A new method for high-precision Sm isotope analyses: applications to natural and perturbed samples

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Analyses of samarium (Sm) have been conducted for many years by TIMS ICPMS for determining the isotopic composition and concentrations of Sm in a wide range of natural and anthropogenic sample types. However, recent improvements in ionization techniques and detector technology allow for measurements at higher precision than in the past.

In this submission, we present a new method for sample loading and ionization on a single TIMS filament, utilizing a tantalum fluoride (TaF) activator. We demonstrate that this method allows for high ionization efficiency and produces long term stable beams for samples as small as 1-10 ng Sm. In concert, we also describe a separation procedure for isolating pure Sm from samples.

One of the major limitations of isotopic analyses in "non-natural" samples is the lack of a stable isotope pair to account for machine-induced fractionation in the TIMS or ICPMS analysis. Typically this is conducted normalizing to a known stable ratio (e.g., ^{147}Sm/^{152}Sm, ^{147}Sm/^{154}Sm ^{149}Sm/^{152}Sm, etc.); however in the case of samples such as natural reactors [e.g., 1], nuclear reactors [2], lunar samples [3], or others where significant fission input or neutron capture has occurred, the choice of normalizing ratio becomes significantly more complicated. In the past, this has been handled by either assuming that the effect of neutron-induced perturbations is minor compared to analytical precision, or by assigning a "factor" to account for the uncertainty. However, the isotopes ^{144}Sm and ^{148}Sm are not perturbed either by fission input, or by neutron capture, and therefore represent a stable isotope pair that can be used for normalization. This situation is complicated by the fact that ^{144}Sm and ^{148}Sm are the least and 3rd least abundance isotopes respectively and analytical precision is consequently expected to be poor. We will demonstrate that analytical precision (both internal, and long-term external) are very good using this normalization technique and that for analyses of natural samples and standards, the calculated values normalized to ^{144}Sm/^{148}Sm are in agreement with those normalized to ^{147}Sm/^{152}Sm.

[1] Ruffenach et al., 1976, EPSL; [2] Sharp et al., 2016, JRNC; [3] Russ et al., 1971, EPSL.