Uranium isotope ratios are not invariant, researchers show

October 23 2007

For years, the ratio of uranium's two long-lived isotopes, U-235 and U-238, has been considered invariant, despite measurements made in the mid-1970s that hinted otherwise. Now, with improved precision from state-of-the-art instrumentation, researchers at the University of Illinois unequivocally show this ratio actually does vary significantly in Earth materials.

The new findings are in line with recent findings in other high-mass isotope systems – such as thallium or mercury – that had been assumed to be invariant. Additionally, the new measurements "could represent the first evidence of the nuclear field shift found in nature," said U. of I. graduate student Charles J. Bopp, who led the study.

What, exactly, causes the variance is not yet clear, though, Bopp said.

There are two basic types of uranium ore deposits: magmatic, which develop due to hydrothermal effects; and sedimentary, which develop by chemical reduction of uranium in groundwater in subsurface aquifers.

In 1976, scientists George Cowan and Hans Adler analyzed gas mass spectrometry results of uranium hexafluoride (before artificial isotopic enrichment processes took place) derived from uranium ores around the world. This assessment revealed a slight offset in the distribution of the ratio of U-235 to U-238, with magmatic-type deposits having on average higher U-235 percentage weight and sandstone-type deposits having lower.

However, the precision of individual analyses remained approximately 3 per mil (3 parts per thousand) while the average offset between deposit types was less than this.

With the higher precision now obtainable in the UI geochemistry laboratory, Bopp and UI geology professor Craig Lundstrom have observed the same offset between uranium ores from different geologic settings.

The researchers used a technique called multiple-collector inductively coupled plasma-mass spectrometry to measure the ratio of U-235 to U-238 in three sandstone-type and three magmatic-type uranium ores provided by the Smithsonian Institution.

“Repeated analysis of the ore samples shows the sandstone-type ores to be consistently depleted in U-235 relative to magmatic-type ores by approximately 1 per mil, which is a significant amount of variation,” said Bopp, who will present the findings at next week’s annual meeting of the Geologic Society of America.

The observed depletion of U-235 is most likely the result of a nuclear field shift effect as isotopes partition between the water and the reduced uranium ore mineral, Bopp said. But what uranium reduction process – biotic or abiotic – is responsible is not yet clear.

“We can’t parse that apart at this stage,” Bopp said. “We observe a depletion, and we know there are microbes present in these types of deposits, but we can’t say for sure who’s doing what without a much more in-depth study of a single locality.”

Source: University of Illinois at Urbana-Champaign