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Developing Zn isotopic analyses for nuclear forensics applications

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The moderately volatile element zinc (Zn) has five stable isotopes that enable its use as a tracer of physical processes including planetary melting [1] and evaporative fractionation at high temperatures [2, 3]. The use of Zn as a forensic tool in the field of geochemistry and its application to nuclear forensics to trace the distance of trinitite samples from ground zero of the Trinity test [2] suggest that Zn isotopes may be useful tracers for a wider array of nuclear forensics applications such as sample origin tracing and characterization of the extreme environments present during nuclear tests. Our current knowledge of these extreme environments is primarily based on a limited set of isotope systems comprised of extremely refractory or extremely volatile elements, and by applying new systems with a broad range of volatilities we can gain additional understanding of extreme conditions through indirect observations of processes that cannot be directly sampled. Zinc isotopes may also provide novel environmental signatures through mass independent fractionation as the result of irradiation and formation of activation products [4]. The development of new isotopic tracers, such as Zn, that are well characterized in natural geological samples will also provide constraints for sample origin tracing of nuclear materials.

We aim to use Zn isotopes as forensic tracers of extreme conditions and sample origins through the study of a variety of nuclear samples including nuclear debris materials. The extreme conditions experienced by the samples of interest make it difficult to utilize traditional internal normalization techniques, so the development of an in-house double spike will enable the determination of high-precision ratios to determine the extent of mass-dependent and in some cases mass-independent signatures. In this study, we report the development of column chromatography methods designed to separate Zn from a suite of geological and nuclear materials, the design of multi-collector inductively coupled plasma mass spectrometry techniques, and the implementation of a Zn double-spike method.

References:

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