Development of ^{226}Ra standards for high-resolution NanoSIMS analyses of environmental samples

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Human activities such as nuclear operations, and uranium (U), coal, and phosphate mining have induced the release of radionuclides into the environment, raising concerns about their persistence and effects on populations and ecosystems due to ionizing radiation exposure. Understanding their sources, mechanisms of dispersion, and spatiotemporal evolution is essential for developing effective remediation strategies.

Traditional bulk sample analyses often conceal critical information about contamination sources because of isotopic mixing and/or concentration dilution caused by the matrix elements of the geochemical background. They rarely provide insights into the nature and past evolution of radionuclide-bearing phases. High-resolution imaging techniques such as SIMS and NanoSIMS offer a powerful alternative, enabling isotopic mapping at the grain scale.

In this work we developed and validated ^{226}Ra-bearing barite ($BaSO_4$) standard (2.89 and 9.65 $mg.kg^{-1}$) for NanoSIMS calibration. This methodological development addresses key analytical challenges related to the low abundance of ^{226}Ra and spectral interferences. We identified $^{88}Sr^{138}Ba^+$ and $^{208}Pb^{18}O^+$ as potential polyatomic interferences and demonstrated that they do not significantly affect the $^{226}Ra^+$ signal when mass resolution and peak alignment are carefully optimized. Measurements have reproducibility of 6% and 7% (2σ) across analytical sessions depending on Ra content.

Applied to contaminated wetland soils from the former Rophin U-mining site (France), SIMS and NanoSIMS revealed distinct U and Pb-bearing phases, identified multiple contamination sources, and documented heterogeneous distributions of ^{238}U, and ^{226}Ra within single grains. These results provide new insight into the incorporation of radionuclides, supporting improved models for contamination evolution and site strategies.