American Mineralogist, Volume 68, pages 651–652, 1983

Acceptance of the Roebling Medal of the Mineralogical Society of America for 1982

JOSEPH V. SMITH

Louis Block Professor of Physical Sciences
Department of the Geophysical Sciences
The University of Chicago, Chicago, Illinois 60637

President Lindsley, Fellows, members and guests:

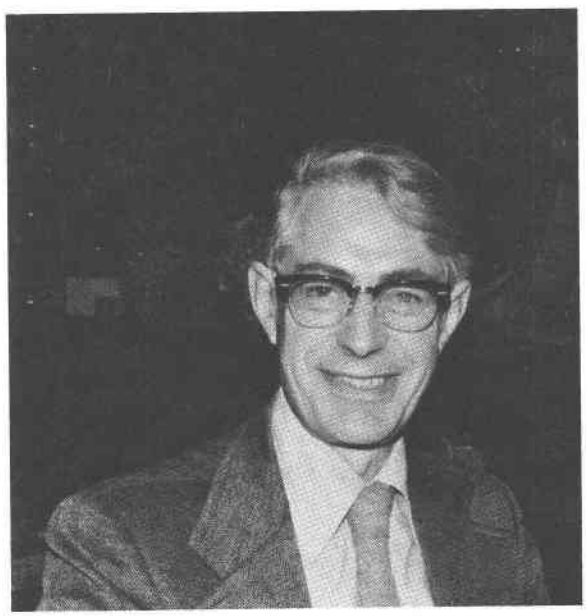
I am deeply grateful for the award of the Roebling Medal. Peter Wyllie was extremely generous, and I must temper his remarks by emphasizing the advantages that came my way in this *Golden Age of Mineralogy*.

I was fortunate to learn by instinct on my father's working farm how complex and fragile is the cycle of life. My mother and an uncle were teachers, and they encouraged me to win a scholarship to an academic high school. The physics and chemistry teachers were busy teaching regular classes. As the only science student at the advanced level, I was excused from all classes to study for the entrance scholarship exam of Cambridge University. Working through 30 years of earlier exams proved to be an excellent training in problem-solving and research. This probably explains why I am impatient with students who require spoon-feeding.

The present state of science teaching in the USA is a matter of concern: for example, there are only 22 chemistry teachers in the public high schools of Chicago. What does this portend for the future? What steps are needed to provide a training like the one I profited from?

I slipped through the gap between World War II and the Korean War. The teaching at Cambridge University was superb, and totally supported by government scholarships and a rich endowment. I specialized at first in nuclear and solid-state physics. It was fortunate that high-energy physics was collapsing at Cambridge, and I chose crystallography for a Ph.D. Helen Megaw, William Cochran and William Taylor ran a marvelous operation. However, I was assigned to work on calcium carbonate silicate minerals, and found the computations so tedious that I almost quit to go into industry.

Perhaps my greatest good fortune was to receive a Fellowship at The Geophysical Laboratory, and not be appointed to the Cambridge faculty. The Geophysical Laboratory was rather primitive in those days, and I built an X-ray generator in the doghouse from junk equipment and chicken wire—you can see how important was my training in farming. William Scott MacKenzie, Frank Tuttle and Hat Yoder started to educate me in Earth Sciences, but I was still as green as grass. Geology was baffling even when expounded by Mac or Felix Chayes. But Mac got me going on feldspars, and I knew that I must learn petrology and geology.



Back in Cambridge, but now in mineralogy and petrology, I was given special tuition by Stuart Agrell and Henry Emeleus in the British Tertiary Province: but I was chastened by the complexities of feldspars in granites.

Cambridge froze faculty tenure, and four years at Penn State in the days of the white coat brigade extended my education under Frank Tuttle, Elburt Osborn and others. I began to consult with the Linde Divison of Union Carbide Corporation to pay for travel to Britain, and fell into one of the great success stories of industrial chemistry. Zeolite molecular sieves have revolutionized catalysis, and I have been guided by two brilliant chemists: Donald Breck (+1980) and Edith Flanigen. Collaboration between industry and university is not easy, but Don and Edith always went out of their way to preserve the scientific integrity of my research. I am particularly indebted to Joseph Pluth and Michael Bennett for their meticulous research, which is now expanding into several new directions. Gerry Gibbs has taken off like a shooting star since our early collaboration.

For years I had admired the work of Julian Goldsmith and Fritz Laves, and could not resist the call to Chicago. Julian's concept of a small, unified Department of Earth Sciences has proven highly successful, and my education continues daily from the other faculty members. Hat

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Yoder will remember the thrill when his pyroxenes checked out the viability of the electron probe. Seems trivial now, but not then. The sun shone 24 hours a day at the NATO Institute on Feldspars at Oslo in 1963. Tom Barth was a genial host, and he inspired me to begin writing a treatise on feldspars. But these carefree days were passing as new responsibilities were assumed, and the forces of fear and destruction began to build up again in the world.

The politically-motivated Apollo landing on the Moon led to the initial euphoria associated with the discovery of new rocks and minerals. In ten years we have made marvelous discoveries about the planets, and have learned how to use diverse cosmochemical and cosmophysical data to infer the origin of the Earth. This is a happy occasion today, and I will not pursue the present state of the space program which is increasingly bedeviled by the evil consequences of political and nationalistic rivalries.

The ion microprobe is now a proven instrument but the establishment of analytical procedures was and is difficult: Ian Steele has done a great job. Our original instrument has been largely rebuilt to mitigate design and construction faults, and I am particularly indebted to Ian Hutcheon and Ron Draus.

The Roebling Medal, of course, is based on past research, and I must confess to a bittersweet feeling at its award to me. Every year there is an increasing number of fascinating problems, and the Roebling Medal signals that many years have gone, and that those to come are numbered. Hence, I am delighted that my colleagues have been so successful this summer. Ian Steele has used the ion probe to measure trace elements in the Keith–Tuttle samples of quartz. Aluminum correlates with the inversion temperature. We can anticipate that a trace-element signature will reveal the provenance of quartz grains in sandstones: Archean sediments should prove particularly interesting.

Joe Pluth has demonstrated aluminum and phosphorous ordering in structure type 81 of a new family of aluminophosphate molecular sieves. We are itching to get cracking with the synchrotron and pulsed-neutron sources.

Richard Exley has demonstrated that the initial strontium ratio can be determined for calcites with the ion probe, and we anticipate important applications to carbonatites and Archean marbles.

Adrian Jones has obtained petrological information on the granulite lower crust of Tanzania, and has developed microprobe techniques for accurate measurement of hydrogen and fluorine in micas.

In the field of meteorites, the enstatite chondrites are proving to be very complex, and we expect to obtain critical data on the formation of chondrules in the early days of the solar system. Just last week, Ian Steele and I showed that an Antarctic achondrite had been cooked in a vapor rich in sulfur and potassium.

Let me finish with a hope for the future. Currently the forces of love and friendship seem to be weakening in the world in the face of scientifically-based technology misdirected by fear, hatred and greed. There is no simple choice for an individual scientist, and the easy out is to get on with research and hope for the best. I trust that this society and other ones will make a special effort to develop programs that will increase international cooperation in as many ways as possible. Just consider how research and teaching in mineralogy and other sciences could be improved around the world with just one percent of the money spent on war machines. This is a small goal which is not immediately relevant to the pressing problems of neutron bombs and cruise missiles. But in the long term international ties between scientists can help to establish that we all belong to one human race, and must learn to live in peace on this planet.

Mr. President, my wife and children have been an essential support to my life and work. I dedicate this Roebling Medal to them, and hope that this *Golden Age of Mineralogy* will continue to shine.