A global survey of oxygen isotopes of uranium ores

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Uranium is a trace element in nature (about 3 and 0.015 ppm in the crust and mantle, respectively), but its high concentrations occur as various types of ore deposits on many continents throughout Earth history. Uranium ore is an essential material in the preparation of nuclear fuel for civilian as well as military uses. Uranium is first extracted from uranium-bearing minerals, precipitated as yellow cakes, and then processed for isotope enrichment. The disintegration of the former Eastern block and frequent unrest in the Middle East have underscored the need for better characterizing source uranium ores for forensic and attribution purposes.

In order to understand their depositional environments and assess the potentials as forensics-attribution tools, we have conducted a global survey and analysis of oxygen isotopic compositions of various uranium minerals. The world's major uranium deposits occur in several distinctly different geological environments: 16 principal types of U deposits with more than 40 subtypes. Combining our own analysis and literature data, we have amassed over 250 oxygen isotope data from 13 major U-producing countries, which vary widely from -32 to +11 ‰ in their $\delta^{18}O$ values. However, interpreting the oxygen isotopic composition of uranium minerals in terms of the composition of the fluid from which they precipitated, or interacted with, requires knowledge of the fractionation factor and temperature of interactions, which are not always available. Since each deposit type occurs within a unique geologic setting and is generally formed from chemically distinct fluids, the chemical compositions of the uranium ores are also distinct: uranium deposits that formed in igneous rocks have higher trace element compositions relative to sandstone-hosted deposits. Our data shows that one of the most useful techniques for distinguishing between different uranium ores and identifying source uranium deposits would be to use a combination of $\delta^{18}O$ values and trace element (e.g. La/Yb ratios).

A desolvating nebulizer system for U-Series dating with multicollector ICP-MS

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Multicollector ICP-MS instruments are specialized devices for high-precision isotope ratio measurements. Often prepared liquid samples are very concentrated, which can cause long analyte washout times and analyte signal spikes.

A low-flow, desolvating nebulizer system with a fast washout accessory will be described. This nebulizer system is also coupled with a dedicated autosampler that has a dual-flowing rinse capability to minimize any sample carryover. Wetted parts are composed of fluoropolymers such as PFA (perfluoroalkoxy) for maximum chemical resistance.

Optimum operating conditions for this combination system with a multicollector ICP-MS will be described, with data concerning signal enhancement and stability, interference reduction, and washout times. Application for the U-series dating of a stalagmite sample will be presented.