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Statistical Discrimination of Uranium Ore Concentrate Using Trace Element Signatures: Developing nuclear forensic fingerprints

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Similar to ordinary forensics, nuclear forensic science uses data and modelling to infer historical information such as origin and production processes. To do this, unique characteristics of different nuclear material that make up nuclear fingerprint must be identified. To date, very few characteristics have been identified as signatures for uranium ore and uranium ore concentrate(UOC) including the REE pattern and trace elements (geological indicators of deposit type). In this study, the concentrations of trace elements: Ti, V, Cr, Co, Ni, Cu, Zn, Ga, Rb, Sr, Y, Zr, Sn, Cs, Ba, W, Pb in 9 different UOC surrogate samples collected from Botswana and Nigeria were determined using Inductively Coupled Plasma Mass Spectrometry. The compositional trace element data were subjected to an arsenal of univariate and multivariate statistical analysis techniques such as correlation analysis, one-way Analysis of Variance, Principal Component Analysis, and Hierarchical Cluster analysis to quantify the statistical significance of the differences observed and to test the potential discriminative power of individual trace elements between ores from the same region. ANOVA revealed significant differences ($p<0.5$) in Ti, Zn and Pb only while no significant differences ($p>0.05$) were observed in V, Cr, Co, Ni, Cu, Ga, Rb, Sr, Y, Zr, Sn, Cs, Ba, W. The study further found three principal components that explained 91% of the variance in the UOC samples. PC1 (V, Ti, Pb, Sn), PC2 (Cr, Cu, Zr) and PC3 (Cs, Rb, Zn), respectively. This study highlighted the potential trace elements signatures to distinguish between uranium ore from different locations.

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