A75 The Utility of Stable Isotope Ratios of Tap Water and Human Teeth as Predictors of Region of Origin in Central and Southern Mexico

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The goals of this presentation are to explore the relationship: (1) between oxygen and hydrogen isotopes in tap water sources available to Mexican populations from traditionally high immigrant sending areas; and, (2) between these water samples and tooth samples of known origin.

This presentation will impact the forensic science community by presenting data on the relationship between Mexican tap water and human tooth enamel and by examining the utility of this relationship to act as a predictor of region of origin.

The use of oxygen and hydrogen isotopes in human drinking water, hair, bone, fingernails, and teeth has demonstrated the ability to track movement and identify the region of origin for modern populations.[1] In this study, the ability of human tooth enamel to predict region of origin in modern Mexican populations by estimating drinking water from tooth enamel is tested.

The water samples consist of 224 samples of tap water collected from 13 contiguous states in Central and Southern Mexico. Hydrogen and oxygen water isotopes were measured for tap water samples for all locations using laser absorption spectroscopy at the University of Utah Stable Isotope Ratio Facility for Environmental Research (SIRFER) laboratory. Sixty-four human tooth samples were collected from four states (Yucatan, Michoacán, Oaxaca, and Mexico) and analyzed for ^{18}O and ^{13}C isotopes at the University of California Santa Cruz (UCSC) Keck isotope facility. All carbonate analysis was conducted for the tooth samples using a Thermo™ Finnegan Gas Bench II connected to a Thermo™ Delta Plus XL continuous flow mass spectrometer. Replicates of NBS-19 resulted in a reproducibility of 0.1‰ and 0.2‰ for $\delta^{18}O$ and $\delta^{13}C$. The results are reported here using delta notation and the Vienna Standard Mean Ocean Water (VSMOW) and Vienna Peedee Belemnite (VPDB) scale. Drinking water values from tooth enamel were estimated using the following equations by Iacumin et al. and Daux et al.[2-3]

All reported data has been calibrated to the VSMOW-Standard Light Antarctic Precipitation (SLAP) scale. Tap water values spanned a range from -12.7‰ to +0.4‰ and -91.7‰ to -4.2 ‰ for $\partial^{18}O$ and $\partial^{2}H$, respectively. The most ^{2}H and ^{18}O depleted tap water samples were distributed over the inland high-altitude regions of Puebla, Morelos, and Oaxaca. The local Meteoric Water Line (LMWL) for tap waters was $\partial^{2}H=7.78 * \partial^{18}O+7.0$, $r^2=0.96$. The slope of the LMWL for tap waters is similar to that of the Global Meteoric Water Line (GMWL), which has a slope of eight.

Oxygen values for tooth enamel ranged from 23.1‰ to 28.1‰. Estimated drinking water values ranged from -4.8‰ to -11.3‰, with the most depleted drinking water estimates coming from inland Michoacán and the most enriched drinking water estimates coming from Coastal Oaxaca. A one-way Analysis of Variance (ANOVA) was conducted to determine if the means of estimated drinking water values and measured drinking water values were different for four regions in Mexico. Means for measured and estimated drinking water were statistically significantly different between regions $F(7,104) = 7.817$, ($p<0.05$). Tukey Kramer post hoc analysis revealed that estimated drinking water values from each of the four regions were not statistically significantly different from actual measured drinking water values from the regions; however, the test also revealed a substantial amount of

overlap between estimated drinking water values and actual drinking water values between regions. In each case, estimated drinking water values were not significantly different from at least two alternate locations in addition to the region of origin. For example, estimated drinking water values for Mexico State were not significantly different from Michoacán actual drinking water values (p=0.167), nor Yucatan actual drinking water values (p=0.162).

Although clear patterns exist among measured water samples from different regions, there is also a significant amount of overlap. In order for patterns in measured water samples to provide useful information on provenance, products such as IsoMap or ArcGIS must be used to identify regional differences and identify areas of overlap based on estimated drinking water values.

Reference(s):

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3. Daux V., Lécuyer C., Heran M-A., Amiot R., Simon L., Fourel F., Martineau F., Lynnerup N., Reychler H., Escarguel G. (2008) Oxygen isotope fractionation between human phosphate and water revisited. J.isotope fractionation between human phosphate and water revisited. *J. Human Evolution.* 55, 1138-1147.

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