Origin assessment of uranium ore concentrates: Sm isotopes as a new nuclear forensic signature

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The ability to trace the origin of intercepted nuclear material is of utmost importance for non-proliferation efforts. Uranium ore concentrate (UOC) is mined and milled from U ore, and is an early product of the nuclear fuel cycle. It is thus a regulated material and diversion of UOC from regulatory control is a genuine concern. Previous work has demonstrated that the isotopic patterns of O, S, Sr, Nd, Pb, and U can be valuable nuclear forensics signatures to determine the source of unknown material [e.g., 1-7]. However, as integrated signatures provide the most confidence in deciphering the origin of unknown samples, new signatures are required; particularly those indicative of source rocks and those that are less likely to be contaminated during processing.

One promising source signature of UOCs is the signature from neutron capture reactions in the ore body. Although this has been investigated using ^{236}U excesses (from neutron capture on ^{235}U) in U ores [5], extreme analytical difficulties and limited facilities capable of making ^{236}U measurements severely limits ^{236}U as a practical signature. Alternatively, the large thermal neutron capture cross section of ^{149}Sm (~40,000 barns) represents another promising monitor of neutron capture reactions in an ore body.

To this, we have analyzed the Sm isotope compositions of over 30 UOCs derived from a variety of U mines worldwide. Approximately half of the studied UOCs exhibit resolved depletions in ^{149}Sm coupled with corresponding excesses in ^{150}Sm, a pattern indicative of neutron capture. Samarium isotopic signatures in UOCs are controlled by a combination of factors, but our data reveal UOC derived from older ore bodies (>1 Ga) in general have significantly more evidence of neutron capture than UOCs from younger ore bodies. Although Sm isotope signatures alone cannot trace the exact source of unknown material, it is a promising new signature for origin assessment.

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