

Bruce Alan Bolt 1930–2005 Professor of Seismology, Emeritus

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Fig. 1 Professor Bolt

Bruce Alan Bolt, Figs. 1 and 2, Professor Emeritus of Seismology at the University of California, Berkeley, died suddenly of pancreatic cancer at Kaiser Permanente Medical Center in Oakland, California on July 21, 2005.

Professor Bolt was born on February 15, 1930 in the small town of Largs, New South Wales, Australia. He attended East Maitland Public School, Maitland Boys' High School, Newcastle Technical College, New England University College of the University of Sydney, Sydney Teachers' College. Majoring in mathematics and physics, he received a B.Sc. degree with honors in mathematics in 1952 from the University of Sydney, and also M.Sc., Ph.D., and D.Sc. degrees in 1955, 1959, and 1972, respectively, from the University of Sydney.

After a year at Sydney Teacher's College (Diploma of Education, 1953) Professor Bolt taught at Sydney Boys' High School in 1953. He was then appointed to the faculty in the Department of Mathematics (Applied Mathematics) at the University of Sydney and progressed through the ranks as Lecturer, 1954–1959, and Senior Lecturer, 1959–1962.

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After completing his Ph.D. thesis in elastic wave theory, he won a Fulbright scholarship to Lamont Geological Observatory at Columbia University in 1960 and to Cambridge University (U.K.) in 1961. Meeting there with Perry Byerly, Professor of Seismology at U.C. Berkeley led to an invitation to a chair in seismology at U.C. Berkeley in 1963.

During the period 1963–1993, he served as Professor of Seismology in the Department of Geology and Geophysics at the University of California, Berkeley (UCB) and as Director of UCB's Seismographic Stations. In his early years at UCB, Professor Bolt developed strong research interests with faculty members in structural and geotechnical engineering, which resulted in his serving as Professor of Civil and Environmental Engineering during the period 1983–1993. Upon retiring from UCB in 1993, he received the campus' highest honor, the Berkeley Citation, then became Professor Emeritus of Seismology and Professor in the Graduate School, thus continuing his academic activities until his death.



Fig. 2 Professor Bolt

While teaching at the University of Sydney, Professor Bolt developed outstanding expertise in the specialty areas of applied mathematics, statistics, and geophysics. As a result, he continued to make valuable contributions to advancing knowledge in these areas throughout his career. His strongest desire was to understand natural phenomena, particularly their mathematical and statistical descriptions. He wrote numerous novel papers pertaining to the deep earth, dispersion, earthquake engineering, free oscillations, seismology, and statistics. His first published paper was a 1957 note in *Nature*, followed by one in

Geophysical Journal of the Royal Astronomical Society, on seismic observations of the 1956 atomic explosions in Australia. In 1960, he published a paper with John Butcher on the dispersion of seismic waves, which began his deep involvement with large data sets and digital computing. His creativity in and knowledge of statistical methodologies, with influence from Harold Jeffreys, led to the estimation technique for the revision of earthquake epicenters still in use today (2006). As part of that work, he led statisticians by some ten years in developing the method of robust regression. His many contributions to seismology, including the development of earth models, have involved finite element methods, elastic wave-propagation theory, broadband and digital recording, strong-motion array development, data collection and interpretation, attenuation relations, and earthquake statistics.

Professor Bolt wrote six and edited eight textbooks on earthquakes, geology and computers among other topics, as well as almost two hundred research papers. His numerous publications on topics in seismology include *Nuclear Explosions and Earthquakes: The Parted Veil*, 1976; four very popular books: (1) *Earthquakes: A Primer*, 1978, (2) *Inside the Earth: Evidence from Earthquakes*, 1982, (3) *Earthquakes and Geological Discovery*, 1993, and (4) five editions of *Earthquakes*. An updated version of the 2003 5th Edition was published in 2006. In recognition of his many contributions to seismology, he was elected Fellow of the American Geophysical Union and the Geological Society of America, Associate of the Royal Astronomical Society, and Overseas Fellow of Churchill College, Cambridge. He served as President of the Seismological Society of America in 1974 and editor of its *Bulletin* from 1965 to 1972, President of the International Association of Seismology and Physics of the Earth's Interior from 1980 to 1983, President of the Consortium of Organizations for Strong-Motion Observation Systems (COSMOS), and President of the California Academy of Sciences.

Notably, Professor Bolt was actively involved from the early 1960's through the mid-1980's in the development of reference earth models and towards this goal, contributed many measurements of body wave travel times as well as free oscillation eigenfrequencies and attenuation. He was particularly interested in constraining the average earth structure near two major interfaces: the solid/liquid core mantle boundary (CMB) and the liquid/solid inner core boundary (ICB) and focused many of his studies on the challenging topic of density. He provided some of the first robust measurements of the density jump at the ICB (1970) and also confirmed the density jump at the CMB (1985) and provided insights on the resolution of the density profile throughout the earth's interior (1975). He studied the shear velocity structure near the CMB, and the compressional velocity profile in the outer core, with a continued interest in characterizing resolution and uncertainty, which developed through a fruitful collaboration with Professor David Brillinger in Statistics. He was one of the proponents of the existence of an anomalous layer at the bottom of the outer core and made prominent observations of compressional waves (PKnKP) bouncing multiple times inside the outer core, which demonstrated that

the CMB must be very spherical, and was illustrated in his textbook “Inside the Earth”.

Many of Dr Bolt’s observations were made on records from the Berkeley Seismographic Stations (BSS), which, in the good tradition of previous Directors, he modernized over the years and kept abreast of current technology. He introduced broadband recording at Berkeley in 1963 and started replacing paper recording by magnetic tape recording in 1964. Continuing in the innovative vein, under his directorship, the BSS developed a regional broadband digital network based on inexpensive PC microcomputers, with telemetry to Berkeley over ordinary phone lines, and including three stations equipped with state-of-the-art broadband seismometers at Berkeley, Mt Hamilton and the San Andreas Geophysical Observatory near Hollister. Because of his involvement in the BSS and the related information service on northern California earthquakes, Dr Bolt’s research interests gradually shifted towards characterizing ground motions from regional earthquakes in relation to earthquake hazards in the built environment.

In addition to many contributions to seismology, Professor Bolt made invaluable contributions to the field of earthquake engineering through teaching of basic seismology to graduate students in structural and geotechnical engineering, conducting research characterizing strong ground motions for engineering design purposes, serving as consultant on important engineering projects, and participating as a member of numerous panels, boards, and commissions. He was an active participant in the UBC Earthquake Engineering Research Center.

Professor Bolt’s consulting work focused primarily on setting seismic criteria for new and retrofit designs of important critical structures, such as dams, nuclear power plants, large bridges, underground structures, and pipelines. These structures included the Aswan Dam, Diablo Canyon Nuclear Power Plant, Golden Gate Bridge, Bay Area Rapid Transit (BART) underground stations, BART transbay tube, and the Alaska Pipeline. His consulting work in 2005 included characterizing the controlling seismic sources and assessing tsunami risk for use in designing the now-planned (2006) suspension bridge crossing the Messina Strait between Italy and Sicily.

His setting of seismic design criteria for critical structures involved identifying seismic-source zones, guiding the conduct of seismic hazard analyses, generating site-specific response spectra and corresponding free-field ground motions, characterizing the spatial variations of ground motions, and predicting expected future fault offsets. Further, he participated in evaluating the seismic performance of such structures. His strong background in applied mathematics and mechanics made it possible for him to effectively communicate with structural and geotechnical engineers on seismic-design and damage-assessment related issues.

The numerous seismic-related panels, boards, and commissions on which Professor Bolt served include the California Department of Water Resources Consulting Board, California Department of Transportation Seismic Advisory

Board, San Francisco Bay Conservation and Development Commission (BCDC) Engineering Criteria Review Board, Metropolitan Transportation Commission (MTC) Engineering and Design Advisory Panel (EDAP), Golden Gate Bridge Seismic Instrumentation Panel, and the California Seismic Safety Commission (CSSC). As a member of CSSC, he actively participated in the Commission's sponsoring of numerous bills introduced into the legislature which became California law, thus greatly enhancing seismic hazard mitigation in the State.

In recognition of Professor Bolt's many valuable contributions to earthquake engineering, he received the Earthquake Engineering Research Institute's 1990 George W. Housner Medal, the California Earthquake Safety Foundation's 1995 Alfred E. Alquist Medal, and was elected to the National Academy of Engineering (NAE) in 1978. His NAE citation reads as follows: "For the application of the principles of seismology and applied mathematics to engineering decisions and public policy."

Having served many years as Chair of the UCB Academic Senate and as President of the Faculty Club, Professor Bolt seemed to know everyone on the Berkeley campus. His close relationship with individuals extended to a myriad of scientists and engineers worldwide. He was sought after as a speaker. Always in meeting one of his many close friends, he would extend a warm greeting with a big smile. His personal character has been admired by all who have had the pleasure of knowing him. He will be greatly missed by his friends, colleagues, students, and all who knew him.

Professor Bolt is survived by his wife Beverley (Bentley) of Berkeley, CA; three daughters, Gillian Bolt Kohli of Wellesley, MA, Helen Bolt Juarez of Fremont, CA, and Margaret L. Barber of Orinda, CA; a son, Robert C. Bolt of Hillsborough, CA; a sister, Fay Bolt of Sydney, Australia, and sixteen grandchildren.