scribed has only become more muddied. We should be working hard to clean up both the science and its reporting.

Stephen M. Smith
Department of Biology, University of Waterloo, Waterloo, Ontario N0B 2L0, Canada

References

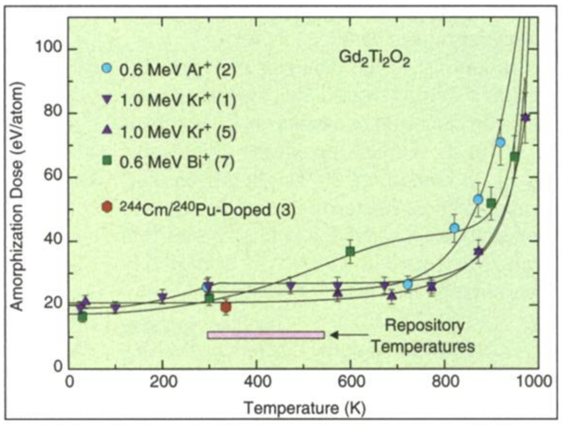
1. J. Lederberg, *Scientist* 9 (no. 4), 13 (1995).

Plutonium Immobilization and Radiation Effects

In their report "Radiation tolerance of complex oxides" (4 Aug., p. 748), Sickafus and colleagues note in the last paragraph "that compounds with the fluorite structure are especially stable in a displacive radiation damage environment," and they propose that complex oxides that have a fluorite structure (with respect to the arrangement of cations and anions in crystals), such as $Er_2Zr_2O_7$, have important applications in nuclear waste management. The most obvious application is plutonium immobilization.

We earlier proposed (*1*) the use of $Gd_2Zr_2O_7$ for plutonium immobilization on the basis of (i) the extremely high cross section of Gd for neutron absorption, which provides criticality safety, and (ii) our discovery that compositions in the gadolinium-zirconate system have the ability to resist radiation damage by energetic particles such as those from radioactive decay of plutonium. These Gd-Zr compounds absorb the energy through a rearrangement of Gd, Zr, and O atoms within the crystal structure without becoming amorphous or otherwise structurally unstable (*1, 2*).

The compound gadolinium titanate ($Gd_2Ti_2O_7$), the primary candidate phase for plutonium immobilization in government-sponsored studies in the United States, Russia, and Australia, is readily amorphized by alpha-decay damage (*3*). This amorphization causes swelling, cracking, and a 50-fold increase in the leach rate of plutonium (*3*). Studies of radiation effects over millions of years in natural titanates (*4*) show that amorphization occurs at a similar alpha-decay dose as that observed for $Gd_2Ti_2O_7$ (*3*). When heavy-ion irradiation is used to simulate alpha-decay effects, $Gd_2Ti_2O_7$ is found to amorphize at the same equivalent dose as for alpha-decay damage at ambient temperature, and high temperatures are required to prevent amorphization (*1, 5*) (see the figure). Heavy-ion irradiation also confirms that amorphization occurs directly in atomic collision cascades (*6*) and increases the aqueous leach rate by at least a factor of 10 (*7*).



The atomic-collision dose, energy dissipated per atom (eV/atom), required to amorphize $Gd_2Ti_2O_7$ as a function of temperature demonstrates the good agreement between the results of alpha-decay and heavy-ion experiments near 300 kelvin. Note the high temperatures that are required to inhibit amorphization compared with the repository temperature range.

CREDIT: W. J. WEBER AND R. C. EWING

A fluorite structure type forms in $Gd_2Ti_2O_7$ during heavy-ion irradiation but does not suppress amorphization (*6*). Similarly, despite its fluorite structure type, $CaPuTi_2O_7$ readily amorphizes at similar low doses from alpha decay of plutonium (*8*). Therefore, the critical parameter for radiation resistance may not be the fluorite structure type, as Sickafus *et al.* suggest, but rather the energy barriers to damage recovery.

In contrast to the behavior of $Gd_2Ti_2O_7$, we have demonstrated the systematic increase in radiation resistance as Zr is substituted for Ti. Under repository conditions, $Gd_2Zr_2O_7$ containing 10 weight percent plutonium-239 (half-life of 24,100 years) will be radiation resistant for at least 30 million years, whereas $Gd_2Ti_2O_7$ will completely amorphize in less than 800 years (*1*).

William J. Weber
Pacific Northwest National Laboratory, Richland, WA 99352, USA. E-mail: bill.weber@pnl.gov

Rodney C. Ewing
Department of Nuclear Engineering and Radiological Sciences, University of Michigan, Ann Arbor, MI 48109, USA. E-mail: rodewing@umich.edu

References and Notes

1. S. X. Wang *et al.*, *J. Mater. Res.* **14**, 4470 (1999).
2. S. X. Wang *et al.*, *Mater. Res. Soc. Symp. Proc.* **540**, 355 (1999).
3. W. J. Weber, J. W. Wald, H. Matzke, *J. Nucl. Mater.* **138**, 196 (1986).
4. G. R. Lumpkin and R. C. Ewing, *Phys. Chem. Miner.* **16**, 2 (1988).
5. W. J Weber, *Nucl. Instrum. Methods Phys. Res. B* **166–167**, 98 (2000).
6. S. X. Wang *et al.*, *Nucl. Instrum. Methods Phys. Res. B* **169**, 135 (2000).
7. B. D. Begg *et al.*, in *Environmental Issues and Waste Management Technologies in the Ceramic and Nuclear Industries V, Ceramics Transactions, Vol. 107*, G. T. Chandler and X. Feng, Eds. (American Ceramic Society, Westerville, OH, 2000), pp. 553–560.
8. F. W. Clinard Jr. *et al.*, *J. Nucl. Mater.* **126**, 245 (1984).
9. Sponsored by the U.S. Department of Energy, Office of Basic Energy Sciences, Division of Materials Sciences.

CORRECTIONS AND CLARIFICATIONS

Pathways of Discovery: "One hundred years of quantum physics" by D. Kleppner and R. Jackiw (11 Aug., p. 893). On page 895, Lord Rayleigh, not Lord Kelvin, wrote a letter to Niels Bohr regarding Bohr's 1913 paper. The top photo on page 897 was incorrectly credited: it should have been credited to A. Zeilinger, *Rev. Mod. Phys.* **71**, S288 (1999). And co-author R. Jackiw is the Jerrold Zacharias (not "Jacharias") Professor of Physics at the Massachusetts Institute of Technology.

Table of Contents: Photo titled "Modern glacial retreat" (14 Jul., p. 208). Credit for the photo, a view from the summit of Mt. Gould of the remnants of Grinnell Glacier in Glacier National Park, Montana, was not provided. The photo was supplied courtesy of Daniel B. Fagre of the U.S. Geological Survey.

News Focus: "Biotech research proves a draw in Canada" by Anne Simon Moffat (30 June, p. 2308). The first item, "Making plants more stress tolerant," incorrectly stated that Peter Steponkus used one of the transcription factor genes identified by Kazuko Yamaguchi-Shinozaki and Kazuo Shinozaki to transform *Arabidopsis* plants. Instead, he used plants transformed by the Shinozakis for his experiments.

Report: "Uninterrupted MCM2-7 function required for DNA replication fork progression" by K. Labib *et al.* (2 June, p. 1643). The URL cited in note 11 for the location of supplementary data at *Science* Online is incorrect. The correct URL is www.sciencemag.org/feature/data/1048585.shl

Policy Forum: "A nuclear solution to climate change?" by W. C. Sailor *et al.* (19 May, p. 1177). In the accompanying table, the units for the entry "Total per capita," referring to energy consumption, should have been GJ/year, not EJ/year.