Molybdenum isotopic determination in uranium-rich materials: Constraints on the nuclear fuel cycle

VALERIE MIGEON[12]*, BERNARD BOURDON[2], ERIC PILI[1] AND CAROLINE FITOUSSI[2]

[1]CEA, DAM, DIF, F-91297 Arpajon, France
[2]Laboratoire de Géologie de Lyon, ENS Lyon, 46 allée d'Italie, 69364 Lyon Cedex 7, CNRS and UCBL, France (*correspondence : valerie.migeon@ens-lyon.fr)

Molybdenum (Mo) shares analogous geochemical properties with uranium. Mo is present as a minor or a trace element in uranium ores under two main oxidation states: +IV and +VI. In natural systems, Mo isotopes were shown to fractionate mainly during redox reactions. As Mo represents an impurity difficult to separate in the nuclear fuel cycle, it has the potential to be used as an indicator for the origins of uranium concentrates, in the framework of nuclear forensics.

This study focuses on analyzing the Mo isotope compositions in uranium ores and in uranium materials produced during the nuclear fuel cycle, until the formation of uranium ore concentrates. The main steps are: i) lixiviation of uranium ores, ii) ion-exchange chromatography or solvent extraction for uranium purification processes and iii) precipitation of uranium ore concentrates. A specific chemical separation was designed for the purification of Mo, from the U-rich matrices, using a three-step separation on ion-exchange resins. Mo isotopic compositions were measured using a double spike on a Neptune Plus MC-ICP-MS equipped with Jet cones, for a concentration of 30 ng/ml, The sensitivity was typically ~1200-1800 V/ppm, and the external reproducibility of 0.02 ‰ (2 SE, n=14) on the δ^{98}Mo values.

Results on lixiviation tests on a U-rich granitic ore have shown a significant enrichment in heavy isotopes in the solution relative to the δ^{98}Mo of uranium ores, which is analogous to what is observed during weathering processes on the Earth's surface. Thus, the Mo isotopic compositions of uranium ore concentrates can be used as a tracer of uranium purification processes.