H71 Application of Stable Isotope Forensics for Provenancing Human Remains Recovered From Southeast Asia and the Pacific

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The goal of this presentation is to highlight the value of stable isotope forensics for provenancing human skeletal remains from unknown contexts. After attending this presentation, attendees will gain an understanding of the potential value of stable isotope forensics and how these approaches complement other human identification methods.

This presentation will impact the forensic science community by highlighting the potential of stable isotope forensics in provenancing human remains to aid in forensic identification.

The application of stable isotope analysis has provided novel approaches for provenancing unidentified human remains from forensic contexts. Stable isotope values measured in human tissues (e.g., bone, teeth, hair, and nails) provide a record of an individual's life history and location. Human bone stable carbon and nitrogen isotopes of collagen and stable carbon isotopes of bioapatite reflect consumption of food resources, which vary between geographic regions due to cultural dietary differences. Stable oxygen isotopes of bioapatite vary between regions due to environmental factors (e.g., aridity, elevation, and distance from large bodies of water) that influence the isotopic composition of drinking water.

This study discusses the application of stable isotope forensics for provenancing human bone obtained by the Joint POW/MIA Accounting Command, Central Identification Laboratory. Stable isotope analysis of human bone was used to determine whether U.S. Americans could be distinguished from Southeast Asians. More specifically, isotope values consistent with consumption of a strictly C_3-based diet (e.g., rice) were considered to be more likely associated with individuals from Southeast Asia, whereas values consistent with greater consumption of a mixed C_3/C_4 diet (e.g., corn, sugar) were considered to be more likely from North America.

The study included 30 human bone samples recovered from various sites in Southeast Asia and the Pacific, which were selected from known incidents and had a known number of decedents (i.e., while the exact identity of each individual may not be known, the origin of the individual is known — either U.S. American or Southeast Asian). mtDNA and haplogroup assignments by the Armed Forces DNA Identification Laboratory were available for 27 of the samples; for three additional samples, other information pointed to the origin of the individual. The database included 27 samples and the remaining three samples were used as a hold-out test case.

Stable carbon isotope values of bone collagen varied from -20.5 to -14.7‰ (mean -17.4‰ ± 2.1), and stable nitrogen isotope values varied from 9.2‰ to 14.2‰ (mean = 11.9‰ ± 1.1). Bioapatite values varied from -17.1 to -8.9‰ (mean = -13.2‰ ± 2.6) for stable carbon isotopes and -9.9 to -4.9‰ (mean = -7.4‰ ± 1.0) for stable oxygen isotopes. The stable carbon isotope values of both collagen and bioapatite form a bimodal distribution and indicate diets consisting of varying amounts of C_3 and C_4 resources. When compared by known provenance, there was minimal overlap in collagen and bioapatite stable carbon isotope values between U.S. Americans and Southeast Asians. As expected, U.S. American stable carbon isotope values were significantly elevated relative to Southeast Asians, reflecting greater contribution of C_4 resources in the diet. Linear discriminant function analysis correctly classified 96.3% (cross validated) of the samples based on stable carbon isotope values. Stable nitrogen isotope values of bone collagen show much lower variation and were not significantly different between groups.

Three samples, representing different skeletal elements from the same individual, were selected as a test case. Stable carbon isotope values were nearly identical; importing the sample and study data into FORDISC® 3.0, custom discriminant functions were generated for analysis. Stable carbon isotopes of collagen classified the samples as U.S. American with posterior probabilities between 0.711 and 0.557. Carbon isotopes of bioapatite yielded similar results. Cross-validated accuracy rates were 96.3% with this model. The addition of stable nitrogen isotopes to the analysis still classified the samples as U.S. American, but with lower posterior probabilities.

Looking forward, isoscape models will next be used to predict possible areas of geographic origin within a specific region based on the spatial distribution of oxygen isotopes in drinking water. This study has demonstrated that stable isotope analysis provides valuable information for estimating the provenance of human remains and can aid in eliminating samples from consideration that are unlikely to be of forensic significance.

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Forensic Anthropology, Stable Isotope Analysis, Provenancing Human Remains

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