GEORGE A. THOMPSON

June 15, 1919–May 12, 2017
Elected to the NAS, 1992

A Biographical Memoir by Mary Lou Zoback

A DISTINGUISHED SCIENTIST, versatile leader, and a valued role model, George A. Thompson was the Otto N. Miller Professor of Earth Sciences and Dean of the School of Earth Sciences (Emeritus). For seventy years, he served Stanford University as student, instructor, professor, chair, and dean. After his retirement, as an emeritus professor, he remained a wise counsel to those who sought his advice. Like the redwoods he so much loved, George Thompson was truly a giant in the field of tectonophysics who profoundly enhanced our understanding of crustal evolution and lithospheric deformation. His studies were always grounded in field observations, through which he masterfully combined geologic understanding with the tools of physics and geophysics to illuminate a number of fundamental processes responsible for evolution of Earth's crust and lithosphere.

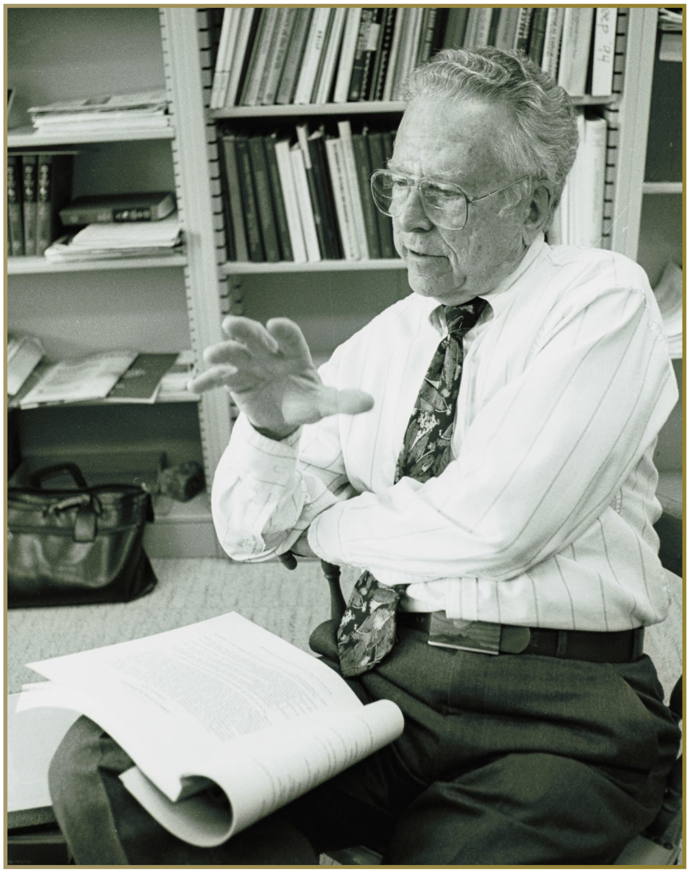

Figure 1 George A. Thompson. *Photo courtesy of Stanford University Oral History Project.*

EARLY LIFE

Born on June 5, 1919, and raised in Swissvale, Pennsylvania, a suburb of Pittsburgh, George claimed he was introduced to science by his older sisters and was drawn to geology through his love of the outdoors and an early trip across the American West. He earned a bachelor of science degree in geology in 1941 from Pennsylvania State University and a master of science degree in geology and physics in 1942 from the Massachusetts Institute of Technology. He then spent a formative period with the U.S. Geological Survey (USGS) seeking strategic minerals for the war effort during World War II. While prospecting for mercury in the mountains of West Texas, George met schoolteacher Anita Kimmel, whom he married in 1944. Anita was a war bride while George served two years as a lieutenant in the U.S. Navy, based in the Aleutian Islands.

In 1946, George entered Stanford as a doctoral student working on mercury deposits, following up his work with the USGS. While there, he agreed to teach Stanford's first course in geophysics. After completing his Ph.D. in geophysics in 1949, George was hired as an assistant professor and comprised half of the newly formed two-person Department of Geophysics.

Scientific Contributions

George's greatest scientific contribution was his ability to apply keen geologic insight to diverse geophysical datasets, beginning with gravity surveys in the Basin and Range Province in the 1950s, seismic-refraction studies in the 1960s, and seismic-reflection data in the 1970s. His publishing career spanned an extraordinary seventy years of first-authored papers, the last being at the age of ninety-seven, shortly before his death.

Thompson made groundbreaking contributions in four distinct, but related, areas of crustal evolution and lithospheric deformation:

Role of lithosphere buoyancy in surface elevation

In 1964, shortly before the plate-tectonics revolution, Thompson and Manik Talwani used seismic and gravity data to demonstrate a thin crust underlying the western United States and positing that low-density upper mantle was required to explain high elevations.[1] At that time, surface elevation was generally considered tied only to crustal thickness. With Ph.D. student Tom Crough a decade later, Thompson established the importance of lithospheric thickness in controlling continental elevation.[2] Noting that the Appalachians and the Sierra Nevada had similar crustal thickness, they used surface waves to show that a thinned mantle lid explains the uplift of Sierra Nevada.[3] Two years later, he and I concluded that a thickened mantle lid relative to the surrounding Basin and Range was needed to hold down the elevation of thick Colorado Plateau crust.[4]

Nature of the lower crust in extended terranes

Thompson demonstrated with gravity and seismic data that upper crust extension by normal faulting in the Basin and Range must be balanced by a mass influx into the lower crust. This fundamental constraint stimulated widespread research into the lower crust of extensional regions. In the 1980s and 1990s, Thompson and his students studied exposed sections of deep crust and upper mantle and analyzed seismic reflection profiles to probe the nature of the ubiquitous highly reflective lower crust observed beneath the Basin and Range and other extended regions. Synthetic seismic studies documented that the reflectivity in these regions can be modeled by numerous laminae tens of meters thick and hundreds of meters across, characterized by inter-layered high and low velocities.[5] With Ph.D. student Jill McCarthy, Thompson proposed that two geologic factors contribute to this layered character: ductile strain, responding to stress in the thermally weakened middle and lower crust, and intrusive layering, corresponding to injection of sub-horizontal sheets of mantle-derived magmas.[6] In a synthesis of seismic data and field observation, he and Ph.D. student Craig Jarchow showed that interlayered mafic and ultramafic rocks explained the laminated and discontinuous Moho reflectivity commonly observed on seismic-reflection profiles.[7]

Mechanics of upper crust deformation

Thompson pioneered quantification of orientation and rates of extension by measuring normal fault throw and subsurface configurations of faults. But scant geodetic data on extensional earthquakes in the Basin and Range indicated that the coseismic (i.e., the deformation occurring during the earthquake) vertical deformation consists almost entirely of subsidence of the hanging wall (basin block). Virtually no range uplift was observed coseismically, which seemed counter to the observed tilted and elevated ranges ubiquitous in the topography of the Basin and Range and other rift zones. Thompson combined his field structural observations, available geodetic data, and understanding of the geologic nature of the lower crust gleaned from seismic reflection studies (noted above) to construct a conceptual model to explain the observed topography. At age ninety-seven, Thompson, together with former Ph.D. student Tom Parsons, published a brilliant, landmark synthesis of his life work.[8] The paper quantitatively modeled the vertical deformation and tilting of range blocks in the Basin and Range as a result of many cycles of coseismic basin block subsidence and longer term post-seismic "rebound" of the fault block facilitated by ductile flow in the lower crust beneath the faulted block to restore isostatic balance, resulting in a bulging of the faulted block bulges upward.

Turning to crustal deformation in the oceans, Arthur Lachenbruch and Thompson demonstrated that the ubiquitous right-angle configuration of mid-oceanic ridges and transform faults is a minimum energy configuration.[9] They concluded that under reasonable assumptions, it is much more difficult for diverging plates to spread a kilometer of ridge than to slip a kilometer of transform fault. This weak-fault concept was later shown by others using heat flow, stress, and earthquake data to be applicable to major continental transform faults, such as the San Andreas fault.

Mantle Plumes as a Unifying Theory

Thompson illuminated the unifying role of mantle plumes in explaining continental extension/breakup, crustal creation/modification, and topography.[10] He posited that many of the events occurring just before and accompanying large-scale continental breakup can be explained by a large plume head interacting with the lithosphere. For example, the actively spreading Basin and Range region of the Western United States received an enormous pulse of energy ~16 million years ago, as indicated by the eruption of hundreds of thousands of cubic kilometers of Columbia River flood

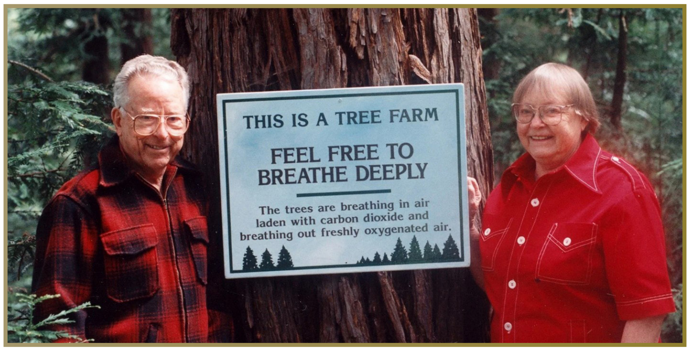

Figure 2 George Thompson and his wife, Anita, stand by a coastal redwood in the Santa Cruz Mountains in 1996. *Photo courtesy of Stanford University, permission and high- resolution version of photo requested via email message on Dec. 26, 2024.*

basalts, emplacement of massive dikes from Washington State to central Nevada, and the emergence of the Yellowstone Hotspot. These events are conceptually modeled as the breakout of a hot rising mantle plume spreading irregularly beneath the lithosphere for hundreds of kilometers and are consistent with gravity and seismic evidence.[11,12] Increasing evidence in the Nevada Basin and Range, based on thermochronology, demonstrates rapid pulses of mountain uplift and normal-fault extension in the same time interval, ~16 million years BP. Understanding the processes operating in the mid-Miocene in the western United States could provide deeper understanding of similar processes in other tectonic settings, such as the Dead Sea-Gulf of Aquaba, or perhaps the rifting and giant magmatic events of eastern North America in the Jurassic.[13]

Service and Awards

In 1967, George began a twenty-year term as chair of the Department of Geophysics (simultaneously chairing the Department of Geology for three of those years) that ended when he agreed to serve as dean of the School of Earth Sciences from 1987–89. Under his leadership, Stanford Geophysics became a world-class department. At age seventy, he accepted an emeritus title in order to give up the deanship and return to active research and mentoring.

Thompson was elected to the National Academy of Sciences in 1992 and was awarded the John Wesley Powell Award from the USGS in 1997 and the Penrose Medal in 2008, the highest honor of the Geological Society of America; he had served as president of that organization in 1997. Thompson served on the U.S. Nuclear Regulatory Commission Advisory Committees on Reactor Safeguards and on Nuclear Waste and on two National Research Council committees related to safe storage of radioactive waste. One group was the Committee on Coupled Processes at Yucca Mountain, the nation's then-proposed high-level radioactive waste repository. He later served as chair of the Committee to Review Scientific Issues of Ward Valley, a proposed low-level nuclear-waste disposal site.

Closing Thoughts

Beyond his lifetime contributions of seminal research in tectonics and crustal evolution, Thompson will always be remembered as a profoundly warm and welcoming colleague, professor, mentor and friend. His quiet, unassuming, and approachable manner immediately put people at ease. He looked for the best in everyone and always found it.

Gary Ernst, NAS member and former dean of Stanford's School of Earth Sciences, recalled George's humility: "When George retired, the university planted some trees and called it the Thompson Grove. George went out and took down the sign—he didn't want any fuss made over him." Another former dean and NAS member, Pamela Matson, recalled, "George did service to the whole school by working unselfishly across departments. He was a true role model who will live on in the students he mentored."

George had a gift for mentoring. I was very fortunate to be one of his graduate students. I recall going to his office for help once when I was really stuck on my dissertation research. Rather than telling me what to do, he guided me by asking questions to give me the opportunity to go back to my office and have the thrill of breaking through the problem on my own.

One of George's former graduate students and USGS senior scientist Tom Parsons recalled, "George trusted former graduate student John Howie and me with a significant amount of grant money to design, carry out, process, and interpret a deep crustal seismic reflection profile across the edge of the Colorado Plateau. Alone in the Arizona desert, we literally learned by doing. Looking back, I realized that while George cared deeply about the results, he cared even more that we learned every aspect of being independent scientists. Such a generous gift from such a generous man. As the years passed by, George would pop by my office at USGS with a twinkle in his eye, the sign that he had a new idea. Or I would find mysterious brown envelopes pushed under my door filled with hand-drawn sketches outlining fundamental problems for us to try to solve."

Generations of colleagues and friends recall wonderful times spent at the Thompsons' Redwood Tree Farm in the Santa Cruz Mountains south of Stanford. George and Anita pursued sustainable forestry long before it was fashionable. Characteristically, he applied his trademark intellectual passion and curiosity to researching the mighty redwoods, their evolution and ecological niche, and how to best help them thrive. George was most happy spending time outdoors;

either conducting fieldwork, clearing brush, or planting trees at his tree farm.

George's beloved wife, Anita, passed away in 2010, and he died at the age of ninety-seven at his home in Palo Alto, California, on May 12, 2017. He is survived by three sons and their partners, Bert and Sue, Dan and Denise, and David and Yvonne, and three adult grandchildren, Paul, Laura, and Ellen. He was a part of Stanford's School of Earth Sciences and the Geophysics Department for so many decades it is still hard to believe he is gone, but—in a sense, he remains, in all of the people and careers he inspired.

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