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Re-interpreting ancient Maya mobility: a strontium isotope baseline for Western Honduras☆

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ABSTRACT

Isotopic data are regularly employed to investigate and reconstruct migration, diet, and other anthropological questions about the past. Here we present new radiogenic strontium isotope values for western Honduras that have been understudied in relation to mobility among the ancient Maya in Mesoamerica. We employ biologically available isotopic compositions ($^{87}Sr/^{86}Sr$) derived from local fauna and plants to create a baseline for these regions to determine the degree of movement into populations at Late Classic (600–820 CE) Copan, Honduras. Our results demonstrate that while movement certainly occurred within the Maya region, it also may have included areas beyond the perceived physical and cultural boundaries of the Maya world. We focus on the biogeochemical data to highlight how paleomobility ($^{87}Sr/^{86}Sr$) data should be used cautiously to understand mobility across Mesoamerica, and to consider how non-Maya peoples were likely part of Maya communities.

1. Introduction

The increasing use of biogeochemical methods in archaeological studies of migration is showing just how mobile people were in ancient Mesoamerican societies, especially among the Classic Maya (250–900 CE). Studies of nearly 900 individuals have identified in-migration into large centers and rural communities using radiogenic strontium isotope assays, finding that men, women, and children relocated to > 33 Maya sites (Cucina et al., 2015; Das Neves, 2011; Davies, 2012; Freiwald, 2011a, 2011b; Freiwald et al., 2014; Micklin, 2015; Miller, 2015; Mitchell, 2006; Novotny, 2015; Price et al., 2008, 2010, 2014, 2015; Scherer and Wright, 2015; Somerville et al., 2016; Sosa et al., 2014; Spotts, 2013; Sutinen, 2014; Trask et al., 2012; Wright, 2005a, 2005b, 2007, 2012; Wright and Bachand, 2009; Wright et al., 2010; Wrobel et al., 2014, 2017). Oxygen isotopes also have been used to examine population movement among the Maya (Donis, 2014; Scherer et al., 2015; White et al., 2001) as well as among other Mesoamerican groups who interacted with the Maya (Bullock Kreger, 2010; Price et al., 2000; Wells et al., 2014; White et al., 2000, 2004, 2007), and the number of published studies is increasing rapidly for both earlier and later time periods. Overall, in-migration reported for ancient Maya sites ranges from 15 to 25%, but movement into large centers may have been significantly higher as suggested by recent research using strontium geochemistry at large cosmopolitan centers (Miller, 2015; Price et al., 2014; see also Wright, 2005a).

Identifying a migrant's place of origin is complex, but is an important part of understanding patterns of population movement in ancient societies. Individuals with values that are statistical outliers from the rest of the sample population are usually designated as non-local to the site, but identifying their potential homelands is no simple task. Baseline radiogenic strontium isotope values ($^{87}Sr/^{86}Sr$) are mapped across much of the Maya region (Freiwald, 2011a, 2011b; Hodell et al., 2004; Price et al., 2008, 2010; Thornton, 2011; Wright, 2005a); however, values are missing for important cultural areas. For example, one of the most well-known Maya centers is Copan, located at the southern edge of the Maya region. Origins in northern and central Guatemala have been suggested for individuals in royal tomb contexts whose isotope values are statistical outliers from the rest of the burial population (Buikstra et al., 2004; Price et al., 2010). However, although researchers have long believed that similar values should exist in Honduras (Miller, 2015; Price et al., 2014), isotope data were not available to assess the possibility of in-migration from non-Maya areas in Honduras.

We report 24 new $^{87}Sr/^{86}Sr$ values from western Honduras from the

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Caribbean coast and the Ulua and Naco Valleys, east to Yoro, and as far south as Tegucigalpa and the El Cajón, Los Naranjos, and Yarumela archaeological sites. We explore how these new values can be used to interpret the migration patterns of a subsample of individuals (n = 12) interred in Copan's Las Sepulturas neighborhood in Patio Group E (see Miller, 2015 for analysis of other patio groups), and how new data could change published interpretations of migration into Copan. These values will be useful in exploring non-Maya population movement of Lenca and Tolupan speaking-peoples in western Honduras, with the broader goal of understanding interactions and population exchange among Mesoamerican groups.

2. Background

There are different ways to determine the range of radiogenic strontium isotope values in a region. The ratio of ^{87}Sr/^{86}Sr values in bedrock varies according to both its age and composition (Ericson, 1985, 1989; Faure, 1986). The decay of 87-rubidium into 87-strontium over millions of years results in different strontium isotope ratios in bedrock that are reflected in plant, animal, and human tissues without measurable fractionation (see overview in Bentley, 2006; Ericson, 1985, 1989; Faure, 1986; Sillen et al., 1989), resulting in low values for volcanic bedrock, intermediate values in marine carbonates and metamorphic formations, and higher values in older igneous and granitic formations. Researchers predict strontium isotope differences using geologic maps and GIS-based and multiple source mixing models to identify isoscapes (Bataille and Bowen, 2012; Bataille et al., 2012; Evans et al., 2010; Maurer et al., 2012; West et al., 2010). Studies also use statistical analyses based on median and mean values to differentiate local and non-local individuals (Freiwald, 2011a; Wright, 2005a, 2012) and establish baseline values to understand isotopic variability in the study area, either by measuring values in water, plants, or rocks (Hodell et al., 2004; Knudson et al., 2014) or by collecting modern or archaeological fauna to obtain biologically available strontium isotope values (Price et al., 2002).

Baseline values are useful for a number of reasons. The range of local values in a region results from a combination of aerial, fluvial, and geologic processes that may have a wider range of values than those of the bedrock (Bentley, 2006). For example, Price and Gestsdóttir (2006) found that sea spray resulted in higher values for inhabitants of Iceland than those predicted and found in the island's volcanic bedrock. Imported foods, such as salt or seafood, also may alter human values depending on the quantities consumed (Wright, 2005a, 2012; Fenner and Wright, 2014), inland versus coastal salt sources (Woodfill et al., 2014), or the use of a dietary catchment that extends beyond the (archaeological) site and its immediate vicinity. Classic period Maya diets consisted of a combination of local and non-local foods (Emery, 2003; Lentz, 1991; Sharpe et al., 2016; Thornton, 2011; Yaeger and Freiwald, 2009), but isotope values are differentially incorporated into human tissues and likely result from a small number of foods and food processing techniques (Burton and Wright, 1995). Human values at most sites in the Maya region are similar to baseline strontium isotope values, but with wider ranges and higher average values, suggesting that more attention to diet is needed. Values derived from human and non-human fauna in and around the Maya region are shown below (Fig. 1).

3. Materials and methods

Honduras baseline samples were collected by Freiwald and Miller Wolf during March 2012 from distinct geological zones, important archaeological sites, and regions in Honduras where different cultural and language groups historically resided. We used bedrock geologic maps (Rogers, 2003; Rogers et al., 2007) as a guide and noted changes in surface geology that might affect strontium isotope variability, such as fluvial deposition, confluence of waterways from geologically distinct areas, or outcrops exposed through soil erosion. We also obtained samples near sites documented in archaeological research in areas where both Maya and non-Maya groups such as the Lenca, Nahua, Chorti, and Chontal (Fig. 2) may have lived (Creamer, 1987; Dixon et al., 1998; Gerstle, 1988; Henderson, 1977; Hirth, 1988; Metz, 2010; Wells and Davis-Salazar, 2008).

We selected 24 of 83 water, plant, and fauna specimens collected from over 50 locations in western and central Honduras for our initial set of samples. We chose a variety of species to represent biologically available strontium isotope values in humans and avoided samples where non-local foods or foddering might have shifted the animals' values away from local sources. We opted to create a broad preliminary baseline map rather than attempt to fully characterize isotopic variability, leaving that to future research to fill in, population-by-population and site-by-site.

The non-human samples collected for this study were curated and processed by Freiwald at the UW-Madison T. Douglas Price Laboratory for Archaeological Chemistry (LARCH). Baseline samples were dried and then reduced to ash in a kiln at 800 degrees Celsius (see Miller, 2015 and Price et al., 2010 for preparation of previously published values). All 2012 Honduran non-human baseline samples were analyzed on the VG Instruments Sector-54 thermal ionization mass spectrometer operated by the UNC at Chapel Hill Isotope Geochron Laboratory, a class-1000 clean lab. Strontium was isolated using Sr-Spec ion exchange resin manufactured by Eichrom Industries in micro columns (~35 μL resin bed volume) columns. Samples were loaded in single rhenium filaments in phosphoric acid and tantalum chloride solution. Samples are analyzed in triple dynamic multicollector mode with ^{88}Sr = 0.1194, which assumes exponential fractionation behavior. Analytic uncertainty in analyses is estimated using the long-term reproducibility of the strontium standard NBS-987 (^{87}Sr/^{86}Sr = 0.710268 ± 0.000020, 2σ; n = 134). Standard error for analyses generally exceeds 0.000011, 2σ. Diagenesis was evaluated at LARCH through mechanical cleaning, processing in nitric acid, evaluation of standard error, and verification of successful batches of samples through mass spectrometer controls.

The human dental samples from the Sepulturas group at Copan were collected by Miller Wolf in 2012 and exported to Arizona State University's Archaeological Chemistry Laboratory (ACL). All teeth were photographed prior to exportation, and two plaster casts were made of each tooth, one to be exported with the tooth and the other to be stored with the sampled burial in Copan (see Miller, 2015:92 for methods). Once in the ACL, each tooth was mechanically cleaned using a dental drill with a carbide burr to remove the outermost layer of enamel to reduce the possibility of diagenetic contamination. Subsequently, 15–20 mg of clean enamel was removed and divided approximately in half with placed a 1.5 ml centrifuge tube and dissolved in 500 μL of twice-distilled 5 M nitric acid (HNO_3) for radiogenic strontium analysis and the remaining 7–10 mg were dissolved for elemental concentration analysis to identify any contamination (see Miller, 2015:92–94). After initial processing in the ACL, the human archaeological and ACL faunal samples were processed in the clean lab at the W.M. Keck Foundation Laboratory for Environmental Biogeochemistry (Keck) at Arizona State University where samples were first evaporated and then re-dissolved in 250 μL twice-distilled 5 M nitric acid then purified and chemically cleaned through a series of washings with 5 M water (H_20) and twice distilled 5 M nitric acid in glass columns filled with Sr-Spec ion exchange resin. Purified samples were evaporated and re-dissolved in 640 μL twice distilled 5 M nitric acid and then diluted with approximately 9.36 ml of 5 M water for analysis on the Keck's Thermo X Series Quadrupole Inductively Coupled Plasma Mass Spectrometer (Q-ICP-MS). After analysis on the Q-ICP-MS, the sample concentrations of the strontium were checked and analyzed on the Keck's Thermo-Finnigan Neptune multi-collector inductively coupled plasma mass spectrometer (MC-ICP-MS). The samples were run with NIST standard SRM 987 at various dilutions at the outset and then interspersed between every five archaeological samples. Five dilutions of NIST SRM 1400 (bone ash)