Presentation of the Roebling Medal of the Mineralogical Society of America for 1998 to C. Wayne Burnham

JOHN R. HOLLOWAY

Arizona State University, Tempe, Arizona 85287-1404, U.S.A.

A look at the literature of igneous petrology in the years prior to 1967 finds scant mention of the role of volatiles in any igneous rock save evolved granites. Neither would you find a discussion of the solubility of silicate components in the aqueous phase often associated with magmas, or even mention of such an aqueous phase. In 1967 the original edition of *The Geochemistry of Hydrothermal Ore Deposits* was published containing Wayne Burnham's chapter on "Hydrothermal fluids at the magmatic stage" in which Wayne described the physical and chemical properties of magmas, their associated aqueous phases, and the distribution of elements between the two. He also showed for the first time that H_2O-saturated crustal magmas could not rise from their source region, and explained the generation and ascent of H_2O-undersaturated magmas.

It was also impossible to find mention of thermodynamic calculations in volatile-bearing igneous systems, but in 1974 Wayne published an exceptional thermodynamic analysis of the system albite-H_2O that revolutionized what we thought was possible in igneous petrology. By the early 1980s it was common to think of H_2O and other volatiles as playing a major role even in the evolution of mafic magmas, and in many cases to calculate the effect of volatiles on thermodynamic properties of magmas.

Wayne has made a series of outstanding contributions to the fields of mineralogy and petrology throughout his career. His early experimental work on pegmatite genesis caused him to believe that volatiles, especially water, were critically important to igneous petrogenesis. That view led him to a major effort to measure water solubilities in silicate melts. As was always the case with Wayne, he was not content just to make important experimental measurements, he wanted to put them in a more general context. So he used the water solubility measurements to develop a model for calculating water solubilities for a range of melt compositions. But that model was not soundly based on theory due to lack of thermodynamic data on hydrous silicate melts. Wayne was convinced that such melts had to be treated thermodynamically, and that meant measuring the thermodynamic properties of the water and silicate components in melts. This was in about 1962, long before most igneous petrologists had even considered a rigorous thermodynamic treatment of anhydrous melts, let alone hydrous melts. He chose the most direct and fundamental of measurements, the variation of melt volume with pressure and temperature. However, before he could measure the *P-V-T* properties of hydrous melts and hence obtain their thermodynamic properties, he had to measure the *P-V-T* properties of pure water over the same *P-T* range so he could use water as a volumetric fluid. Moreover, he had to make precise measurements into *P* and *T* extremes not previously explored by experimentalists. The apparatus Wayne designed and refined was unique, and wonderfully complicated! The *P-V-T* of water measurements took a solid six years of effort, during which Wayne was in the lab almost continuously. (Sometimes he was still in the lab a few minutes after the official starting time of his famed graduate class "Igneous Petrogenesis".) The result of this six years was "The thermodynamic properties of water to 1,000°C and 10,000 bars," which became a cornerstone of the application of thermodynamics to hydrothermal geochemistry and metamorphic and igneous petrology. Once water had been done, Wayne and Nick Davis succeeded in measuring the *P-V-T* properties of hydrous albite liquid over the same *P-T* range. After publishing the volumetric data, they spent another three years developing a thermodynamic description of phase relations in the system albite-H_2O. A series of papers on thermodynamic properties of magmas followed; the Nobel Symposium paper laid out his melt speciation model in detail. Unfortunately, it was so densely written that it was largely misunderstood. Nevertheless, it was the first attempt at a comprehensive thermodynamic model for real magmatic systems. But full application of the model was prevented because Wayne didn't do programming. This problem was solved by Hanna Nekvasil who was both a good programmer and one of the few people who could fully understand Wayne's model. Among other things, the resulting calculations allowed the separation of the effects of total pressure from water activity during the partial melting and crystallization of granitic magmas, a feat that had needed to be done since Tuttle and Bowen's classic monograph.

Working in Wayne's research group was a great experience; the experiments were nearly impossible, but Wayne would guide us through to find solutions to the problems. He was always enthusiastic about new results and would often be looking at run products with the petrographic microscope when the samples were barely cold. His approach was always a frontal attack on the problem at hand. In addition, he insulated his research group almost perfectly from university red tape. He was feared among grad students outside his research group because he looked a bit like a bull dog in those days, and he was always in a hurry. But students who got to know him found a very generous person, always loaning money to students in need and never letting students pay for Friday evening beverages!

The problems Wayne worked on are of fundamental importance to petrology and geochemistry, and both the experiments he has done and his thermodynamic analysis of the resulting data have been some of the most difficult attempted to date. His publication list includes no trivial papers and several landmarks. It is my great honor to present Wayne Burnham as the 1998 Roebling medalist.

0003-004X/99/0708–1199$05.00