Don L. Anderson (1933–2014)

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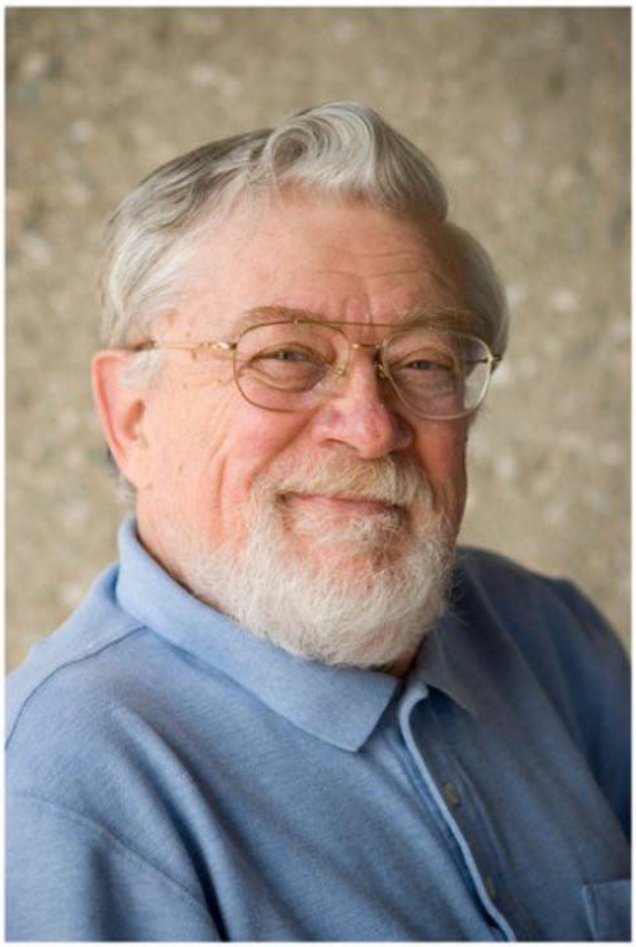

Don L. Anderson. Credit: Caltech

By Adam M. Dziewonski 6 hours ago

Don L. Anderson (http://srl.geoscienceworld.org/content/85/1/91.full), former president of the American Geophysical Union (AGU), passed away 2 December 2014. He was 81.

Don was a true renaissance man in the field of Earth and planetary science. In more than 350 papers published between 1958 and 2014, he sought to address problems in mineral physics, seismology, heat flow, geochemistry, tectonophysics, planetary sciences, and petrology. The emphasis of his research varied with time but remained very broad for over 50 years.

Early Life and Work

Don was born in Frederick, Md., on 5 March 1933. After finishing high school, he accepted admission to Rensselaer Polytechnic Institute, which he completed with high honors in 1955. After a year with Chevron Oil, he joined the Air Force Cambridge Laboratories, where his research focused on properties of sea ice.

This assignment involved fieldwork at Thule Air Base in northwest Greenland, 1500 kilometers from the North Pole. Don's first five papers focused on the strength and other properties of sea ice, specifically on how thick ice needs to be (http://www.gps.caltech.edu/content/don-l-anderson-0) to support aircraft that need to make emergency landings.

His 1962 Ph.D. thesis focused on anisotropy, and the phenomenon remained a lifelong topic of interest.
In 1958, he became a graduate student at the California Institute of Technology (Caltech), moving his family from Cambridge to Pasadena. The research on sea ice led Don to the more general problem of anisotropy (http://onlinelibrary.wiley.com/doi/10.1029/JZ066i009p02953/abstract)of solids—how the speed of seismic waves varies with the direction of seismic waves traveling through a medium; isotropy is a special case when the speed is the same in all directions. His 1962 Ph.D. thesis, conducted under the supervision of Frank Press, focused on anisotropy, and the phenomenon remained a lifelong topic of interest.

Work on Seismology and Planetary Science

Don became a faculty member at Caltech in 1963 and in 1967 was appointed the director of the Seismological Laboratory (http://www.seismolab.caltech.edu), a position that he held for the next 22 years. During that time, he established the Seismolab as the world's leading institution in global seismology. His seismological research focused on the Earth's structure and, in particular, its laterally heterogeneous properties. From measurements of surface wave dispersion, he inferred that the differences in shear wave speeds under continents and oceans may persist to depths as great as 400 kilometers. This was a revolutionary concept at the time; the accepted view was then that differences end at about 100 kilometers.

In the mid-1960s, he also conducted intensive experimental and theoretical research on anelasticity (attenuation) of seismic waves, another important parameter that is particularly sensitive to temperature. His early accomplishments earned him AGU's Macelwane Medal in 1966—at that time, only one such distinction was granted each year.

Don became involved in planetary sciences prior to the first flights to the Moon, and he presided over the seismic component of the Viking (http://nssdc.gsfc.nasa.gov/nmc/masterCatalog.do?sc=1975-075C)missions to Mars. Unfortunately, contrary to his recommendation, the seismometer on Viking 1 was placed near the top of the lander and recorded only wind-generated noise; the seismometer unit on Viking 2 malfunctioned. Don called the experience of several years on the Viking planning committee one of the worst in his professional life.

Views on Plate Tectonics

The highlights of his work in the 1970s were papers on the elastic and anelastic structure of the Earth. Also, Don became fascinated with the issue of the driving mechanism of plate tectonics. Although surface evidence left only a few opponents to the idea that plate tectonics reorganized continents and oceans on broad scales, the question of what makes the plates move was not satisfactorily answered.

Controversy persists regarding the spatial and temporal scale of mantle convection and how it may drive plate tectonics. For 40 years Don supported the view that the upper mantle (down to 650 kilometers depth) and the lower mantle (650 to 2900 kilometers—down to the top of the liquid core) do not mix. For much of this time, this view was opposed by geodynamicists who model mantle convection. Only recently has the view that the true answer may lie somewhere between these two alternatives become acceptable to a sizable fraction of the community.

Developing the Preliminary Reference Earth Model

In the early 1970s, the International Union of Geodesy and Geophysics decided that there was a need for a Reference Earth Model (REM), a description of seismic velocities and density as a function of radius from the Earth's center to the surface. At a committee meeting in 1977 Don and I agreed to join forces and collaborate on the design of a specific model that would satisfy a wide variety of data: travel times of body waves, periods of free oscillations, and attenuation of seismic waves.

Several controversial issues had to be resolved. Don was a coauthor of a 1976 paper that finally led to the recognition that attenuation of seismic waves must lead to frequency dependence of the elastic moduli. Another issue was that of anisotropy; attempts to fit the data with an isotropic model led to unrealistically high velocities at the top of the mantle. Introduction of radial anisotropy, characteristic of hexagonal symmetry with the vertically oriented symmetry axis, brought these down to a realistic range, with horizontally polarized waves having higher shear and compressional wave speeds than those vertically (or radially) polarized. The data did not demand anisotropy below 220 kilometers in depth.

The paper introducing the Preliminary Reference Earth Model now has about 7000 citations. The model we developed, named the Preliminary Reference Earth Model (PREM), differed from all others by including depth-dependent attenuation of shear and compressional energy, velocity dispersion, and radial anisotropy near the top of the mantle. We called it "preliminary" because we thought that it would be improved in a few years.

However, for various reasons, revisions did not happen, and the paper (http://www.sciencedirect.com/science/article/pii/0031920181900467) introducing the model now has about 7000 citations. PREM also became somewhat of a generic term; many papers use it without formally referencing it.

In the Vanguard of Seismic Tomography

Although PREM is one-dimensional, Don was fascinated with the three-dimensional (3-D) heterogeneities within Earth, particularly in his observations of differences as large as ±10% at the top of the mantle and ±2.5% near the core-mantle boundary. Three-dimensional wave speed models, with lateral variations reflecting changes in temperature and/or composition, could provide "in situ" information on patterns of mantle convection.

Don embraced 3-D "seismic tomography (http://www.iris.edu/hq/files/programs/education_and_outreach/aotm/7/SeismicTomography_Background.pdf)" with enthusiasm; in my opinion, he should be credited with popularizing this term, which is now commonly used. Many of Don's papers published in the past 30 years rely on inferences from tomographic models.

A Pioneer for Broadband Seismographic Networks

Don was an early proponent of creating a broadband, high dynamic range global seismographic network. His efforts and influence were essential in driving a community-wide initiative that led to the formation of the Incorporated Research Institutions for Seismology (IRIS).
The excitement caused by early 3-D tomographic models provided a fertile ground for the argument in favor of major improvement in seismic research infrastructure, on both global and regional scales. Don was an early proponent of creating a broadband, high dynamic range global seismographic network. His efforts and influence were essential in driving a community-wide initiative that within 1 year led to the formation of the Incorporated Research Institutions for Seismology (IRIS (http://www.iris.edu/hq/)), a consortium of, at present, more than 100 U.S. universities and nearly 100 foreign associate institutions.

As a member of the first IRIS executive committee, Don was influential in securing the required support from the National Science Foundation (NSF) and the U.S. Geological Survey. Now, 30 years after its founding, IRIS is one of the most successful undertakings of the NSF's Geosciences Directorate, just one example of how Don's knowledge, vision, wisdom, and prestige benefited research in the Earth sciences. This aspect of his work was specifically acknowledged when he was awarded the National Medal of Science in 1998.

Other Honors

In 1998, Don and I were selected by the Royal Swedish Academy of Sciences to share the Crafoord Prize. The citation reads in part, "with particular emphasis on the Dynamics of the Deep Earth, for your fundamental contributions to the knowledge of the structures and processes of the deep Earth interior."

Don received many other honors. Among them are the Emil Wiechert Medal of the German Geophysical Society (1986), the Day Medal of the Geological Society of America (1987), the Gold Medal of the Royal Astronomical Society (1988), and the Bowie Medal (1988). He was elected to the American Academy of Arts and Sciences (1972), the National Academy of Sciences (1982), the American Philosophical Society (1990), and many other honorific organizations and lectureships.

He contributed greatly to the activities of AGU, serving as president from 1988 to 1990. He chaired the Tectonophysics section (1972–1974) and was a member and chair of several AGU committees, mostly dealing with AGU Honors. He also served on many committees advising NASA, NSF, the U.S. Geological Survey, the National Academy of Sciences, and the National Research Council.

Persistent Dedication to Research and Scientific Debate

Don loved debating; with Gillian Foulger (Durham University, U. K.) he created more than a decade ago a website (http://www.mantleplumes.org/RoadMap.html) for deep and sometimes heated discussions on mantle plumes. The site contains contributions from hundreds of scientists and has been visited by thousands.

Don worked to the very end of his life, focusing mainly on the dynamics of plate motions. His last published papers propose a paradigm of the mechanics and chemistry explaining plate tectonics. He believed that most of the activity is contained in the top 250 kilometers of the mantle (the "perisphere") and opposed the common perception of the importance and depth of the origin of hot spots. Rather than being connected to plumes traveling from the core-mantle boundary, he thought that hot spots originate near the bottom of the lithosphere. He called this paradigm "Eureka" in honor of Archimedes and the importance of flotation.

A mentor and a provocative debating partner to many, Don would often end debates with a chuckle and a twinkle in his eyes.

Don is survived by Nancy, his wife of 58 years; his son, Lee; his daughter, Lynn; and four granddaughters. He, and his great scientific mind, will be missed.

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