

## Presentation of the 2016 Roebling Medal of the Mineralogical Society of America to Robert M. Hazen

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Madame President, MSA members, and guests. It is an honor to present Robert Miller Hazen, the recipient of the 2016 Roebling Medal. If there is anything to the concept of “emergent phenomena,” it is Bob Hazen and the evolution of his remarkable career—a career that has not only influenced the mineral sciences in diverse ways but has broadened the scope, relevance, and impact of mineralogy in many fields and communities beyond.

Bob’s earliest mineralogical publications included his highly cited first paper based on his MIT masters thesis on trioctahedral micas performed under the direction of David Wones. In his Ph.D. thesis research carried out with Charles Burnham, he applied high-pressure X-ray techniques to olivine, work that led to his highly cited paper in *American Mineralogist*. As a postdoc in Cambridge working with Charlie Prewitt, he developed empirical relationships for the thermal expansion and compressibility of structural elements in oxides and silicates that were foundational to the emerging field of mineral physics.

Bob subsequently joined the Geophysical Laboratory, initially measuring optical properties of lunar minerals with Peter Bell and Ho-Kwang Mao but soon partnering with Larry Finger in X-ray crystallography. Together, he and Larry created an astounding body of work that led to a thousand or so crystal structures determined at variable *P-T* conditions, including many mantle phases. They literally wrote the book on *Comparative Crystal Chemistry*, which was published in 1982, the same year that Bob won the MSA Award. At the same time, Bob was developing new X-ray and other crystallographic techniques. The huge influence of these efforts as summarized in *High-Temperature and High-Pressure Crystal Chemistry*, volume 41 of *Reviews in Mineralogy and Geochemistry*, a volume that he co-edited with Bob Downs.

Beyond Earth science, Bob has greatly influenced condensed matter physics, for example by showing physicists that the cuprate superconductors are nothing but mantle-like minerals with peculiar compositions and defects that cause electrons to pair and superconduct at then-astonishingly high temperatures. The remarkable series of papers he wrote during this time rank among his most highly cited publications, an example of how a deep understanding of complex natural materials can be used to elucidate the nature of potentially revolutionary technological materials. If this was not enough, Bob at the same time expanded his research to non-traditional minerals of planetary science, helping to determine the first high-pressure structures of solid hydrogen and other planetary gases and ices.

In 1996, Bob turned his attention to the biosphere, specifically with a fresh exploration of connections between mineralogy and life’s origins and evolution. His pioneering studies of mineral catalyzed prebiotic organic reactions, initially with Hatten Yoder,

led to the discovery that transition elements can mediate different distinct reactions. Separate investigations of the origins of biochemical homochirality were begun, work that has impacted the manufacture of pharmaceuticals. With a deep knowledge of paleontology, he initiated the use of new mineralogical techniques in the study of organic molecular and isotopic signatures preserved in ancient sediments. Much of the knowledge gained is summarized in his book *Genesis: The Scientific Quest for Life’s Origins* as well as many other publications.

In 2007, Bob launched an ambitious study of the changing diversity and distribution of minerals of Earth and other terrestrial planets and moons through time—a field that he called “mineral evolution.” A report in *Science* called this “the first paradigm shift in mineralogy in 200 years.” His 2012 book, *The Story of Earth*, expands on all of these themes—including its evolution to what is now called mineral ecology. Just as he began to develop these fields, Bob’s mind turned to the nature of carbon and launched the Deep Carbon Observatory, a major 10-year research program sponsored by the Sloan Foundation to understand all aspects of carbon in the planet. He edited *Carbon in Earth*, volume 75 of *Reviews in Mineralogy and Geochemistry*, and he contributed to five chapters—altogether chapters of this book so far have been downloaded 700,000 times.

Bob’s well-known broader outreach in the name of mineralogy was highlighted when he received the MSA Distinguished Public Service Medal in 2009. That effort has continued unabated through the DCO, his teaching at George Mason University, tireless numbers of lectures, appearances in the media, and his continued dedication to science literacy. Also here I must mention Bob’s passionate support of early career scientists, something I witnessed many years ago firsthand as his postdoc. Beyond these accomplishments, Bob is also distinguished at the highest levels in music, history, the some 20 books he has written, all the while being dedicated to his family and his remarkable wife Margee.

This leads me to Bob’s newest endeavor and current passion—bringing data analytics to mineralogy—that is, the use of statistical, network, and other mathematical methods for treating very large data sets of mineral and rock properties. This work has the potential to uncover altogether new findings about the origin and evolution of the planet and of life—with implications well beyond Earth. The new initiative ties together much of what he has done so far in his storied career—yet another of example of continued “emergent phenomena” in a career that gives new meaning to the concept of “intelligent design.”

It is this society’s great fortune to recognize Robert M. Hazen—mineralogist extraordinaire, ambassador for the field, spokesperson for science, and one of my mentors—with MSA’s highest honor, the Roebling Medal.