Memorial to Peter W. Birkeland (1934–2022)

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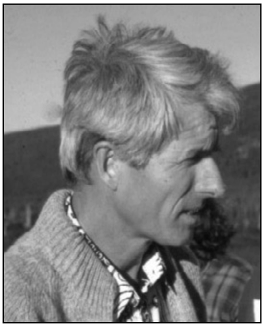

Peter W. Birkeland (1987).
Photo by Vance T. Holliday.

Peter Wessel Birkeland died of natural causes in Boulder, Colorado, on 25 January 2022, a snowy day befitting a lifelong skier. He is survived by his wife Suzanne, children Robin and Karl, and his three grandchildren. Pete was born in Seattle, Washington, on 19 September 1934, and grew up in the greater Seattle area. He served in the U.S. Army from 1953 to 1955, ending his service as a ski trooper in the Mountain and Cold Weather Training Command at Camp Hale in Colorado. In 1958, he graduated from the University of Washington in geology, and in 1961, he completed a Ph.D. in geology from Stanford University, studying under Art Howard and J. Hoover Mackin. Pete's professional career began in 1962 as an instructor and assistant professor in the Department of Soils and Plant Nutrition at the University of California, Berkeley. In 1967, he took a position in the Department of Geological Sciences at the University of Colorado–Boulder, where he taught and conducted research in soils and Quaternary geology until his retirement in 1997.

Pete was a prolific researcher for more than four decades. His work was geographically broad and generated a steady stream of publications, commonly with his students. His main area of research was soil geomorphology—the application of pedology to address landform and landscape evolution. This work had tremendous importance to Quaternary stratigraphic, neotectonic, and paleoclimatic problems.

Pete was first exposed to the significance of soils in Quaternary geology during his Ph.D. research on the glacial geology of the Truckee area, north of Lake Tahoe, California. During that work Dwight "Rocky" Crandell (U.S. Geological Survey) opened Pete's eyes to the use of soils in dating surficial deposits. As a result of his application of soils in geology, Pete was hired in the Soils Program at Berkeley to teach geomorphology to the soils students. There, under the guidance and support of Hans Jenny and Rod Arkley, he began to focus his work on combining soils and geomorphology.

Pete's work in soil geomorphology and soil stratigraphy evolved over the ensuing four decades. His early work used soils to develop a relative age framework for glacial deposits in the Sierra Nevada, and that framework challenged some of the established concepts of glacial stratigraphy. He extended this work into the Great Basin and was a pioneer in the use of soils to correlate events between mountain ranges and adjacent basins. He was also one of the first to use soil clay mineralogy to interpret paleoclimate in this climatically sensitive region. After moving to Colorado, Pete used a similar approach to understanding the glacial stratigraphy of the Rocky Mountains. Here too, much of his detailed work challenged the few existing stratigraphic frameworks then available, and he provided the first firm basis for correlation of glacial and other surficial deposits between mountain ranges. His students in those early years were an energetic bunch who spread out from Boulder all over the West to view landscapes with new eyes. Their perspective was based firmly in traditional field work in stratigraphy and geomorphology but had the added dimension of the importance of that magical rind on the surface of every landform that could tell them so much about landscape evolution.

A key innovation in Pete's research on soil geomorphology came directly from Hans Jenny, the eminent pedologist who framed the well-known "equation" for soil formation as a function of five factors: climate, organisms, relief, parent material, and time, famously expressed as "S = f(cl, o, r, p, t)." Pete recast the "clorpt" approach to establish a research paradigm for using soils to help reconstruct the past. A significant advantage of Pete's approach was the availability of a wide variety of analytical methods, especially numerical dating techniques, to establish truly quantitative soil-forming functions. The "clorpt equation" combined with Pete's quantitative approach provides a powerful tool for addressing research questions regarding soil-landscape relationships.

The result of Pete's approach was publication of the first edition of *Pedology, Weathering, and Geomorphological Research* in 1974. At the time, there were only a handful of Earth scientists who used or even bothered to notice soils within Quaternary deposits, on landforms, and at archaeological sites. Soil science at that time was largely within the domain of agronomists. Pedology—the study of soils in their natural field settings—was typically an underfunded, understaffed subdepartment of most agronomy departments, and most pedology courses at agricultural schools emphasized the importance of pedology in soil surveys and as a necessary part of crop science. With the publication of *Pedology, Weathering, and Geomorphological Research*, Pete brought new excitement to the use of soils in understanding stratigraphy, stratigraphic breaks, ages of landforms, paleoclimate and overall landscape evolution.

In the 1980s and 1990s, Pete's work evolved into a global view of soil genesis and landscape evolution. His own studies and those of his students took him to Arctic Canada, Peru, New Zealand, China, Israel, and various South Pacific islands. His work on soil genesis became multidimensional, with new studies showing how soils evolve not only over time, but on different positions on a landform over time and in wildly diverse climates, from polar to tropical. By this time, many geomorphologists and Quaternary stratigraphers had been inspired by Pete's holistic view of pedology and began applying his approach in their own studies of soils and landscape evolution. Studies of soil genesis and the use of soils in paleoclimatology, geomorphology, Quaternary stratigraphy, and paleoseismology exploded in the past two decades, and Pete is largely responsible for this rich period in the history of pedology.

In 1984, Pete synthesized many of the results that derived from the very researchers who were so motivated by his first book. This masterful revision entitled *Soils and Geomorphology* included expanded sections on the effect of climate change on soil development, the effect of topography on soil development, and the application of soils to the burgeoning field of tectonic geomorphology. Inclusion of the neotectonic aspect of soil research fueled a host of new studies—especially in the western United States, but also around the world—aimed at estimating the repeat time of large-magnitude seismogenic faults. One testament to the significance of this book is that in 1988, it earned Pete the Kirk Bryan Award, which is given by the Quaternary Geology and Geomorphology Division of the Geological Society of America to the author of the "most significant publication in the preceding four years."

In 1999, the third edition of *Soils and Geomorphology* was a capstone to Pete's impressive career. Expanded to be even more comprehensive and holistic than its predecessors, this edition provides the reader with a detailed overview of the myriad applications of soils to geomorphology and Quaternary science—all in a down-to-earth writing style that both invites new workers into the field and exudes the excitement of one of the most significant developments in geomorphology in the twentieth century.

The three editions of his ground-breaking books are undoubtedly Pete's most lasting accomplishment in the Earth sciences, but he amassed dozens of publications in many of the most highly regarded journals such as *Quaternary Research*, *Geological Society of America Bulletin*, *Geology*, *Catena*, *Geoderma*, and *Geomorphology*. He also authored and co-authored book chapters and monographs. *Soils as a Tool for Applied Quaternary Geology*, co-authored with former students Michael Machette and Kathleen Haller for the Utah Geological and Mineralogical Survey (1991) is a well-worn handbook in many a library. Pete and colleague Edwin Larson also authored three editions of a successful introductory geology textbook, *Putnam's Geology.* These books are a testament to Pete's interest in fostering the next generation of Earth scientists.

Pete's remarkable accomplishments in research resulted in Distinguished Career Awards from both the Quaternary Geology and Geomorphology Division of the Geological Society of America (2000) and the American Quaternary Association (2009).

Few faculty members of any generation have had as profound an effect on their students as has Pete. He held high standards not only for academic performance and scientific rigor, but also for one's behavior in the community of Quaternary scientists. He was capable of simultaneously providing encouragement to those who lacked confidence and moderating those whose confidence was brimming over. He demanded that his students learn to write clearly and efficiently, and his detailed editing of theses and manuscripts is famous in the field. Pete was committed to undergraduate education to an extent that is rare for a professor at a large research university such as the University of Colorado. He taught introductory geology to thousands of University of Colorado undergraduates over the years. Pete took special interest and pride in the development of his graduate students—as budding scientists and as people.

Pete taught by example how to balance family and profession, research and teaching, and seriousness and fun. His wife Sue, and their kids Robin and Karl, went on many of his field trips and they all pitched in to make each trip a family adventure as well as a scientific success. Pete's zany antics and humor on field trips are legendary and seemed to tell us all not to take ourselves too seriously. Most of his graduate students went on to leadership positions in Quaternary science, either in academia, in government agencies, or in industry. Pete kept in touch with all of us who were his students until the very end. It is with pride that we tell others we were Birkeland students, and many feel, as we do, that we are standing on the shoulders of a giant. We are all better professionals and better people as a result.

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