Frank Press, A life of magnitude

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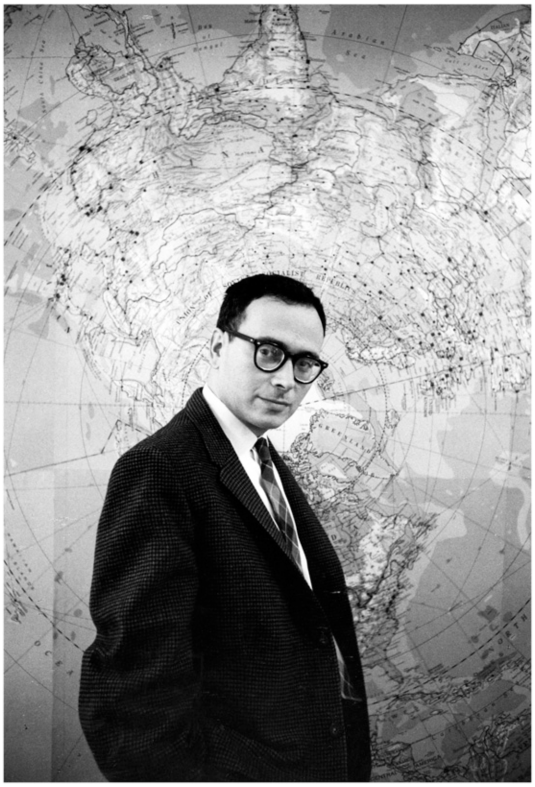
Frank Press, 19th president of the National Academy of Sciences, died on Wednesday, January 29, 2020, at his home in Chapel Hill, North Carolina, at the age of 95. His career spanned the golden age of postwar science, and its arc took him to the highest levels of leadership in academia and government. Frank served in many roles with great distinction and is remembered for his sharp intellect and steady leadership and for his self-composure, fair-mindedness, and good judgment. Few scientists of the past century have had such an enduring impact on United States science policy and the organization of the federal scientific enterprise.



Frank Press. Image credit: Ohio History Connection/ Joseph Munroe.

Frank was born in New York City, the child of Russian émigrés, graduating from the Samuel J. Tilden High School in the East Flatbush section of Brooklyn in 1941. He received his bachelor's degree in physics from the City College of New York in 1944 and enrolled as a graduate student at Columbia University. Frank married Billie Kallick in 1946, when he was 21 years old. She was the love of his life and constant companion until her death in 2009.

At Columbia, Frank studied sound propagation in oceans under the supervision of the geophysicist and oceanographer Maurice "Doc" Ewing. He received his doctorate in 1949, the same year that Ewing founded the Lamont Geological Observatory on a cliff overlooking the Hudson River. With generous funding from the Defense Department, Ewing and his two assistant professors, Frank and Joe Worzel, quickly developed Lamont into a world-class research laboratory. Frank learned a lot from Ewing's hard-driving style and quoted his advice, "Make a better instrument or measure in a place where no one else has been and a great discovery will come your way."

Following this dictum, Frank expanded his research to fundamental studies of Earth structure using new data from an instrument he codesigned with Ewing. The Press–Ewing seismograph was built using available technology, incorporating Galitzin's electromagnetic sensor and La Coste's zero-length spring, but it was much more sensitive to ground motions at low seismic frequencies than previous instruments, and it could record the long-period surface waves excited by earthquakes and nuclear explosions with higher fidelity.

The prototype was installed at Lamont in 1951. On November 4, 1952, a magnitude 9 earthquake occurred offshore of the Kamchatka Peninsula, radiating surface waves of exceptional amplitude. Frank and Ewing observed Rayleigh waves with periods up to 480 seconds, and they were able to measure the period-dependent velocities of wave groups that had orbited the Earth more than seven times before decaying into the background noise. These observations of

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Rayleigh-wave propagation provided new constraints on the elastic structure of Earth's solid mantle and the mechanisms of its anelastic dissipation.

Frank's observational papers opened up the field of surface-wave seismology and motivated new methods for imaging deep-Earth structure, a major subject of seismological research for the next 50 years. He also contributed to the theory of elastic wave propagation by writing with Ewing and the mathematician Wenceslas Jardetzky an influential monograph on structural seismology, *Elastic Waves in Layered Media* (1).

Frank left Lamont for a professorship at the California Institute of Technology (Caltech) in 1955, where he tried but failed to convince the faculty to start an oceanography program. Two years later, at the age of 32, he was appointed as the director of Caltech's Seismological Laboratory, succeeding Beno Gutenberg. Frank was also elected to the National Academy of Sciences (NAS) as one of its youngest members ever.

Frank played a major role in the International Geophysical Year (IGY, 1957–1958). He was a United States delegate to the IGY conferences in Moscow and cochaired the IGY Glaciology Committee. He had Press–Ewing horizontal seismographs built for the IGY seismic stations deployed by Lamont. Using waves propagating through the crustal waveguide, he and his Lamont colleagues confirmed that Antarctica, under all that ice, was a contiguous continent rather than a large island group. A 3,760-m peak in Antarctica's Sentinel Range was named Mt. Press in recognition of his IGY activities, which helped to reestablish the international scientific dialogue disrupted by the Cold War.

New impetus for scientific exchange came from arms control. By the mid-1950s, both superpowers had become focused on a nuclear test-ban treaty as a logical first step toward arms control, and it was clear that seismology would be the dominant technology for detecting underground nuclear explosions. Eisenhower and Khrushchev agreed to convene a bilateral Conference of Experts on the technical problems of test-ban treaty verification in advance of political negotiations. Frank was among those experts when they gathered in Geneva in July 1958. Their report concluded that a nuclear test-ban treaty could be verified by global monitoring systems.

With this green light, formal negotiations began in October 1958, under the auspices of the Geneva Conference on the Discontinuance of Nuclear Weapons Tests and continued through early 1962. The negotiations were difficult and protracted, in part because of United States insistence of on-site verification. The negotiators also had to contend with political crises. Frank chaired the United States delegation to the Seismic Research Program Advisory Group in Geneva, which met on May 11, 1960, just 10 days after the Soviet Union shot down a U2 spy plane.

The previous year, James Killian, President Eisenhower's science advisor, invited Frank to join an Ad Hoc Panel on Seismic Improvement, chaired by Lloyd Berkner. The Berkner Report, submitted in April 1959, emphasized the need for basic research to solve the problems of detecting nuclear explosions and discriminating them from earthquakes; the public summary was written by Frank, Jack Oliver, and Carl Romney. Frank led the effort to implement its recommendations. The result was the Vela Uniform Program of the Defense Department's Advanced Research Projects Agency, which increased the annual federal support for United States seismology by more than a factor of 30.

A major component of Vela Uniform was the deployment of the World Wide Standardized Seismographic Network (WWSSN), proposed by Frank and David Griggs to improve global seismic recording capabilities. The WWSSN comprised 120 continuously recording stations widely distributed on land areas around the world. Each station was equipped with Benioff short-period seismometers and Press–Ewing long-period seismometers. About three-quarters of the WWSSN had been installed by the time the Limited Nuclear Test-Ban Treaty was signed in 1963, and the quality and geographic extent of the data that it produced proved to be far superior to previous seismographic networks.

Among the early benefits were more accurate measurements of earthquakes at smaller magnitudes, which allowed seismologists to delineate the plate boundaries more precisely and determine the directions of relative plate motion. Data from the WWSSN were thus pivotal in the formulation and testing of plate-tectonic concepts during the mid-1960s, when the paradigm shift was in full swing. Lamont seismologists and oceanographers were fully involved in the plate-tectonic revolution, but those at Caltech less so, where the focus was on large, damaging earthquakes.

Two seismic events were particularly significant. The magnitude 9.5 Chilean earthquake of May 22, 1960, was the largest earthquake ever recorded, and its effects were enormous, sending a tsunami across the Pacific that killed thousands. It rang the Earth like a bell, and those free oscillations were recorded on Hugo Benioff's fused-quartz strainmeters and the Press–Ewing seismometers operated by Caltech. In their ground-breaking paper, "Excitation of the free oscillations of the Earth by earthquakes," Hugo Benioff, Frank Press, and Stewart Smith presented free-oscillation spectra down to the lowest orders (2), and they were able to measure the period of the gravest spheroidal mode ${}_0S_2$ at 54 minutes, in good agreement with theoretical calculations. They also observed the splitting of the spectral lines due to Earth's rotation and placed constraints on the length and velocity of the Chilean fault rupture.

The second largest seismic event on record, magnitude 9.2, ruptured the southern margin of Alaska on March 28, 1964, also generating a destructive Pacific-wide tsunami. Interdisciplinary studies of the crustal deformation caused by the Alaskan earthquake led scientists to understand how oceanic lithosphere subducts beneath continents, a seminal contribution to the 1965 to 1968 synthesis of the plate-tectonic theory. Caltech deployed seismometers to improve the recording of the aftershocks, but Frank's main role was in Washington, DC, not Alaska.

The surprising economic damage and high loss of life suffered by that rural, largely uninhabited state awoke politicians to the seismic threat nationwide. President Lyndon Johnson's Office of Science and Technology appointed Frank as the chair of an Ad Hoc Panel on Earthquake Prediction. The Press Panel released its report, "Earthquake Prediction: A Proposal for a Ten-Year Program of Research," in October 1965 (3). The panel's recommendations were controversial because of what some thought was an overemphasis on short-term prediction at the expense of earthquake engineering, but the Press Panel Report laid the foundation for a federal policy to reduce seismic risk.

Frank was hired as Head of Massachusetts Institute of Technology's (MIT) Department of Geology and Geophysics in 1965. He restructured its faculty, recruited an oceanographer, and changed its name to the Department of Earth and Planetary Sciences. In 1968, MIT and the Woods Hole Oceanographic Institution launched a joint program in oceanography, and Frank served as its first MIT Director.

Frank contributed to the Apollo lunar seismology program and continued his research on Earth structure, introducing Monte Carlo methods for the inversion of seismological data and applying pattern-recognition techniques to earthquake prediction. He and Ray Siever of Harvard University published a landmark textbook, *Earth* (4), which was the first to fully incorporate the new plate-tectonic theory. Its several editions and its daughter undergraduate text, *Understanding Earth* (5), taught new generations of students about the content, benefit, and potential of geoscience.

While at MIT, Frank continued to advise the federal government on science-policy issues. He was appointed to the National Science Board by President Nixon in 1970. Frank helped the Ford Administration formulate the 1976 legislation that established the Office of Science and Technology Policy, giving it a broad mandate to advise the President on all aspects of science and technology. Within the year, he had taken its helm.

President Jimmy Carter swore Frank in as his Science Advisor and Office of Science and Technology Policy Director on June 1, 1977. His appointment early in Carter's term allowed Frank to foster personal connections within the new Administration and participate in managing the White House information flow. Frank had direct access to the President, and they built a close working relationship. Frank respected Carter, a nuclear engineer, calling him "the most technically literate President since Thomas Jefferson." Carter respected Frank for his cogent analysis and recommendations, stating early on that "he's been very helpful in helping me to make the right decisions."

Frank was a tireless and effective advocate for federal investment in basic research. He worked with the Office of Management and Budget to push through budget increases for the National Science Foundation and National Institutes of Health, and programs were begun at both agencies to support instrumentation and facilities at research universities. He also advocated for increases to the mission agencies targeted to encourage them to invest in mission-aligned basic research. The gains in the federal research and development budget were substantial, although double-digit inflation compromised their net impact.

Frank was a consummate scientist–diplomat who recognized the constructive role of scientific exchange in cultivating international relations. In 1974, while still at MIT, he had led one of the first scientific delegations to China in the wake of Nixon's ping-pong diplomacy, and he had served under President Ford as chair of his Committee on Scholarly Communication with the People's Republic of China. In 1978, the Chinese government expressed an interest in formalizing an exchange of students, scholars, and scientists. Frank organized a large delegation of senior representatives from the federal science and technology agencies, and they traveled to Beijing on an Air Force plane in July 1978, where they were warmly received by the Chinese Premier, Deng Xiaoping. At one point in the negotiations, evidently at Deng's insistence, Frank woke Carter up at 3:00 AM Washington time to confirm whether the United States would permit as many as 5,000 Chinese students to study at its universities. Carter famously responded, "Tell him to send a hundred thousand!" The first 50 Chinese students arrived in the United States after the normalization of relations in early 1979, and that number exceeded a hundred thousand by 2010.

Frank sought policy changes to facilitate technological innovation by industry and to increase the role of informed technical judgments in regulatory decision making. He was behind the Bayh–Dole Act of 1980, which permitted nonprofit organizations and small business contractors to retain ownership of inventions made under federal contracts. Frank delivered sound scientific advice to Carter after the Three Mile Island nuclear accident and the Mount St. Helens volcanic eruption. By all accounts, he was one of our most successful presidential science advisors.

Frank was elected president of the National Academy of Sciences shortly after returning to MIT in early 1981, and he served two full 6-year terms. He spurred a 1982 reorganization of the National Research Council (NRC) that cut overhead costs and streamlined report writing. Many notable NRC reports were published during his tenure. Frank pushed to disseminate the NRC's findings to a larger public audience, and he expanded NAS activities outside Washington, DC by establishing the Arnold and Mabel Beckman Center adjacent to the campus of the University of California, Irvine. He recruited major industrial leaders to membership in his newly created President's Circle, and he launched the Government–University–Industry Research Roundtable to bring all sectors into the discussion of science policy. Frank also created the Frontiers of Science program, in which the best and brightest young researchers learn about new developments in other fields and build professional networks. Recognizing the need for funding independent of the government, Frank worked with NAS treasurer Elkan Blout to increase the endowment from $28 million in 1981 to $128 million in 1993, enabling the Academy to undertake activities for which outside funding was not available.

Frank's tenure at the NAS was a time of tremendous change across the spectrum of American science. The biological revolution was accelerating to warp speed, and plans were afoot for a human genome project. New issues were emerging, such as the AIDS epidemic and the teaching of creationism as an alternative to evolution, both of which were addressed using funds from the Academy's endowment. He worked to rationalize the budgetary processes by which the federal government allocated research and development funding, emphasizing central planning based on scientific consensus, a model he had used as Science Advisor. Frank fought against the rise of academic earmarking and pork-barrel science, and he worried that projects, such as the Superconducting Supercollider, would distort the balance between Big Science and Small Science at a time when the latter was threatened. At an NAS Annual Meeting in 1988, Frank urged scientists to work more closely together to prioritize their research goals.

Frank walked the corridors of federal power with uncommon intellectual authority and considerable political acumen. There were tensions between the NAS and the Reagan Administration regarding the scientific basis for the Strategic Defense Initiative, but Frank successfully avoided the politicization of the NAS advisory process. In a commentary on Frank's first term as NAS President, Daniel S. Greenberg called him "one of the shrewdest and most effective operators in a city renowned for that breed." He was also a true gentleman with charm and an elegant manner that added to his authority as a scientist.

Frank articulated in passionate terms the conscience of science and its role in promoting the general welfare of nations. In 1984, he proposed that the United Nations organize an International Decade for Natural Disaster Reduction (IDNDR) to disseminate and apply new scientific knowledge to reduce the tragic losses of natural disasters. The IDNDR was launched in 1990 and involved over 140 participating countries.

After his NAS tenure ended, Frank accepted a 4-year fellowship at the Carnegie Institute of Washington. He was showered with honors, receiving the Kyoto Prize in 1993 and the National Medal of Science in 1994. He continued in his role as policy advisor, chairing a 1995 NRC panel that reported to the Senate Appropriations Committee on "Allocating Federal Funds for Science and Technology." The recommendations built on his long-standing advocacy for a more centralized advisory process to guide federal expenditures in science and technology.

In 1996, Frank cofounded the Washington Advisory Group (WAG), a global consulting company with clients that included 50 leading universities in the United States and abroad. As a chief WAG consultant, he played a notable role in all phases of the founding of King Abdullah University of Science and Technology (KAUST) in Saudi Arabia, and he chaired the KAUST international advisory committee until 2010.

In 2005, the Seismological Society of America initiated its Frank Press Public Service Award by selecting him as its first recipient. In presenting the award to him at the Seismological Society of America annual meeting, I stated, "Young scientists, if at times you feel there are no heroes any more, please reconsider: You have the example of Frank Press." This retrospective supports that view.

1 W. M. Ewing, W. S. Jardetzkey, F. Press, *Elastic Waves in Layered Media* (McGraw Hill, New York, 1957).

2 H. Benioff, F. Press, S. Smith, Excitation of the free oscillations of the Earth by earthquakes. *J. Geophys. Res.* **66**, 605–619 (1961).

3 Ad Hoc Panel on Earthquake Prediction, Earthquake Prediction: A Proposal for a Ten-Year Program of Research (Office of Science and Technology, Washington, DC, 1965).

4 F. Press, R. Siever, *Earth* (W. H. Freeman, San Francisco, 1974).

5 F. Press, R. Siever, *Understanding Earth* (W. H. Freeman, San Francisco, 1995).