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Gadolinium Isotopic Signatures in Nuclear Material

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Establishing geochemical and isotopic techniques that can uniquely identify and geolocate nuclear material is of great interest to the international nuclear forensics community. In this effort, isotopic systems such as uranium and plutonium can be used as indicators for the provenance of nuclear materials. However, additional systems are needed to uniquely and confidently identify signatures and sources of nuclear material across the fuel cycle. Two isotopes of gadolinium, 155Gd and 157Gd, have extraordinarily high thermal neutron capture cross-sections (the probability the nucleus will capture a thermal neutron at a given neutron energy). Consequently, the isotopic composition of Gd will be altered as a function of neutron fluence, and thus potentially act as an isotopic signature in samples that have experienced significant neutron exposure. Whereas the isotopic composition of Gd has been used for decades to investigate the neutron fluence on the Moon, Gd isotopes have yet to be widely applied in the nuclear forensic community. Because Gd is present at fairly high concentrations throughout various stages of the fuel cycle and the isotopic composition of Gd is significantly altered by the exposure to neutrons, Gd represents a prime candidate as an isotopic fingerprint in nuclear materials.

Procedures for the chemical separation and high-precision measurement of Gd isotopes in various substrates have been recently developed at Lawrence Livermore National Laboratory. Our current level of precision working with samples of ˜100 ng total Gd allows the detection of deviations in Gd isotopes as small as 1 part in 10,000 from a terrestrial standard and potentially provides a very powerful isotopic signature for nuclear materials. Preliminary investigation of Gd isotope variations in nuclear material are underway.

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