B201 Modeling of Elemental and Isotopic Data for Reference Populations Distribution Functions to Be Used in Comparison Evidence and Provenance Intelligence

Jurian A. Hoogewerff, PhD, National Centre for Forensic Studies, Faculty ESTeM, University of Canberra, Bruce - Canberra, ACT ACT 2601, AUSTRALIA*

After attending this presentation, attendees will appreciate the potential of using multivariate geochemical elemental and isotope data to establish background population data for comparison analyses of soil and other natural materials and the use of the spatial distribution of this data for geographical provenancing intelligence.

This presentation will impact the forensic science community by creating awareness that it is possible to produce fit-for-purpose population distribution functions for natural materials with existing geospatial data, which can be used in forensic comparison analysis and for provenance intelligence.

In many instances, comparison analysis of trace evidence involves statistically open sample sets (e.g., that the source of a questioned sample might either be in a control set or not). The extreme case is where no control samples are available. In such a case, any intelligence about a possible source of a questioned sample, or exclusion of non-relevant sources, would greatly assist an ongoing investigation as it could provide guidance as to where to deploy resources.

At first glance, using multivariate elemental and isotopic data, typically 30+ variables, would seem to enable high levels of evidentiary discrimination; however, due to the nature of physical and geochemical processes involved, many of the elemental and isotopic data distributions are not independent and thus typical Random Match Probabilities (RMP) are in the order of 1 in 1,000 to 1 in 100,000, which is much lower than in forensic nuclear DNA analysis where sets of typically 16 independent genetic markers give RMPs in the order of 1 in billions.

As with forensic DNA analysis, it is essential for any forensic or intelligence interpretation to make reasonable assumptions about the structure of the background population distribution (e.g., the Population Distribution Function (PDF)) for each of the variables, element concentration, or isotope ratio, in the relevant context of a case.

With closed sample sets, one can determine the PDFs by measurement, if affordable, and create a closed database. The database can subsequently be used in either a frequentist or Bayesian approach to determine the RMP and/or Likelihood Ratio (LR).

With open sample sets, the challenge is to extrapolate outside a (by its nature) closed measured control database or, as mentioned above, make predictions even without a control database. Although at first instance it may seem paradoxical to predict outside the "box," it is possible to take advantage of the aforementioned systematic physical and chemical processes and natural boundary conditions to model and predict the PDFs of element abundances and isotope ratios in natural materials. The models will have uncertainties but, as they can be quantified, their effect on the RMP and/or LR can be expressed. Typically those uncertainties are small relative to the magnitude of the RMP and/or LR and thus do not affect their probative value.

In this presentation, a combination of climate and geological data models for Europe will be used to create intelligence about the likely provenance of a murder victim from a cold case in the United Kingdom. This cold case is from the south of the United Kingdom where a beheaded and "behanded" torso was discovered in 1991 and buried as unidentified in 1994. Exhumation in 2010 and subsequent oxygen, strontium, and lead isotopic analysis combined with spatial models for these three isotopes gave the cold case investigators the information to reinitiate the search for the origin of the victim.

Distribution Functions, Provenance, Comparisons

*Presenting Author