# Application of Stable Isotopes for Geolocating Unidentified Border Crossers from the Texas-Mexico Border

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## Abstract

This presentation uses stable isotope analysis in the identification of deceased undocumented border crossers (UBCs) from the U.S.-Mexico border. Since the 1990s, the U.S. launched security operations along the southern US border to curb undocumented immigration. This led to an increase in deaths and created a massive identification challenge (De León 2015; Jimenez 2009). This study uses isotopic data on border crossers to develop prediction tools for narrowing region-of-origin, which ultimately will aid in identification efforts.

## Introduction

Beginning in 2013, forensic anthropologists from Texas State University, the University of Indianapolis, and Baylor University began a collaborative service-learning project, Operation Identification (OpID), to aid in the identification and repatriation of unidentified migrants who died after crossing the border into the United States (Spradley et al. 2018).

The first large-scale excavation began in 2013 at the Sacred Heart Cemetery in Falfurrias, Texas, to exhume and identify as many individuals buried as possible. Migrant remains were transferred to the Forensic Anthropology Center at Texas State (FACTS) for skeletal processing, analysis, DNA sampling, and temporary curation. The Argentine Forensic Anthropology Team (EAAF) acquired family reference sample for DNA collection in collaboration with other U.S. and foreign government groups and NGOs (Gocha et al. 2018).

As of 2018, only 29 individuals have been positively identified out of the more than 270 cases processed through OpID. Many of those individuals identified were found to have been from various Central American countries such as Guatemala, Honduras, and El Salvador (i.e., The Northern Triangle). This project demonstrates how stable isotope analysis can be used as an exclusionary tool in the process of identifying missing migrants in the United States.

## Materials

The sample for this study consisted of 43 individuals. A paired sample of one premolar tooth and one metatarsal was collected from 30 individuals from the OpID project at FACTS. Bones and teeth from another 13 individuals were sampled by colleagues at the University of Indianapolis from the 2013 excavation.

## Methods

Stable isotopes are atoms of an element that contain the same number of protons and electrons but vary in number of neutrons. They are incorporated into skeletal tissues from the food we eat, beverages we imbibe, and the air we breathe. Life history information can be derived from isotope analyses of tissue types that form over different time intervals (Bartelink and Chesson, 2018).

Carbon isotope ratios vary based on which photosynthetic pathway a plant uses. Most foods, including fruits, vegetables, beans, and most grains, are $C_3$ plants. $C_4$ plants (like corn) and marine resources have higher $\delta^{13}C$ values compared to $C_3$ plants. Carbon isotopes may reflect residential histories because these foods are variably consumed according to cultural and regional dietary practices (Bartelink et al. 2018).

Stable isotope ratios of oxygen ($\delta^{18}O$) and hydrogen ($\delta^{2}H$) in meteoric water vary spatially based on temperature, distance from large bodies of water, aridity, and altitude (Chesson et al. 2018). Variations in O and H isotope ratios across space are incorporated into human tissues through drinking water. Strontium isotope ratios ($^{87}Sr/^{86}Sr$) reflect the geological age of the underlying bedrock in a region and are incorporated into plants and the animals that consume them.

## Results

The mean $\delta^{13}C$ values of bone collagen as well as bone bioapatite and enamel bioapatite are consistent with our expectations for UBCs and indicate a very high dietary contribution from $C_4$ resources. Similarly, bone and enamel bioapatite $\delta^{13}C$ values show a strong positive correlation ($r = 0.897$, $p < 0.001$), indicating dietary continuity in the consumption of $C_4$ resources between childhood and adulthood. For the majority of the UBC samples, isoscape prediction maps based on $\delta^{18}O$ isotope values are consistent with a Latin American origin and include areas within Mexico as well as portions of Central America. Some areas of the continental U.S. are also included.

Out of 41 tooth samples with available $\delta^{18}O$ isotope data, 88 percent (n = 36) included predictions within Latin America. Only five individuals fell into the continental US *only* based on their $\delta^{18}O$ values (between –8.7 and –6.9 ‰). **Fig. 1** is a histogram of the 43 bone collagen $\delta^{13}C$ values, and shows a multimodal distribution. When this distribution is equally partitioned into low (n = 6), medium (n = 13), and high (n = 24) $C_4$ diet groups, $^{87}Sr/^{86}Sr$ ratios of paired enamel and bone bioapatite $\delta^{13}C$ values tend to cluster by group (**Fig. 2**). This suggests a relationship between the amount of $C_4$ consumption and geographic location.

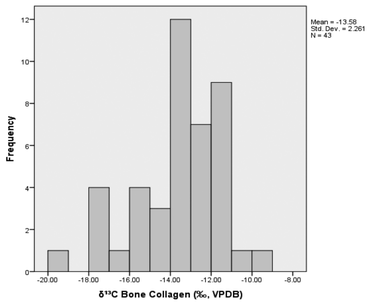


**Fig. 1. Histogram of bone collagen $\delta^{13}C$ values.**

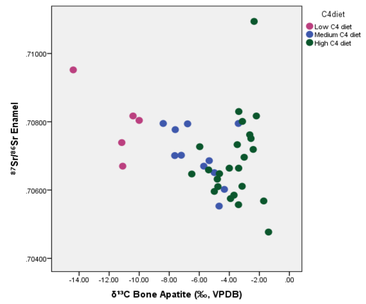


**Fig. 2. Bivariate plot of bone bioapatite $\delta^{13}C$ values .**

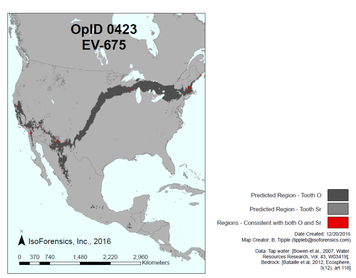


**Fig. 3. Isoscape prediction map for Case Study 1 (OpID 423) .**

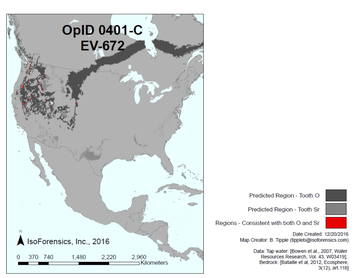


**Fig. 4. Isoscape prediction map for Case Study 2 (OpID 401-C).**

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## Case Studies

Two cases studies are used to illustrate how a multi-isotope approach can be used to generate investigative leads regarding unidentified UBC cases.

The first case study (OpID 423) is an unidentified Hispanic male, 29-54 years of age. His remains were discovered in Falfurrias, Texas in 2010. The decedent was wearing a shirt that was made in Guatemala, providing possible region-of-origin information. The $\delta^{13}C$ values for bone collagen (–9.8‰), bone bioapatite (–4.8‰), and enamel bioapatite (–1.7‰) indicate a diet heavily focused on $C_4$ resources (i.e., corn products), consistent with UBCs from Latin America. The isoscape prediction map based on enamel bioapatite $\delta^{18}O$ values includes the continental US, central and southern Mexico, Guatemala, and Costa Rica (**Fig. 3**). Although the isoscape prediction map only includes Sr predictions for the US, the $^{87}Sr/^{86}Sr$ ratio (0.70568) is consistent with known reference data for Guatemala, especially regions along the Motagua River Valley. Although not definitive, the data cannot rule out that OpID 423 could be a Guatemalan national.

The second case study (OpID 401-C) is an unidentified Hispanic female, 15-21 years of age. Her remains were discovered in Falfurrias, Texas in 2011. Although clothing and other personal effects were recovered with the remains, none pointed to a specific country or region-of-origin. The $\delta^{13}C$ values for bone collagen (–13.1‰), bone bioapatite (–7.1‰), and enamel bioapatite (– 4.7‰) indicate a dietary emphasis on $C_4$ resources (i.e., corn products), consistent with Latin American dietary practices. However, the isoscape prediction map based on enamel bioapatite $\delta^{18}O$ values excludes an origin in Latin America. The map also includes Sr predictions for the U.S. (0.70648), which overlap primarily within areas of the Intermountain West (**Fig. 4**). However, when only the $^{87}Sr/^{86}Sr$ ratio is considered, the results could be consistent with the Motagua River Valley of Guatemala or Copan region of Honduras. It is possible the decedent was born in Mexico or Central America, lived in the U.S. for some period of time, and then traveled back or was deported to that Mexican/Central American location from the US, before dying in an attempt to re-cross the border into Texas. This case highlights the complexity of predicting region-of-origin given that different isotope systems can be consistent with more than one location. At this point in time, there is not enough information to narrow the region of origin of OpID 401-C, so several possible scenarios should be considered.

## Conclusions

- This study highlights the value of stable isotope analysis as a useful tool in the identification of deceased migrants across the US-Mexico border by narrowing the possible regions-of-origin.
- This research identifies a dietary emphasis on $C_4$ foods (such as corn products) among the decedents in this study.
- This study stresses the presence of dietary continuity between childhood and adult diet among the decedents in this study.

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