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Memorial of Ray E. Wilcox, 1912–2012

Daniel E. Kile*

U.S. Geological Survey, MS 413, Denver Federal Center, Denver, Colorado 80225, U.S.A.

Ray Everett Wilcox, born on March 31, 1912, in Janesville, Wisconsin, passed away peacefully in Lakewood, Colorado, at age 99 on March 12, 2012, only a few weeks away from his 100th birthday. He was a distinguished Research Geologist at the U.S. Geological Survey (USGS) in Denver for nearly 40 years. His record of publications spanned 64 years, from 1935–1999, with more than 86 reports and articles.

Few scientists establish prominence in a single field, but Ray was exceptional in that he made groundbreaking contributions to two distinctly different disciplines, volcanology–igneous petrology and optical mineralogy. Ray used his extensive knowledge in mineral optics to identify sources of volcanic ash beds and utilize the beds as stratigraphic markers; this work helped solve problems not only in geology, but also in the fields of archeology, botany, and forestry.

Ray attended the University of Wisconsin, Madison (where he was a member of Sigma Xi), receiving degrees in geology for his Ph.B. in 1933; his Ph.M. in 1936 (with a thesis on "The solubility of certain silicate materials in body fluids as a factor in silicosis"), and his Ph.D. in 1941 (with a dissertation on "Contact relations between rhyolite and basalt on Gardiner River, Yellowstone Park, Wyoming"). His graduate experience exposed him to some of the outstanding scientists of that era. He held a Geology Fellowship from 1934–1936 with R.C. Emmons (an icon in optical mineralogy and universal stage work) where he worked on developing a rotation apparatus for a modified universal stage and coauthored a paper on mineralogy on silicosis in 1937 (Emmons and Wilcox 1937). Following his tenure with Emmons, he became a teaching assistant for A.N. Winchell from 1936–1939. Ray's tutelage under Emmons and Winchell gave him a solid foundation of the principles and utility of optical mineralogy, which served him well throughout his career. He married Mary Marks in 1942, who was then a geology major (and in a mapping class Ray was teaching) in the University of Wisconsin-Madison Geology Department.

During World War II, with the military draft looming, Ray enlisted in the U.S. Army; he chose the Signal Corps as he knew they were interested in developing quartz mineral resources for radio oscillator crystals, and thought he might be called on to utilize his geological expertise. This did not transpire, but his assignment was nonetheless fortuitous, as he served as a lieutenant from 1944–1946 as a Radio Officer in the Aleutian Islands; his duty in the Aleutians provided an opportunity for him to study firsthand the volcanoes of those islands. Geologic interest in the area increased in June 1945, with the eruption within Okmok Caldera on eastern Umnak Island; serendipitously, Ray had been transferred to the nearby Ft. Glenn airbase just 10 days prior to the eruption (Fournelle and Robinson 1999). He was able to team up with G.D. Robinson, a young Survey geologist dispatched from Anchorage to evaluate the potential danger to the airbase, which was being readied for a possible invasion of Japan.

Ray Wilcox in 2007, shown with his spindle stage prototype and the improved commercial version. Photo by Mary Wilcox.

His introduction to U.S. Geological Survey personnel in the Aleutians led him to accept employment in 1946 with the Survey, for which he did fieldwork in Mexico, the Aleutian Islands, Central America, Hawaii, and the western United States. As his first assignment with the Geological Survey, Ray was the first Survey scientist to conduct long-term observations of Parícutin Volcano in Mexico (which erupted in an open corn field in February 1943), where he spent two years as the "resident observer", with his wife and young son near the remote village of Angahuan. Conditions were primitive by modern standards, e.g., there was no running water or electricity, and a gasoline camp stove was employed for daily cooking. Here, he was responsible for monitoring seismic and explosive activity, and sampling

*E-mail: dkile4@comcast.net

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tephra and lava (Fournelle 1998). An example of Ray's patience and generosity is evidenced when he noticed that a local helper who assisted in daily recordation of volcanic events, Celedonio Gutiérrez, was having difficulty with time management; Ray realized that Celadonio, like many locals, had never been taught to read time, whereupon Ray bought him a watch and showed him how to use it. A level of adaptability was required on the job; when surveying posts were absconded by the local villagers, Ray determined that if a cross-beam was set (to assume the form of a cross), the highly religious residents would leave them in place—a strategy that proved effective. A series of publications on the growth and evolution of the erupting volcano ensued, culminating in a significant report published in U.S. Geological Survey Bulletin 965-C that constituted a classic study of the variation in magma during an eruption cycle (Wilcox 1954); this work significantly advanced scientific understanding of volcanic processes. Ray's services were subsequently requested by the government of Nicaragua to study the eruption of Cerro Negro in July of 1947 and also the effects of fumes from the Santiago Volcano (Wilcox 1952).

Ray returned to the Aleutians in 1949 and 1950 as a member of the Survey's Volcano Investigations Unit, and again in 1953 with the eruption of the Mount Spurr Volcano (Fournelle 1998), which culminated in a paper describing the effects of volcanic ash in Alaska (Wilcox 1953, 1959a). A volcano on Seguam Island now bears his name.

Extending his Ph.D. research on the mixing of rhyolite and basalt magmas in Yellowstone culminated in major contributions to the understanding of magma mixing in volcanic eruptions. Recognition of his work in magma mixing is evident in a citation given when Ray received a U.S. Geological Survey Meritorious Service Award in 1983: "Early in his career he proposed a concept of magma mixing that was so much ahead of its time that it was not confirmed until nearly 30 years later." In addition, Ray recognized early on that multiple beds comprise the Pearlette ash, a widespread marker deposit in the western U.S. (Izett and Wilcox 1982) that became known to be the product of three different eruptions at Yellowstone National Park. Another significant contribution was given in an invited chapter published in *The Evolution of the Igneous Rocks* (Wilcox 1979) that summarized developments in igneous petrology; Ray's article modified and widened Bowen's approach to the use of variation diagrams in the investigation of igneous rock chemistry.

Ray was unqualifiedly an expert in mineral optics. He applied his considerable knowledge in this discipline to his fieldwork, utilizing the optical properties of minerals to characterize the mineralogy of volcanic ashes to distinguish individual ash beds, which could then be applied to identification of the source-area volcano. For example, with Howard Powers (whom Ray had first met as field party chief on the Aleutian project), Ray identified the source of a widespread Holocene blanket of volcanic ash in northwestern states as originating from Mount Mazama at Crater Lake (Powers and Wilcox 1964), rather than from Glacier Peak, thereby providing a marker for the end of the first third of the Holocene. Also with Powers in 1964, Ray identified cummingtonite as a primary phenocryst in fresh volcanic pumice. Although cummingtonite was widely regarded as an index mineral of metamorphic rocks, it had been previously unknown in fresh volcanic rocks in the western world. In the Pacific Northwest, he had also identified cummingtonite in the Mount St. Helens deposits (Wilcox 1965), which facilitated recognition of multiple eruptions of Mount St. Helens prior to 1980; ash containing cummingtonite became a distinctive constituent marking the end of the middle third of the Holocene for geologists and many other researchers.

Accordingly, his studies of volcanic processes necessitated using the optical properties of minerals to help characterize volcanic ashes and to use mineral assemblages to distinguish individual beds. These studies led to groundbreaking contributions to the field of optical mineralogy and resulted in international recognition for his development of optical methods, especially spindle stage methods. Although spindle stages had been casually used since the late 1800s, Ray's introduction in 1959 of a novel and inexpensive design of spindle stage (Wilcox 1959b), and an efficient protocol for its use in studying single mineral grains, proved to have a far-reaching impact, rejuvenating the method of spindle stage work throughout the geological and mineralogical communities.

Perhaps the most telling tribute to Ray's contributions to optical mineralogy was related by Don Bloss, also a 20th century icon of optical mineralogy:

> "After my 1961 book, *Introduction to the Methods of Optical Crystallography*, was published, Ray was an enthusiastic endorser. Subsequently, Ray tried to interest me in his 'spindle stage'. Unsuccessfully. I couldn't see how his single-axis stage could be superior to my 4-axis universal stage. In 1970 I invited Ray to come to Blacksburg and, in preparation for his visit, my assistant Judson Mitchell and I studied up on spindle stage literature. Suddenly, the scales dropped off my eyes. Here was a device, that at a cost of practically nothing, could run rings around my $900 U-stage for studying single crystals. This led to my developing (1) the detent spindle stage; (2) EXCALIBR, a computer program for mathematical analysis of its data; and (3) a book, *The Spindle Stage: Principles and Practice*. I owe it all to Ray."
>
> F. Donald Bloss

Author's note: By the mid-1990s the cost of a universal stage had exceeded $10,000!

Ray was also among the first to venture into the realm of dispersion staining methods (e.g., Wilcox 1983), now commonly employed worldwide in the study of the asbestos minerals. This technique, extending works in Russian literature, greatly simplified and expedited the rapid determination of the principal refractive indices of mineral grains by immersion methods. He also developed a suite of high-dispersion immersion liquids for use in dispersion staining, which were widely adapted.

Ray's contributions to optical mineralogy did not end with the aforementioned works; his persistence and tenacity in his work, evidenced by the many weekends and evenings spent at the office, culminated in other important projects. He contributed significantly to Bulletin 1627, published by the U.S. Geological Survey (Fleischer et al. 1984); this exhaustive work constituted an important and long-standing reference of mineral optical

data. In 1969 he was one of two mineralogists in the Geological Survey chosen for the Lunar Sample Preliminary Examination Team to analyze lunar samples from the Apollo 11 and Apollo 12 missions; this preliminary work was done prior to a wider distribution of the samples to other scientists worldwide. These studies culminated in two publications in the prestigious journal *Science* (1969 and 1970).

He was generous with his time, and committed to passing along his skills to other Geological Survey employees, as well as industrial scientists, university professors, and students. To this end, he taught numerous short courses at the Survey on spindle stage use, focal masking techniques, and methods for optical identification of the feldspar-group minerals, preparing detailed in-house publications that served students well for many years.

Ray received many well-deserved honors and awards throughout his professional career, including the University of Wisconsin Distinguished Alumni Award in 2001 (for "distinguished contributions in mineralogy, petrology, and volcanology, for service to the scientific community, and for international cooperation in science"), the U.S. Geological Survey Department of Interior Meritorious Service Award in 1983 (for "distinguished contributions in mineralogy, petrology, and volcanology"), the U.S. Geological Survey Scroll of Honor (40 years of public service), and the Geological Society of America 50-Year Fellow Award. He was also a Life Fellow of the Mineralogical Society of America.

Although Ray retired from the U.S. Geological Survey in 1985, he continued in an active role as Scientist Emeritus as a mentor and scientist for the formation of the U.S. Geological Survey Volcanic Hazards Program. Despite his deteriorating eyesight, he continued writing about volcanic processes long after retirement (e.g., Wilcox 1999).

Mary, his wife of 69 years, four children, nine grandchildren, and ten great-grandchildren, survive him. Ray, always soft-spoken, was a capable, considerate, thoughtful scientist, and more importantly, a true gentleman. His productive career as an igneous petrologist and optical mineralogist set high standards for those who followed; it was a true privilege to have known him.

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Selected References

Emmons, R.C., and Wilcox, R.E. (1937) A mineralogic study of silicosis. American Mineralogist, 22, 256–267.

Fleischer, M., Wilcox, R. E., and Matzko, J. (1984) Microscopic Determination of the Non-Opaque Minerals. U.S. Geological Survey Professional Paper 1627, 453 p.

Fournelle, J. (1998) Badgers in the Aleutians. Alumni Newsletter, Department of Geology and Geophysics, University of Wisconsin-Madison, 7–9.

Fournelle, J., and G.D. Robinson (1999) 1999–1949: 50th anniversary of M.S. Eider's first season studying Aleutian volcanoes and geology, EOS (Transactions, American Geophysical Union), 80, F1088.

Izett, G.A., and Wilcox, R.E. (1982) Map showing localities and inferred distribution of the Huckleberry Ridge, Mesa Falls, and Lava Creek volcanic ash beds (Pearlette family ash beds) of Pliocene and Pleistocene age in the western United States. U.S. Geological Survey Miscellaneous Investigations Field Studies Map I-1325.

Lunar Sample Preliminary Examination Team [Wilcox, R.E.] (1969) Preliminary examination of lunar samples from Apollo 11. Science, 165, 1211–1277.

Lunar Sample Preliminary Examination Team [Wilcox, R.E.] (1970) Preliminary examination of lunar samples from Apollo 12. Science, 167, 1325–1339.

Mullineaux, D.R., and Wilcox, R.E. (1980) Stratigraphic subdivision of holocene airfall tephra from the climactic series of eruptions of Mt. Mazama, Oregon. EOS (Transactions, American Geophysical Union), 61, 67.

Powers, H.A., and Wilcox, R.E. (1964) Volcanic ash from Mount Mazama (Crater Lake) and from Glacier Peak. Science, 144, 1334–1336.

Wilcox, R.E. (1935) Insoluble residues of the Mendota formation. Wisconsin Academy of Sciences Transactions, 29, 268–271.

Wilcox, R.E. (1936) Occurrence of large zircon needles in a basic pegmatite. American Mineralogist, 21, 459.

Wilcox, R.E. (1944) Rhyolite-basalt complex on Gardiner River, Yellowstone Park, Wyoming. Geological Society of America Bulletin, 55, 1047–1079.

Wilcox, R.E. (1947) Activity of Parícutin Volcano from September 18 to November 30, 1946. American Geophysical Union Transactions, 28, 567–572.

Wilcox, R.E. (1952) The problem of damage by fumes of Santiago Volcano, Nicaragua. Report submitted to the Government of Nicaragua, 38 p.

Wilcox, R.E. (1953) Preliminary report of the eruption of Mount Spurr Volcano, Alaska, and the ashfall in the Anchorage area. Report submitted to the Alaskan Command Headquarters, Elmendorf AFT, 22 p.

Wilcox, R.E. (1954) Petrology of Parícutin Volcano, Mexico. U.S. Geological Survey Bulletin 965-C, 281–354.

Wilcox, R.E. (1959a) Some effects of recent volcanic ash falls, with special reference to Alaska. U.S. Geological Survey Bulletin 1028-N, 409–476.

Wilcox, R.E. (1959b) Use of the spindle stage for determination of principal indices of refraction of crystal fragments. American Mineralogist, 44, 1272–1293.

Wilcox, R.E. (1959c) Universal stage accessory for direct determination of the three principal indices of refraction. American Mineralogist, 44, 106–107.

Wilcox, R.E. (1961) Igneous rocks of the Near Islands, Alaska. International Geological Congress Proceedings, Mexico, 1956, 365–378.

Wilcox, R.E. (1962) Cherkasov's "focal sceening" for determination of refractive index by the immersion method. International Microscopy Symposium Proceedings, Chicago, 1960, 160–165.

Wilcox, R.E. (1964) Immersion liquids of relatively strong dispersion in the low refractive index range (1.46-1.52). American Mineralogist, 49, 683–688.

Wilcox, R.E. (1965) Volcanic-ash chronology. In H.E. Wright and D.B. Frey, Eds., The Quaternary of the United States, 7th Congress of the International Association for Quaternary Research, Princeton Press, 807–816.

Wilcox, R.E. (1979) The liquid line of descent and variation diagrams. In H.A. Yoder, Ed., Evolution of the Igneous Rocks (Fiftieth Anniversary Perspectives), p. 205–232. Princeton University Press.

Wilcox, R.E. (1984) Optical properties of micas. In S.W. Bailey, Ed., Reviews in Mineralogy, 13, Mineralogical Society of America, 183–200.

Wilcox, R.E. (1991) Mount Spurr. In Alaska's Volcanoes, Alaska Geographic, Alaska Geographic Society, 18, 39–41.

Wilcox, R.E. (1999) The idea of magma mixing: History of a struggle for acceptance. The Journal of Geology, 107, 421–432.

Wilcox, R.E., and Gutiérrez, C. (1948) Activity of Parícutin Volcano from April 1 to July 31, 1948. American Geophysical Union Transactions, 29, 877–881.

Wilcox, R.E., and Izett, G.A. (1966) Optic angle determined conoscopically on the spindle stage: Part 1. Micrometer ocular method. American Mineralogist, 53, 269–277.

Wilcox, R.E., and Naeser, C.W. (1992) The Pearlette family ash beds in the Great Plains: Finding their identities and their roots in the Yellowstone country. Quaternary International, 13/14, 9–13.