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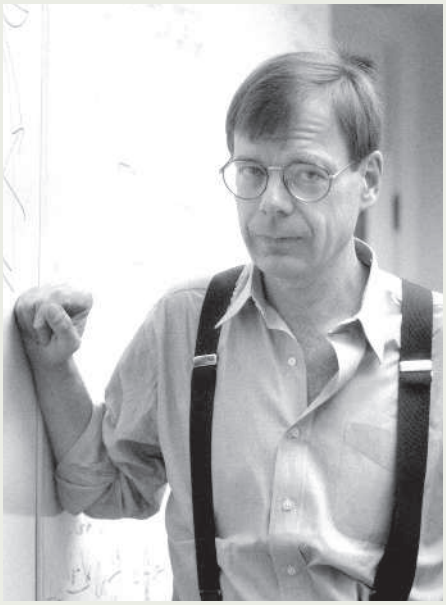
OBITUARY

F. Anthony Dahlen (1942–2007)

Pioneering and versatile theoretical geophysicist.



Tony Dahlen, probably the most important theoretical geophysicist of his generation, died on 3 June 2007, in Princeton, New Jersey. His seminal research on topics as far apart as seismology, Earth's rotation and the growth of mountains exerted a lasting influence on modern geophysics.

Dahlen was born in 1942 in American Falls, Idaho, while his father was serving in the US Navy in the Second World War, and moved with his reunited family to Winslow, Arizona, at the end of the war. There, in the shadow of the Barringer crater, he grew up searching for fossils and meteor fragments. Although it was a combined passion for geology, mathematics and physics, not American football, that earned him a Sloan Scholarship to the California Institute of Technology, he was nonetheless one of five members of the college football team who later became distinguished professors of geoscience.

His PhD research began in 1964, working with George Backus and Freeman Gilbert at the Scripps Institution of Oceanography of the University of California, San Diego. In the wake of the wartime boom in marine geophysical research, Scripps had become one of the principal US geoscience laboratories. It was a heady time, particularly for global seismology: two huge earthquakes, in Chile in 1960 and Alaska in 1964, had excited Earth's lowest 'eigenvibrations' — modes of oscillation in which the whole planet rings like a bell, with frequencies of a few cycles per hour. Two observed oscillations, with periods of 54 and 36 minutes, showed a splitting, akin to the Zeeman effect, in which an atom's energy levels split in a magnetic field. In this instance, it is the Coriolis force — an effect of Earth's rotation — together with Earth's slightly elliptical shape, that breaks symmetry and splits the spectral line into several closely separated oscillations.

Dahlen's thesis tracked the problem of the coupling of these modes. A fast worker, he could have graduated early in 1968, but decided to satisfy his broad interests by spending a further year sampling courses in other areas. In addition, in his first year at Scripps, he had caught the attention of a beautiful freshman one afternoon on the beach. She noticed he was reading a physics textbook, and asked if he would tutor her. Tony and Elisabeth Dahlen remained together until his death.

In 1970, Dahlen joined the faculty at Princeton University. His early work on eigenfrequencies provided a starting point for the idea that modes of oscillation split because of anomalous structures in Earth's interior, an idea that culminated in 1979 in a celebrated paper written with John Woodhouse. This work allowed seismologists to use eigenfrequencies for seismic 'tomography', to image small variations in Earth's elastic properties that are mostly caused by temperature variations. In the same period, Dahlen made important contributions to dislocation theory, which models the deformation due to earthquakes.This work led to a seminal paper on the energy balance of earthquakes.

Together with Martin Smith, Dahlen developed a linearized perturbation theory to describe the direction dependence of seismic-wave velocities in the interior of Earth. Today, this is the most practical means of visualizing the directions of the flow in Earth's mantle that is generated by convective processes. The two also determined the mantle's viscous response to stresses using the damping of a phenomenon known as the Chandler wobble, a 14-month precession of Earth's rotation. This followed on from earlier work in which Dahlen had developed a complete description of the effects of the oceans on variations in Earth's rotation.

In the 1980s, Dahlen moved on to work on the mechanics of the fold-and-thrust mountain belts and accretionary wedges that form at the margins of tectonic plates as they collide with each other. Collaborating with geologists Dan Davis and John Suppe, he showed how the formation of mountains in such regions can be explained in terms of a critical taper, mechanically analogous to the wedge of soil that forms in front of a bulldozer. Calculating the energy balance of such a system in western Taiwan, he showed that internal deformation contributes comparatively little energy to rock-transformation processes. Since then, submarine wedges such as those found off the Niger delta have been shown to act similarly. He also modelled the role of erosion of mountains and showed how this dominates the thermal evolution of mountain belts — a subject of much current interest.

The influential textbook *Theoretical Global Seismology* (1998), written with his former student Jeroen Tromp, marked the culmination of three decades of research by Dahlen and others into low-frequency seismic waves. By the time the book came out, however, Dahlen had shifted his attention to the higher-frequency 'body waves'. These seismic waves reveal more detailed information about features deep within Earth if sampled sufficiently densely, although the theory underlying their propagation had barely evolved since the early twentieth century.

Dahlen rejected the paradigm that seismic waves propagate as narrow rays, as they do in classical optics, and he formulated an efficient computational strategy to take into account the diffraction of seismic waves. The advance allowed seismic-wave travel times to be interpreted more exactly as tomographic images. A first application by Raffaella Montelli led in 2003 to the serendipitous imaging of convecting plumes in the lower mantle — the first visual confirmation of a 30-year-old hypothesis that such plumes are the origin of ocean islands such as Tahiti and Hawaii.

Dahlen was an erudite and courteous scientist, unassuming and generous towards students and colleagues alike. Seismology is evolving into a science driven by huge quantities of data, with projects such as the USArray, funded by the National Science Foundation, providing hundreds of sensors to permit the sampling of a whole wavefield, rather than arrival times of individual rays. The scale of these endeavours demands the kind of theoretical advances that Dahlen provided, and the influence of his work is likely to be felt for years to come.

Although he received many honours, it is certainly the continuing relevance of his discoveries, and those of his students, that would have pleased Tony Dahlen most. Throughout his life he was driven by his love for science; his greatest pleasure was that his son Alex also decided to pursue a career in science.

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