American Mineralogist, Volume 105, pages 776–777, 2020

Presentation of the 2019 Roebling Medal of the Mineralogical Society of America to Peter R. Buseck

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Fellow Mineralogists, Ladies, and Gentlemen:

This Sunday, we had a great session with the title "Visions of minerals at the nanoscale, in honor of this year's Roebling Medalist Peter R. Buseck." The title alluded to the fact that Peter accomplished his highly successful career by using mostly electron microscopy. But the word "vision" was meant to suggest more. Great scientists have vision—i.e., knowing which problems are important for science and society, which topics are worth choosing—and Peter is one of those with a vision and a mission.

Peter has been active for more than 50 years in mineralogy, and his contributions to our science are tremendous. His group produced groundbreaking results in fields as diverse as solid-state geochemistry, cosmochemistry, and atmospheric science.

But how did it all start? I am borrowing a few lines from David Veblen's abstract for his talk at Sunday's symposium honoring Peter: "Fifty years ago, crystallographic mineralogy was focused on the precise refinement of ideal, average crystal structures. The R-factor was king. Defects in crystalline solids were seldom considered. Then along came young Peter Buseck. The first experiments he proposed, probing the effects of oxygen fugacity on diffusion kinetics in olivine, were met with skepticism. Yet he persisted. Peter's experiments with Dan Buening were the first to show that another extensive variable, along with *P* and *T*, and through its influence on point defects, controlled diffusion rates in the mantle's most abundant mineral." Additionally, these were the first detailed Mg-Fe interdiffusion measurements for olivine and perhaps for any rock-forming silicate mineral.

Peter's interest in defects in crystals naturally led him to use transmission electron microscopy. He was invited to explore the technique during a sabbatical leave at Oxford University. Soon after his sabbatical year, the Center for High Resolution Electron Microscopy at ASU was initiated, and Peter had a chance to develop and use TEM techniques firsthand for studying mineral structures. In the 1970s, for the first time, the microstructures of pyroxenes, polysomatic defects in amphiboles, point defects in pyrrhotite, dislocations in garnet, and the tunnel structures of manganese oxides were directly observed and interpreted by Peter and people in his research group. Prominent names of this era include Sumio Iijima, David Veblen, Jeff Post, and Michael O'Keefe, among others. The results immediately entered standard mineralogy and geology textbooks and remain to this day as examples of nanoscale features and processes in minerals.

Meteorites are another long-time scientific interest of Peter's. Because of their fine-grained character and limited sample availability, primitive meteorites lend themselves ideally to TEM studies. Peter and his coauthors—Kazu Tomeoka, Lindsay Keller, Hua Xin, Laurence Garvie, and many more—published papers in *Nature* and *Science* on a regular basis on the microstructures of silicates and carbon species in carbonaceous chondrites, contributing to the birth and rapid expansion of a new field in cosmochemistry.

For the mineralogical community, perhaps the least known of Peter's accomplishments is his work on atmospheric aerosol particles. Inventive use of electron microscopy opened a new research direction in atmospheric science. Although this large field was mainly concerned with the bulk properties of atmospheric aerosols, a stream of papers from the 1980s up to the present from Peter and his group provided new insights into the physical and chemical properties of individual particles in our atmosphere, providing atmospheric chemists with new visions and data to calculate the global radiative effects of various particle types in both pristine and polluted parts of the troposphere.

Along the way, or on the side, whenever an interesting form of elemental—or nearly elemental—carbon showed up, Peter got interested and studied their structures. Notable examples include the first reports of fullerenes in the geological environment and studies of graphitic carbon in meteorites, soot, and shungite. Again, many *Science* papers resulted.

Let me give you some numbers: Peter authored or coauthored about 450 papers. These have been cited 25,000 times, according to Google Scholar, and he has an h-index of 89. He published 44 papers in *Science*, *Nature*, and *PNAS*.

Peter's impact on science cannot be measured solely by the volume and significance of his actual results. The visual appeal and power of TEM images influenced generations of scientists by guiding their thinking about certain problems and spurring them to explore new ideas.

As Peter always stresses, all the above resulted from the combined efforts of members of his research group. I mentioned a few names, but it would be unreasonable to list them all. As of today, Peter has mentored 139 graduate students and postdoctoral scientists. The group could not have functioned for decades without Peter's special talent for assembling and managing people with diverse backgrounds, providing guidance, support, and critical commentary for young scientists. With his unique mentoring style, by gently provoking people into exploring new directions while encouraging them to enjoy the subject, he usually got the best out of everyone. Probably all of us former members of his group have vivid memories

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0003-004X/20/0005–776$05.00/DOI: https://doi.org/10.2138/am-2020-AP105510

of the odious but useful experience of writing proposals and the seemingly unending but equally useful process of going through numerous drafts of written material to say things clearly, accurately, and (sometimes) concisely. Peter had the vision to recommend exciting topics that turned out to be of interest to the wider science community and, besides, were fun to work on.

In addition to providing a stable professional environment for researchers who came to ASU from all over the world, Peter has always been generous with his time and personal support. He and his late wife Alice made us feel at home. For many of us, Peter's group at ASU was a launchpad from which our careers took off, and even after leaving ASU we could always count on his support.

Finally, I have good news for you: there is no sign of his slowing down! In 2016 Peter won a prestigious Keck Foundation Award to study the origin of Earth's water. Then, just last year, he won another Keck award for studying an elusive, chain-like form of carbon that he and colleagues called pseudo-carbyne. It seems that even at this point in his career, Peter is still getting into some risky but fascinating science projects. In any case, Peter still has plenty of vision, and we can expect exciting results to continue flowing from his lab.

Peter, I hope you keep going and congratulations!

Ladies and Gentlemen, it is my privilege to introduce to you Peter Buseck, this year's recipient of the Roebling Medal.