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Applying the isotope geochemistry toolkit to nuclear forensics

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The relatively young field of nuclear forensics that has emerged over the last few decades uses a range of analytical techniques to determine the origin and history of radioactive materials to inform law enforcement investigations. This presentation summarises recent, ongoing and future areas of research at our laboratory that employ advanced isotope geochemistry techniques to characterise special nuclear material. These research areas include (A) The use of high precision uranium isotopic measurements ($\delta^{234}U$, $\delta^{238}U$) to infer the depositional redox environment of uranium ore concentrates [1]. (B) Application of geochronological methods to man-made radioactive materials to determine a model date of last chemical separation. Recent work on radiochronometry includes: an international multi-laboratory comparison exploring discordance of $^{230}Th/^{234}U$ and $^{231}Pa/^{235}U$ in depleted uranium metals produced via different casting methods [2]; collaborative work with the European Commission to establish certified reference materials for plutonium radiochronometry measurements [3]. (C) A brief description of future work exploring the diagnostic value of traditional stable isotope signatures in special nuclear material, specifically $\delta^{18}O$. Finally, an overview of our laboratory's participation in the seventh collaborative materials exercise (CMX-7) (conducted January 2022), organised by the International Technical Working Group on Nuclear Forensics, to demonstrate and test these analytical techniques.

[1] Keatley A. C., Dunne J. A. et al. (2021). Uranium isotope variations within vein-type uranium ore deposits. Applied Geochemistry 131: 104977.

[2] Higginson M. A., Dunne J. A. et al. (2022). Application of plutonium radiochronometry to the analysis of plutonium age dating reference materials. Journal of Radioanalytical and Nuclear Chemistry (*In review*).

[3] Higginson M. A. et al. (2022). Establishing discordance as a radiochronometric signature for nuclear forensics investigations: a multi-laboratory intercomparison exercise. Journal of Radioanalytical and Nuclear Chemistry (*In prep.*).