American Mineralogist, Volume 90, pages 1021–1022, 2005

Presentation of the Mineralogical Society of America Roebling medal for 2004 to Frances R. "Joe" Boyd

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Mr. President, Margo and family, distinguished guests, and fellow mineralogists:

It is indeed a great honor to be the Roebling Medal citationist, but it is also with great sadness that Joe Boyd, the recipient, is not among us to celebrate the occasion and to personally receive MSA's most prestigious award.

In nominating Joe, I was joined by a distinguished group of scientists that included Doug Smith (Texas), Dean Presnall (Texas), Peter Nixon (Leeds), Nick Sobolev (Novosibersk), and jointly by Rick Carlson, Steve Shirey, and Yingwei Fei (Carnegie), all of whom had close associations with Joe, and all of whom commented at depth on Joe's illustrious career.

Joe's excursion into the geosciences began at Harvard (1949–1953), with rugged fieldwork on the Yellowstone pyroclastics, and experimental studies in the equally rugged environment of George Kennedy's laboratory. Fieldwork and tightly coupled petrochemistry, backed by experiment, were hallmarks of Joe's career, and as recognizable as his distinctive handwriting, these were signatures to each of his creative contributions.

Joe's work with George Morey at the Geophysical Laboratory in the 1950s produced the first *P-T* stability curve for tremolite, and solid solutions among members of the amphibole mineral group were also explored. His experimental inventiveness are marvels to behold: He was possibly the first, in 1954, to couple a heating stage to an X-ray diffractometer to record mineral transformations in action; the Boyd and England high pressure (5 GPa), and high temperature (1750°C) press, in which diamond was synthesized in 1960, can still be seen, some now modified, in many laboratories around the world. This press has advanced both the science and the careers of many a noteworthy experimentalist; Joe was the driving force in automating electron microbeam analyses, first introduced at the Geophysical Laboratory with the skillful assistance of Larry Finger and Chris Hadidiacos, and soon thereafter followed by all of the major microprobe manufacturers. It is fair to comment, and without exaggeration, that the improvements he made to high-*P* and high-*T* experimental systems, and the advances he introduced to the automated acquisition of mineral and glass compositions, have truly revolutionized the Earth sciences.

His experimental studies on the Ca-Mg-Al-Si oxide system with *Uncle* Frank Schairer, was the foundation for the now widely used pyroxene geothermobarometer. It was in Joe's Presidential Address to the Geochemical Society in 1973 that he introduced the concept of the pyroxene geotherm; although not all aspects of interpretation were correct, he nonetheless demonstrated that the frozen *P* and *T* equilibria preserved in mantle xenoliths from kimberlites corresponded to heat flow measurements in cratons. A major revelation that confirmed the Clark and Ringwood Archean continental geotherm, and the Pollock heat flow value that are now standard fare in mantle studies. I was in Joe's company at an AGU meeting in 1971 when Ted Ringwood walked up and, without greeting, warmly congratulated Joe on his latest experimental work that illustrated the link between and among members of the mantle peridotite suite—"I should have done that years ago," was Ted's only comment.

With Henry Meyer in 1972 and their ground breaking studies of mineral inclusions in diamonds, with Peter Nixon in1973, Joe produced over 600 high quality electron microbeam analyses on xenoliths from Lesotho, and with Cater Hearn, Bobby Danchin, and Nick Sobolev, Joe had his feet firmly in the mantle**,** and it was global. He made significant contributions to specific mineral studies in kimberlites and mantle xenoliths that included olivine, the *noble* oxide mineral group, pyroxene, garnet, and graphite. But he also developed a mineral homogeneity index, and he determined for the first time the densities of fertile and depleted xenoliths.

He made major contributions to our understanding of the evolution of the continental lithosphere, by noting that the 200 km thick keels of cratons must have been in place at the time at which most diamonds were formed at 2.8–3.2 Ga. This conclusion is a significant constraint on the rate of continental crustal growth, which must have been rapid in the Archean and less so in the Proterozoic. From a comparison of continental and oceanic peridotites, he again showed for the first time in a simple and elegant way that these were produced by different mechanisms. And from the bulk chemistry of xenoliths he showed that partial melting of garnet lherzolite, with the early extraction of komatiite, could indeed produce the abundant restites of harzburgites and dunites that are so prevalent in the mantle sample.

The crowning glory of Joe's major contributions to mantle petrology must surely have been in his participation in the multifaceted, multi-million dollar project on the characterization of the Kaapvaal Craton.

Joe Boyd and Henry Meyer dreamed up the idea of having a kimberlite conference in 1971. Their notion was a meeting of the small number of workers that existed at that time in the field of mantle petrology. Most research had been on shallow, spinel-facies xenoliths in alkali basalts, and on Alpine-type peridotites. Along with John Gurney, who had been a post-doc fellow at the Smithsonian Institution, they successfully persuaded Barry Hawthorne, then Chief Field Geologist of De Beers, that the vast waste dumps of past diamond mining in South Africa were in fact a treasure trove of clues to the upper mantle. Word got out, the gates were unlocked, and for the first time, deep Earth samples became directly available to the vastly oversubscribed attendees at The First Kimberlite Conference in 1973. We have never

0003-004X/05/0506–1021$05.00/DOI: 10.2138/am.2005.443

looked backed. On the time scale of the Olympics, the meetings have now become a regular, International, affair. The 8th IKC was held in Vancouver in 2003, and the next International Kimberlite and Diamond Conference is scheduled for India in 2007.

Joe's retirement from the Geophysical Laboratory was marked in 1997 by a one-day symposium and the publication *Mantle Petrology: Field Observations and High Pressure Experimentation* (Spec. Pub. 6. The Geochemical Society.) There are 16 papers with 31 authors and each bears on an aspect of Joe's outstanding contributions to our knowledge of Earth's mantle. It's a spectacular tribute that ranges from the thickness and heat production of Archean lithosphere, keel evolution, structural geology of the mantle, diamond geology and diamond formation, mantle phase transitions, geothermobarometry, effects of pressure on fractional crystallization, dense hydrous magnesium silicates, and carbon and carbonatites in the mantle. Joe's impact and his influence are clearly marked in the 300 pages that were dedicated to his career. It is a marvelous endorsement of truly outstanding achievements—and more remarkably, it was all by one person.

I first met Joe as a post-doc fellow at the Geophysical Laboratory in 1968. In a wonderful collaborative spirit, along with Peter Bell (P.I.), Larry Finger, and Bill Bryan we worked on the first returned lunar samples in which we described two new mineral oxides, one of which we successfully synthesized and had the privilege of naming, *armalcolite*, after the Apollo 11 astronauts. Growth and independence were encouraged at the *Geewiz Lab*, but it was more than that. Don Lindsley, another Roebling Medalist, was my mentor. A recognized world authority on mineral oxides, and with high Ti basalts teeming with irresistible ilmenite and beautifully zoned spinel, Don chose instead, in the spirit of Carnegie, to provide strong sideline encouragement, insight, and guidance. It was an honor to be first author among these senior scholars. I owe Joe, Peter, and Don a debt of gratitude for setting so fine an example. Thanks a lot for the important lesson!

I got to know Joe pretty well, but it was only when I was about to leave the Lab for UMass, Amherst, that Joe, in his usual quite manner, casually remarked, "It might be fun to look at the opaque minerals in kimberlites." On reflection, it was not only fun, but sound advice. It was a major factor in forging my research career, and it has allowed me to see an enormous number of diamond deposits around the world, many in the warm and wonderful company of Joe. He was a remarkable scientist and a gentleman's gentleman.

Mr. President, in recognizing Joe Boyd for the Roebling Medal, we are acknowledging the depth of a truly outstanding scientist: One who made major and lasting contributions; one who had a significant influence in driving the science; and one who aroused the curiosity of many. Seminal, creative, scholarly, modest, and unselfish, are all qualities of distinction, and worthy, in the true sense of the word, of a Roebling Medalist.