A101 Assigning Region of Origin in the Southeastern United States Using Stable Oxygen Isotopes of Modern Human Enamel

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After attending this presentation, attendees will understand the importance of developing regional stable oxygen isotope drinking water comparisons. Attendees will be informed of the application of assignment models to determine accurate predictions of region of origin in forensic investigations using isotopic signatures.

This presentation will impact the forensic science community by demonstrating the advantages of applying human enamel from individuals with known residential histories to tap water isoscapes for accurately predicting the decedent's region of origin in forensic investigations.

Isotope analysis has become increasingly popular for narrowing the region of origin for unidentified human remains in forensic investigations. Stable oxygen isotopes ($\delta^{18}O$) in enamel reflect early life residential history and stable hydrogen isotopes ($\delta^{2}H$) in hair keratin records later geographic movement, months before death. Skeletal preservation in the southeastern United States is typically poor due to the humid subtropical climate, sometimes limiting the isotope analysis package to $\delta^{18}O$ of enamel.

Distinct spatial $\delta^{18}O$ distributions in tap water assist in narrowing the decedent's region of origin in unidentified persons cases. Human oxygen isotope measurements are compared to the spatial tap water distributions using baseline tap water isoscapes. Furthermore, understanding the relationships of enamel and water isotopes improves the assignment prediction models in forensic investigations. The goals of this research were to investigate the relationship between enamel and tap water oxygen isotopes in the southeast and use the relationship to improve region of origin predictions for modern human enamel.

Enamel (n=11) samples obtained by the United States Air Force Academy (USAFA) from individuals whose third molars were extracted between 2004 and 2005 were processed.[1] Residential history information recorded for the participants included birth city and state, and residential history including the year and geographic information of relocations. The USAFA sample measurements ($\delta^{18}O$ carbonate) reported on the Vienna Peedee Belemnite (VPDB) scale were converted to $\delta^{18}O$ phosphate (Vienna Standard Mean Ocean Water (VSMOW)).[2,3] Tap water data were extracted from previously reported oxygen tap water values for the United States.[4,5] Converted AFA data, (i.e., $\delta^{18}O_{ep}$) from individuals with early southeastern United States residential origins were regressed against tap water isotope $\delta^{18}O_{tw}$ values.

To determine if the relationship would improve predictions for human enamel in the southeast, an assignment model based on likelihood predictions was used to estimate region of origin. Likelihood assignment methods based on probability are more accurate and may incorporate prior probability using Bayes' rule to directly estimate origin based on previous data. A likelihood assignment model was developed using Geographic Information Software (GIS) and the USAFA sample (AFA134) from Southaven, MS, was assigned to the calibrated isoscape.

The relationship between the southeastern individuals and the tap water was $\delta^{18}O_{ep} = 0.704 * \delta^{18}O_{tw} + 20.07$ ($R^2 = 0.89$) and was calibrated into the isoscape assignment model. The $\delta^{18}O_{ep}$ for the state of Mississippi ranged from 16.22‰ to 16.94‰, compared to AFA134 whose oxygen isotope value was 15.846‰. Sample AFA134 was an ideal participant for this study, being a local resident of Southaven, MS, from birth until the age of 20. The likelihood model predicted the region of origin for AFA134 from a geographical band spanning from southern Washington County to central Alcorn County on the northern Tennessee boundary. The Southaven area had a slightly lower predicted outcome than the 90% probability band just south of the actual residential origin of AFA134.

Since enamel reflects the $\delta^{18}O$ sources of body water, the human signature is enriched compared to the $\delta^{18}O$ of the tap water. Therefore, the tap water isoscape was calibrated to make it comparable when assigning region of origin for modern human dentition in the southeastern United States. Individuals sampled from Florida were omitted from the study due to disproportionate relationships with tap water. The relationship between tap water and human enamel from this study ($\delta^{18}O_{tw} = 1.2704 * \delta^{18}O_{ep} - 26.01$) is similar to the relationship Daux et al. ($\delta^{18}O_{tw} = 1.54 * \delta^{18}O_{ep} - 33.72$) demonstrated for human $\delta^{18}O$ values.[6] The differences between the two conversion equations may relate to source water and sample availability, suggesting that specific human-to-drinking-water $\delta^{18}O$ conversions should be applied dependent upon the geographic region of the research study. Variability is expected as many factors complicate regional $\delta^{18}O$ values, especially in modern humans and globalization.

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Isotope, Oxygen, Assignment Model