass spectrometer for terrestrial geochemical research.

Al Nier's energy and curiosity remained unabated upon his retirement in 1980. He returned to his practice of seeking out colleagues for whom he felt his expertise in mass spectrometry might be useful. As he had done in 1938 when he contacted Arthur Holmes, he asked Don Brownlee about the value of obtaining data on He and Ne concentrations and isotopic abundances in individual nanogram interplanetary dust particles. With Dennis Schlutter, Al moved this new area of research from "simple" measurements to the acquisition of stepwise, pulsed heating profiles and experimentation on implantation and thermal release. As Holmes in the 1940s had seen unexpected advances in geochronology result from his collaboration with Al Nier, so Brownlee and the interplanetary dust community have been similarly blessed with new insights into the thermal history of interplanetary dust and a tool to distinguish between asteroidal and cometary dust. Walking into Al's laboratory in these later years to give him scanning electron microscope images of interplanetary dust particles, I never had the feeling that I was in the presence of a distinguished octogenarian but rather that I was interrupting a young graduate student who had just stumbled onto some exciting result, or who occasionally felt compelled to apologize for the fact that he was just leaving for or had just returned from a short ski trip to Colorado with his wife, Ardis!

Except for his two-year postdoctoral stay at Harvard (1936-1938) and a leave of absence (1943-1945) while on the Manhattan project, Al Nier spent his entire career in the physics department at the University of Minnesota. He served as chairman of the department for 12 years and was made a Regents Professor in 1966. He was elected to the National Academy of Sciences, the American Academy of Arts and Sciences, and the Royal Swedish Academy of Science; and he was a recipient of the Geological Society of America's Arthur L. Day Medal, the Viktor M. Goldschmidt Medal of the Geochemical Society, NASA's Medal for Exceptional Scientific Achievement, the American Chemical Society's Field and Franklin Award, and the American Geophysical Union's William Bowie Medal. Recognition of the significance of Al Nier's contributions to the field of mass spectroscopy came early and persisted throughout his career. This recognition continues posthumously; a recent example is approval by the Commission on New Minerals and New Mineral Names of the International Mineralogical Association of the name nierite for a new trigonal silicon nitride (Si3N4) found in ordinary and enstatite chondrites. Certainly he must be counted among those who, in Shakespeare's words, have "greatness thrust upon them." Perhaps his greatest personal achievement was the fact that he accepted all honors and recognition with honest humility and gratitude and never wasted a moment of his life seeking affirmation of his work or belittling the work of others to enhance his own. He remained faithful to his lifelong personal pride in painstaking, persistent, and productive day-to-day work. Edward Ney, Al Nier's distinguished student and close friend, made perhaps the most apt and succinct statement of Al's life work when he said, "Al Nier did just about everything that could be done with a mass spectrometer and did it better than most others." It should be added that what Al Nier did and the way he did it were not done out of competitive false pride but out of a lifelong curiosity that drove him to find the right answers to questions that the world about us presents to an open and inquisitive mind.

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