# THE HAWLEY MEDAL FOR 1997 TO PETER C. BURNS, MARK L. MILLER AND RODNEY C. EWING

The Hawley Award is presented for the paper judged as the best to appear in *The Canadian Mineralogist* for the preceding year. This year's award committee is pleased to announce their choice for the paper coauthored by Peter C. Burns, Mark L. Miller, and Rodney C. Ewing, titled $U^{6+}$ minerals and inorganic phases: a comparison and hierarchy of crystal structures (Vol. **34**, pages 845- 880). The committee notes that there were many fine papers from which to choose, but this one stood out as very special.

The award committee views the paper by Burns *et al.* as a benchmark for an understanding of the structural relations among $U^{6+}$ minerals. It brings together the crystal structural data on one hundred and eighty $U^{6+}$-containing minerals and synthetic inorganic compounds, identifies the schemes of polymerization of polyhedra, and develops a well-organized hierarchical structure scheme. This is a monumental task, bringing order to a complex and diverse group of structures. The insights, organization and order inherent in this paper serve as the necessary starting point for all future crystal-chemical and mineralogical work on oxidized and secondary uranium minerals. This is especially relevant to our increasing dependence on nuclear power; it is essential to an understanding of those processes involving $U^{6+}$-containing minerals, both in the natural geological environment and as alteration products of spent nuclear fuel in, for example, nuclear-waste repositories.

Burns *et al.* have built on earlier work of others such as Howard Evans, who identified the linear uranyl ion as the important structural element in most structures of $U^{6+}$ oxy-minerals, of Deane K. Smith, who classified many of the same structures, and of Paul Moore and Frank Hawthorne, who have brought order to structural classifications of minerals based on cation polyhedra of higher bond-valence. The hierarchical structural classification that results is elegant. More importantly, even interested non-crystallographers such as aqueous geochemists will find the descriptions quite readable, and the paper will therefore prove to be of especial practical significance to a variety of researchers. It is extensively and handsomely illustrated, with diagrams illustrating the structural relations in particularly easy-to-understand fashion.

Roger H. Mitchell
President

Mr. President, Members of the Mineralogical Association of Canada, and guests,

I was very pleased, and rather shocked, when Fred Wicks informed me that we had been chosen as the recipients of the Hawley Award for 1996. This comes ten years after my other award from the Mineralogical Association of Canada: a Student Award, which consisted of a two-year subscription to *The Canadian Mineralogist*. Over the past ten years, I have developed a deep appreciation of the quality of the manuscripts published in *The Canadian Mineralogist*, so I feel particularly honored to receive the Hawley Award. It is my opinion that *The Canadian Mineralogist* is the finest mineralogical journal published today, largely owing to the herculean efforts of the editorial staff, headed by Bob Martin.

Perhaps one of the most significant contributions that structural mineralogists can make to the Earth Sciences is an understanding of the paragenesis of complex low-temperature mineral assemblages that is based upon a knowledge and understanding of the crystal structures of the minerals. We created the structural hierarchy for hexavalent uranium phases as the first step toward such an understanding for uranium minerals. We study hexavalent uranium minerals because they have diverse and fascinating structures that are the key to understanding uranium ore deposits, and because of their environmental significance. In addition to the oxidized portions of uranium ore deposits, they also form by the weathering of radioactive mine tailings, and they will impact upon the release rates of uranium and lead into the environment. These minerals will also form when spent nuclear fuel is corroded in a geological repository, and it is likely that they will control the release rates of many of the radionuclides that are contained in the spent fuel. This is just one of the many areas where mineralogists can contribute to solving important environmental problems.

The technique of X-ray diffraction has become a staple of structural mineralogists, as it is the standard technique for revealing the details of crystal structures. Despite this, the instrumentation used for these studies has remained essentially unchanged for almost three decades. However, the field has just been revolutionized with the introduction of CCD X-ray area detectors. These new detectors have pushed the envelope of doable problems so far that it is now possible to determine the structures of crystals with maximum dimensions of only a few micrometers. We can now access many mineral structures that were ruled out by the lack of suitable single crystals. With the brilliant monochromatic X-ray beam that will soon be available from the Advanced Photon Source at Argonne, we will do structures for mineral crystals that are as small as 1 $\mu m^3$. These innovations provide the means to take an entirely new approach to low-temperature mineralogy, and the interaction of fluids with mineral surfaces. Today is an incredibly exciting time to be doing mineralogy, and I am very pleased to be part of it.

In closing, thank you very much for this honor.

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Mr. President, members of the Mineralogical Association of Canada, and guests,

I was very pleased, and surprised, when Fred Wicks informed me that my coauthors and I were to be honored with the Hawley Award for 1997. As always the honor only shines on a few who deserve some part of the recognition. In this case, I want to emphasize that this paper grew out of the hard work and frustration suffered by two colleagues: Janusz Janeczek, a professor at the University of Silesia in Poland, and Bob Finch, a recent Ph.D. student. Janusz and Bob were the first in our research group to tackle the problems of the uranium oxides and their alteration products. Janusz made the explicit connection between the behavior of uraninite and the $UO_2$ in spent nuclear fuel. Bob studied the alteration products of uraninite, his work culminating in a fine but difficult solution to the structure of schoepite, also published in *The Canadian Mineralogist*. In the absence of these early efforts, the present work would have lacked purpose and direction.

I must also acknowledge those who provided the funding for this research. In the early days, we were first guided to this subject by Lars Werme of SKB, the Swedish Nuclear Fuel and Waste Management Company; however, the work in this paper was supported by the Office of Basic Energy Sciences in the U.S. Department of Energy.

I am also pleased to acknowledge *The Canadian Mineralogist* and its editor, Bob Martin. Few prominent journals today would accept such a paper, a 35-page compilation and analysis of 180 crystal structures.

The pleasure of this moment is, of course, the recognition by peers and colleagues in the mineralogical community; however, the greater pleasure is to see mineralogy find an important and visible application. During my career, I have seen mineralogists define for themselves a smaller and smaller niche in both the geosciences and materials sciences. The opposite should be the case! Mineralogists should be addressing the widest range of solid-state problems in the geosciences, environmental sciences, and materials sciences. Mineralogists have unique skills, and this skill and knowledge should place us at the center of many issues, particularly environmental isues, and not at the periphery. The work in this paper, for which we are receiving the Hawley Award, grew directly out of the need to understand the corrosion processes and products of the $UO_2$ in spent nuclear fuel. If risk to the public and cost to the taxpayer are any measure, this must be considered one of the pressing scientific and environmental issues of this decade. In the United States, nuclear waste management has become a large and costly effort, running to the billions of dollars and employing many thousands of scientists and engineers; too few are geoscientists, and very few are mineralogists. In part, this is due to the fact that we educate students with too narrow a vision of the aesthetics, excitement and important applications of mineralogy. In this paper, I hope that we, the authors, have arrived at some balance between the aesthetics of these $U^{6+}$ structures, the use of solid-state concepts by which to analyze the structures, and the use of this knowledge in an important application, that is to trace the fate of actinides in the near-surface environment.

Thank you for this recognition.

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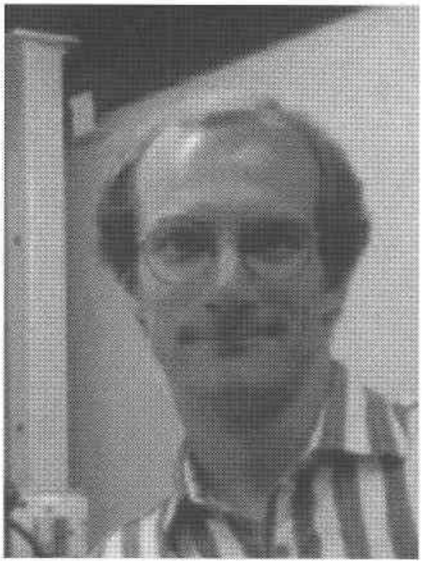
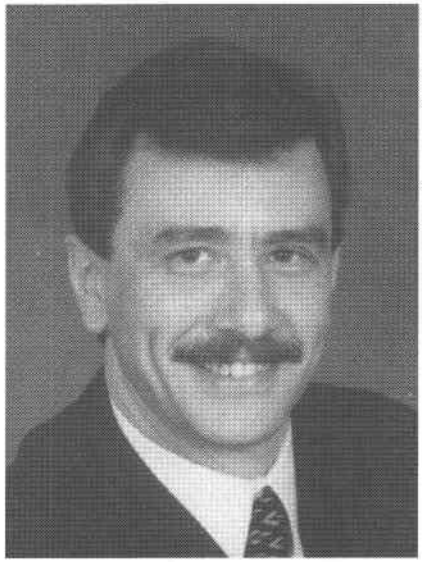
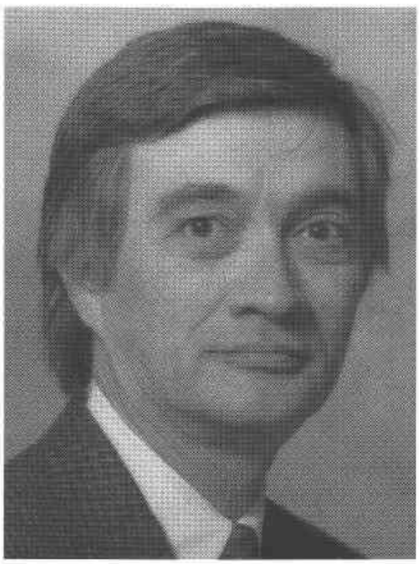


PETER C. BURNS



MARK L. MILLER



RODNEY C. EWING