Mo isotopes as a tracer of the nuclear fuel cycle

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It is a challenging question to be able to identify, based on chemical and isotope analysis, the provenance and transformation of materials derived from the nuclear fuel cycle. With this goal in mind, we have attempted at developing a new isotope tool, Mo isotopes. In constrast to uranium isotopes that are not fractionated in U concentrates, the effort aimed at eliminating Mo from these concentrates tend to maximize its fractionation, making it a particularly effective tool for tracing materials from the U nuclear cycle.

The first challenge was to develop an analytical method to analyze Mo isotopes in U-rich matrices. This has required redesigning entirely the chemical separation of Mo. The technique we developed also enables minimal amounts of Mo to be analyzed to avoid handling of large amounts of uranium in the laboratory. Second, we have analyzed Mo-isotopes in a series of U-bearing minerals that are commonly contained in ores, in different types of U ores and in U ore concentrates from various plants around the world. Third, we have performed experiments to reproduce the individual processes involved uranium hydrometallurgy.

Our Mo isotope survey shows that it is possible to distinguish uranium ores based on the origin of uranium found in the ores. Namely, the ores where uranium is of sedimentary origin show a fractionated Mo isotope composition relative to that of the bulk silicate Earth. Our results on leaching experiments, solvent extraction and uranium salt precipitation provide essential keys to understanding the isotope compositions of uranium ore concentrates. We have been able to demonstrate the existence of Mo isotope fractionation during leaching and show that the processes leading to isotope fractionation are both linked to the dissolution itself and to Mo adsorption. The role of adsorption is highlighted and the nature of leaching agents controls the existence of these secondary reactions. Beyond the tracing, understanding Mo isotopes provides key insights into the reactions taking place in this complex media.