Distinguished Scientist Seminar Series
Friday, June 12th, 10:30 AM
B66 Auditorium

Pyrochlore: The Elegant Response of a Simple Structure to Extreme Conditions of Irradiation and Pressure
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Abstract
During the past sixty years, more than 1,800 metric tonnes of plutonium (Pu), and substantial quantities of the “minor” actinides, such as neptunium (Np), americium (Am), and curium (Cm), have been generated in nuclear reactors. Some of these transuranium elements can be a source of energy in fission reactions (e.g., $^{239}$Pu), a source of fissile material for nuclear weapons (e.g., $^{239}$Pu and $^{237}$Np), and of environmental concern because of their long-half lives and radiotoxicity (e.g., $^{239}$Pu and $^{237}$Np). In fact, new strategies for the advance fuel cycle initiative (AFCI) are, in part, motivated by an effort to mitigate some of the challenges in disposal of these long-lived actinides. There are two basic strategies for the disposition of these elements: (1) to “burn” or transmute the actinides using nuclear reactors or accelerators; (2) to “sequester” the actinides in chemically durable, radiation-resistant materials suitable for geologic disposal. There has been substantial interest in the use actinide-bearing minerals, such as isometric pyrochlore, $A_2B_2O_7$—$A =$ rare earths, actinides; $B =$ titanium (Ti), zirconium (Zr), tin (Sn), hafnium (Hf)—for the immobilization of actinides, particularly Pu. Systematic studies$^1$ of rare-earth pyrochlores have led to the discovery that certain compositions ($B =$ Zr, Hf) are stable to very high doses of alpha-decay event damage. Three different processes were observed: (i) radiation-induced amorphization, (ii) an order-disorder transformation, and (iii) phase decomposition. The radiation stability of these compositions is closely related to the structural distortions that occur for specific pyrochlore compositions and the effect of electronic structure on bonding. Additionally, in situ synchrotron X-ray diffraction and Raman spectroscopy measurements were performed on a range of pyrochlore compositions at pressures up to 43 GPa. Similar structural transformations were observed in the pyrochlore structure-type at high pressures. These results demonstrate that there are parallel responses to energetic particle irradiations and high pressure, although the mechanisms of the structural transformations are quite different$^2$. The most recent work$^3$ involves the use of swift heavy ions to investigate the internal structure of individual ion tracks.


BIOSKETCH

Rod Ewing is the Donald R. Peacor Collegiate Professor in the Department of Geological Sciences at the University of Michigan. He has faculty appointments in the Departments of Nuclear Engineering & Radiological Sciences and Materials Science & Engineering, and is an Emeritus Regents' Professor at the University of New Mexico, where he was a member of the faculty from 1974 to 1997.

Ewing received a B.S. degree in geology from Texas Christian University (1968, summa cum laude) and M.S. (1972) and Ph.D. (1974, with distinction) degrees from Stanford University where he held an NSF Fellowship. His graduate studies focused on an esoteric group of minerals, metamict Nb-Ta-Ti oxides, that are unusual because they have become amorphous due to radiation damage caused by the presence of radioactive elements. This radiation-induced phase transformation from a crystalline to amorphous state can have significant effects on the properties of materials, such as the decreased durability of radioactive waste forms. Over the past thirty years, the early study of these unusual minerals has blossomed into a broadly based research program on radiation effects in complex ceramic materials. This has led to the development of techniques to predict the long-term behavior of materials, such as those used in radioactive waste disposal.

Ewing is the author or co-author of over 600 research publications and the editor or co-editor of 14 monographs, proceedings volumes or special issues of journals. He has been granted a patent for the development of a highly durable material for the immobilization of excess weapons plutonium. He is a founding Editor of the magazine, Elements. He has received the Hawley Medal of the Mineralogical Association of Canada in 1997 and 2002, a Guggenheim Fellowship in 2002, the Dana Medal of the Mineralogical Society of America in 2006 and the Lomonosov Gold Medal of the Russian Academy of Sciences in 2006 and a Honorary Doctorate from the Université Pierre et Marie Curie in 2007.

Professor Ewing has served on National Research Council committees for the National Academy of Sciences that have reviewed the Waste Isolation Pilot Plant in New Mexico (1984 to 1996), the remediation of buried and tank wastes at Hanford, Washington and INEEL, Idaho (1992 to 1995), the INEEL high-level waste alternative treatments (1998-1999), the end points for spent nuclear fuel and high-level radioactive waste in Russia and the United States (2002-2003), and the disposition of transuranic and high-level radioactive waste (2004-2005). He has been an invited expert for the Advisory Committee on Nuclear Waste of the Nuclear Regulatory Commission, a consultant to the Nuclear Waste Technology Review Board, and a member of the Board of Nuclear and Radiation Studies of the National Research Council.

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