Strontium Isotopes Identify Locals and Non-Locals at CA-SCL-919 and CA-SCL-928 in Milpitas, California

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We present new strontium isotope data from 14 individuals buried at CA-SCL-919, a Late Phase II site, and three individuals from CA-SCL-928, a Middle Holocene site, in Milpitas, California. Results show that migration and mobility patterns vary between the two sites, pointing to differences in landscape use over time. In particular, data reveal that 80% of the individuals at CA-SCL-919 were immigrants to the site, having been born and living their teenage years in a range of different locations. All immigrants date to a narrow window of time, at approximately 400 cal BP, marking the beginnings of the cemetery component of the site, and presumably, the origins of a permanent village at this location. As such, the data may provide insight into how new villages form in Central California.

New approaches in stable isotope analysis are opening novel windows into ancient behaviors. These techniques have only recently been applied in California, but are revealing important aspects about ancient diets (Bartelink 2009; Eerkens et al. 2013, 2015), weaning behavior (Eerkens et al. 2011; Eerkens and Bartelink 2013; Martinez et al. 2015), childhood foraging (Greenwald et al. 2016), warfare (Eerkens, Barfod, Jorgenson, and Peski 2014; Eerkens et al. 2016), and post-marital residence patterns (Eerkens, Barfod, Leventhal, Jorgensen, and Cambra 2014; Harold et al. 2016; Jorgenson 2012). Indeed, a recent edited volume highlights the breadth of subject matter that stable isotope analyses in California can address (Greenwald and Burns 2016).

This paper focuses on strontium isotopes, contrasting two pre-contact sites in southern San Francisco Bay, CA-SCL-919 and CA-SCL-928 (Figure 1). Strontium (Sr) isotope signatures are reflective of underlying geological landscapes, related especially to the age of formations (Capo et al. 1998; Faure 1986). Strontium is passed up the food chain and is easily incorporated into human tissues, including bone and teeth, as it can substitute for calcium in the calcium-phosphate biomolecules that comprise the mineral component of skeletal tissues. The diverse geology of Central California ensures that there is much regional variation in strontium isotopes. Because people in pre-contact times obtained the majority of their food from their immediate environment, human populations from different parts of Central California tend to display distinctive regional signatures in strontium isotopes (Eerkens et al. 2016).

Further, because teeth do not remodel once they are formed, the strontium incorporated into dental tissues, including enamel, is reflective of where a person was living when that tooth was forming. By

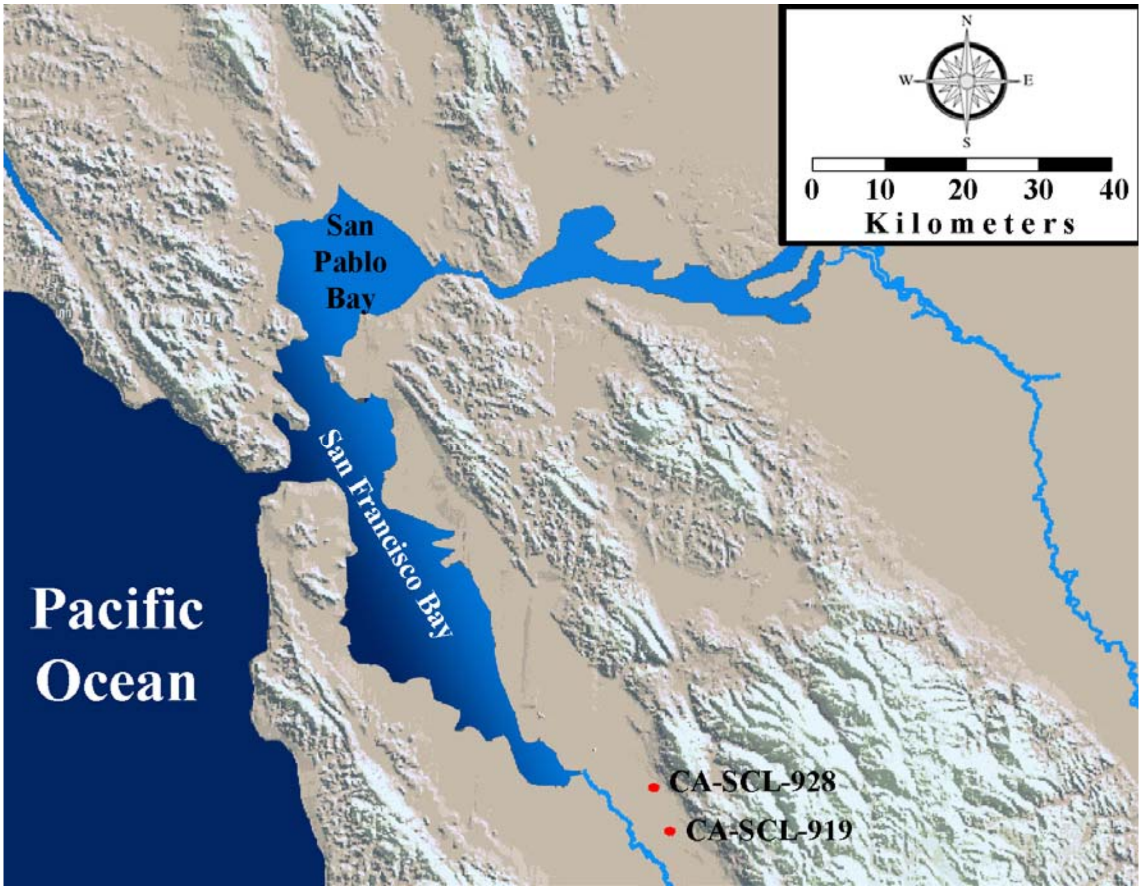

Figure 1. Map of Central California and San Francisco Bay, showing general location of CA-SCL-919 and CA-SCL-928 towards bottom-center.

analyzing teeth that form at different points in a person's life it is possible to trace the migration history of an individual, provided they crossed strontium isotope boundaries and spent significant time in those areas consuming local foods.

Bone, on the other hand, is a living tissue and continually remodels throughout a person's life. The strontium in bone, therefore, is a reflection of where a person was living during the last several years of life. The amount of time it takes for a bone to acquire a local strontium isotope signature has not been measured empirically. However, estimates vary between 5 and 15 years, depending slightly on the bone and the age of the individual (Hedges et al. 2007; Manolagas 2000), with older individuals experiencing slower strontium turnover.

Together, isotopic analyses of bone and teeth can provide a sort of isotopic life history, or isobiography, for an individual. By comparing multiple individuals across a site, archaeologists can gain new insights into mobility and migration patterns of populations, including, for example, insight into post-marital residence patterns (e.g., patrilocal vs. matrilocal if one or the other sex is differentially moving from their natal village).

SAMPLE

This study draws on bone and tooth samples from 17 individuals from two sites in Santa Clara County (see Figure 1). Burials were discovered during construction activities for expansion of the Bay Area Rapid Transit system by the Santa Clara Valley Transportation Authority (VTA). Co-author Katherine

Perez was assigned by the Native American Heritage Commission as Most Likely Descendent (MLD) and authorized all isotopic analyses.

Radiocarbon dates, temporally diagnostic artifacts, and stratigraphic context suggest both sites comprise single-component accumulations of material. CA-SCL-928 is a Middle Holocene site containing three fragmentary adult burials, but with little additional midden accumulation or artifacts. Morphometric analyses of skeletal markers (e.g., pelvis, cranium) suggest one possible female and two male individuals. Bone collagen from each of the individuals was submitted for AMS dating. A linear mixing model developed by Bartelink (2009) was used to estimate the percentage of carbon deriving from marine sources in the collagen samples. A marine reservoir correction of 365 ± 50 for San Francisco Bay was then used to help calibrate the dates, using the online version of Calib 7.1 (http://calib.qub.ac.uk). AMS results produced dates in excess of 5500 years ago (Table 1), confirming the suspected Middle Holocene age.

By contrast, CA-SCL-919 is a Late Holocene site with a more significant accumulation of midden and other debris. Dating of the site is secured by a series of 21 radiocarbon dates, including 14 associated with cultural features and seven from human bone collagen. The oldest dates from features suggest the site was intermittently used beginning 700 cal BP and continuing through 500 cal BP. However, the majority (n=18) of the radiocarbon dates, including all on human bone collagen, fall in a narrow window between 505 and 280 cal BP (2-sigma; see Table 1). This suggests a more intensive and permanent occupation after 500 cal BP, continuing until the beginning of the Mission Period.

METHODS

A complete $^{87}Sr/^{86}Sr$ base map does not exist for California. To assist in this study we also analyzed $^{87}Sr/^{86}Sr$ in the enamel of six rodent teeth collected from the two sites, all thought to be pre-contact in age. All rodent teeth are from species that do not migrate over long distances. These faunal $^{87}Sr/^{86}Sr$ values help establish what a human forager with a rodent-like diet would look like isotopically if they were consuming foods only in the immediate environment of these two sites. Of course, humans typically forage over a larger area than rodents, and we also recognize the possibility that rodents were gathered by humans during foraging bouts and brought to the site for consumption. Thus, we do not expect human values to duplicate the fauna. Instead, the small mammal data help us to develop a context for interpreting the human bone and tooth data, establishing a hypothetical "local" signature. Along with the human bone data themselves, the isotopic data from small mammals provides a baseline for identifying non-local tooth strontium isotope values in the human population, which in turn can provide information about migration patterns.

While enamel appears to be relatively conservative, bone can sometimes undergo diagenetic change (Budd et al. 2000), though recent studies suggest some parts of bone are also more resistant (Scharlotta et al. 2013). To minimize the potential effects of diagenesis, we mechanically removed the outer layers of bone and tooth samples more susceptible to diagenetic change. We also subjected the remaining bone to chemical cleaning. As such, our study focuses on interior sections of well-preserved cortical bone, and enamel, minimizing the potential effects of diagenetic changes to isotopic values (Knudsen et al. 2005). Our analyses at other sites in Central California show that bone strontium isotopes of burials identified as non-locals based on other criteria (e.g., burial style) have not converged on the local value, despite being buried for hundreds to thousands of years (Eerkens, Barfod, Jorgenson, and Peske 2014; Eerkens et al. 2016; Jorgenson et al. 2009). This suggests that human bone from Central California cleaned in this manner can recover the original Sr-isotopic signature.

Strontium from bone and tooth samples was separated and purified. This process removes all isotopes of rubidium (Rb), one of which (^{87}Rb) can interfere with the measurement of ^{87}Sr. Bone and enamel (~0.05 grams of powder each) were treated with 2 milliliters (mL) of 15% hydrogen peroxide (H_2O_2), sonicated for 5 min, and then soaked for 24 hours to remove organic material. Samples were then rinsed in distilled water, dried down and treated with 2 mL of 0.1 N Acetic Acid and soaked for 24 hours to remove secondary non-biogenic carbonates. They were then rinsed two times with distilled water, dried down and dissolved with 4 mL of 2.5 N hydrochloric acid (HCl).

Table 1. Samples from CA-SCL-919 and CA-SCL-928 included in this study.

Site	Burial#	Age (Years)	Sex	Burial Position	^{14}C Date BP	Calibrated Date BP*	
						Median	2-Σ Range
SCL-919	1	Subadult	Indet.	Indet.			
SCL-919	2	10-13	Indet.	Flexed			
SCL-919	3	7-9	Indet.	Partial Cremation	410±20	384	306-454
SCL-919	4	40-45	Male	Partial Cremation	465±33	396	315-484
SCL-919	5	30-34	Male	Flexed	460±40	379	294-461
SCL-919	7	35-39	Male	Partial Cremation			
SCL-919	8	2-4	Indet.	Sitting facing N			
SCL-919	9	40-44	Male	Partial Cremation			
SCL-919	10	12-15	Indet.	Indet.	350±27	307	154-427
SCL-919	11	30-39	Male	Flexed			
SCL-919	12	40-49	Male	Flexed	465±30	406	317-492
SCL-919	14	40-44	Indet.	Partial Cremation			
SCL-919	15	35-44	Female	Flexed	420±20	384	304-452
SCL-919	16	50+	Female	Sitting facing N	435±25	389	314-476
SCL-928	1	25+	Female?	Flexed	4940±60	5677	5586-5761
SCL-928	2	35-45	Male	Flexed	4940±35	5661	5601-5733
SCL-928	3	35-50	Male	Flexed	5350±30	6133	6133-6214

Notes: Indet. = Indeterminate; * - Calibrated using Calib 7.0 with a marine carbon offset determined from bone collagen carbon isotopes.

All samples were dissolved completely (i.e. no residual solids remained) by placing them on a hotplate for 24 hours while soaking in HCl. Samples were dried down to evaporate HCl and brought up in 800 microliters (μL) of 8 N Nitric Acid (HNO_3) and centrifuged. The supernatant was loaded onto teflon columns containing Eichrom® Sr Spec resin. Rubidium (Rb), barium (Ba), lead (Pb), and most other elements were eluted in 2 mL 3 N HNO_3. Strontium was collected in 2.8 mL of 0.5 N HNO_3, dried down and reloaded onto the columns a second time (in 8 N HNO_3) to ensure complete purification of strontium from lead. All acids used were distilled to ensure their purity and titrated to ensure the correct concentrations.

Strontium isotope ratios were determined by Nu Plasma HR MC-ICP-MS at the UC Davis Interdisciplinary Center for Plasma Mass Spectrometry. Sample solutions were introduced through a DSN 100 desolvating nebulizer and isotope analyses were mass-fractionation corrected internally to the 'true' $^{86}Sr/^{88}Sr$ ratio of 0.1194. ^{85}Rb and ions with mass 84 (including ^{84}Kr and ^{84}Sr) were monitored to correct for ^{87}Rb interfering with ^{87}Sr and ^{86}Kr with ^{86}Sr, respectively. ^{85}Rb was only present at a few mV or less due to the double-pass of Sr through the columns. ^{84}Kr and thus ^{86}Kr interference on ^{86}Sr was corrected by iterations using the assumption that $^{84}Sr/^{86}Sr = 0.00675476$.

The analytical protocol involves 3-4 samples bracketed by the strontium standard SRM987 allowing for normalization of sample $^{87}Sr/^{86}Sr$ isotope measurements to an accepted value of 0.710249 for SRM 987. Sample uncertainties for SRM987 were less than 0.00002, determined by measuring 2 standard deviations on repeated measures of ocean coral that was run with the CA-SCL-919 and CA-SCL-928 samples (0.70794±.000022; n=3).

RESULTS

Results from the analyses of rodent teeth are presented in Table 2 (rodent teeth). The three rodents from CA-SCL-919 are very similar in their $^{87}Sr/^{86}Sr$ isotopes, averaging to 0.7069 with a standard deviation of 0.0001. By contrast, the three rodents from CA-SCL-928 are more divergent, averaging 0.7072, but with a standard deviation of 0.0004. While the average values are still close to one another, given the range of values seen over Central California in general, they may indicate that the rodents at CA-SCL-928 were gathered over a wider geographic range than the CA-SCL-919 rodents. This would be consistent with a less circumscribed or residentially mobile population that foraged over a larger territory. We use these values to place the human $^{87}Sr/^{86}Sr$ in greater context.

Table 3 presents the strontium isotope data for the human teeth and bones from the two sites. As seen, the bone $^{87}Sr/^{86}Sr$ values are nearly homogenous within sites among the individuals. At CA-SCL-919, human bone values average 0.7067, slightly below the rodents from that site. Like the rodents, humans display a similarly small standard deviation of 0.0001. We suggest that "local" values at this site vary between 0.7066 and 0.7070. At CA-SCL-928, the three humans average 0.7064, and are more divergent from rodents from the site (which average 0.7072). The CA-SCL-928 human values are also slightly lower than the humans or rodents from CA-SCL-919, but have a very small standard deviation of 0.00003. For this site, we define "local" as between 0.7064 and 0.7068, although the range is more difficult to determine due to the discordant human bone and rodent values.

Together the $^{87}Sr/^{86}Sr$ bone data suggest that, within sites, humans were gaining the majority of their food from the same general area. We argue that this accounts for the intra-site similarity of sample values and low inter-individual variation. This would be expected if people from a village were either foraging in the same defined territory and/or were extensively sharing food within the community. The difference between the sites suggests that the people who were buried in these two locations were probably foraging across slightly different territories. This could mean that foraging territories either shrank or enlarged over time, or that Middle Holocene foragers were exploiting a different part of the landscape than Late Holocene foragers.

Comparison of the tooth values to the bone values in Table 3 provides additional insight into the migration history of people in the two sites, and allows us to identify locals (someone who was born at the site and continued living there as an adult) and immigrants (someone who was born elsewhere but lived at the site as an adult). We can further subdivide immigrants as "early immigrants," or people who were born elsewhere but migrated to a site by their teenage years when third molars were forming, and "late immigrants," or people who were born elsewhere but only immigrated to the site after their early teenage years (i.e., after their third molars formed). For individuals lacking teeth, we are unable to evaluate migration history, of course.

Figure 2 plots first molars and bone strontium isotope data (y-axis) versus estimated age at death (x-axis; median age for age ranges) for CA-SCL-919, with our reconstructed "local" range shown in gray. As shown, all the bone values fall within the local range. However, only two first molars (from Burials 8 and 10) fall in the local range. This suggests that of the 10 individuals with first molars, only two appear to have been born at or near the site. Both of these individuals died as juveniles. The remaining eight individuals, including all the adults, are immigrants to the site.

A similar graph for third molars (Figure 3) shows that none of the adults appear to have been living at the site during their teenage years. In other words, all eight immigrants are "late immigrants," coming to CA-SCL-919 after the enamel of their wisdom teeth had formed (age 9-16 years, see Hillson 2005:123).

By contrast, we reconstruct that two of the three individuals buried at CA-SCL-928 were locals. Only one individual, an adult male, appears to have immigrated to the site. Based on third molar values, he appears to have immigrated after his early teenage years (i.e., late immigrant).

Table 2. $^{87}Sr/^{86}Sr$ values for rodents from CA-SCL-919 and CA-SCL-928.

Site	Sample	Enamel $^{87}Sr/^{86}Sr$
SCL-919	Rodent 1	0.70689
SCL-919	Rodent 2	0.70696
SCL-919	Rodent 3	0.70700
SCL-928	Rodent 1	0.70682
SCL-928	Rodent 2	0.70738
SCL-928	Rodent 3	0.70760

Table 3. $^{87}Sr/^{86}Sr$ values for humans from CA-SCL-919 and CA-SCL-928.

Site	Sample	$^{87}Sr/^{86}Sr$ M1	$^{87}Sr/^{86}Sr$ M3	$^{87}Sr/^{86}Sr$ Bone	Migrant Interpretation
SCL-919	Burial 1	n/a	n/a	0.70673	n/a
SCL-919	Burial 2	0.70732	0.70723	0.70676	Late Immigrant
SCL-919	Burial 3	0.70789	0.70737	0.70679	Late Immigrant
SCL-919	Burial 4	0.70788	0.70807	0.70683	Late Immigrant
SCL-919	Burial 5	0.70820	0.70807	0.70698	Late Immigrant
SCL-919	Burial 7	n/a	n/a	0.70663	n/a
SCL-919	Burial 8	0.70686	n/a	0.70661	Local
SCL-919	Burial 9	n/a	n/a	0.70665	n/a
SCL-919	Burial 10	0.70684	n/a	0.70668	Local
SCL-919	Burial 11	0.70789	0.70773	0.70668	Late Immigrant
SCL-919	Burial 12	0.70733	0.70766	0.70666	Late Immigrant
SCL-919	Burial 14	n/a	n/a	0.70665	n/a
SCL-919	Burial 15	0.70707	0.70773	0.70681	Late Immigrant
SCL-919	Burial 16	0.70730	0.70776	0.70665	Late Immigrant
SCL-928	Burial 1	0.70670	0.70686	0.70638	Local
SCL-928	Burial 2	0.70723	0.70716	0.70645	Late Immigrant
SCL-928	Burial 3	0.70680	0.70668	0.70639	Local

Notes: n/a indicates tooth was not present for analysis.

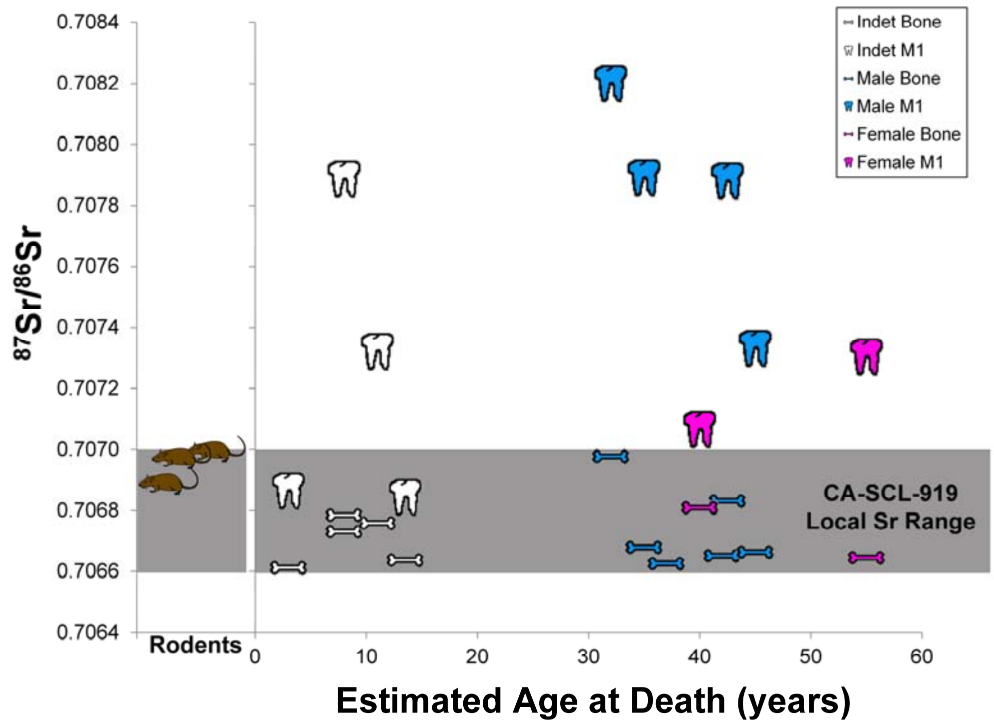

Figure 2. $^{87}Sr/^{86}Sr$ *vs. Age at Death, for human first molars and bone at CA-SCL-919. Rodent Sr values are plotted on left.*

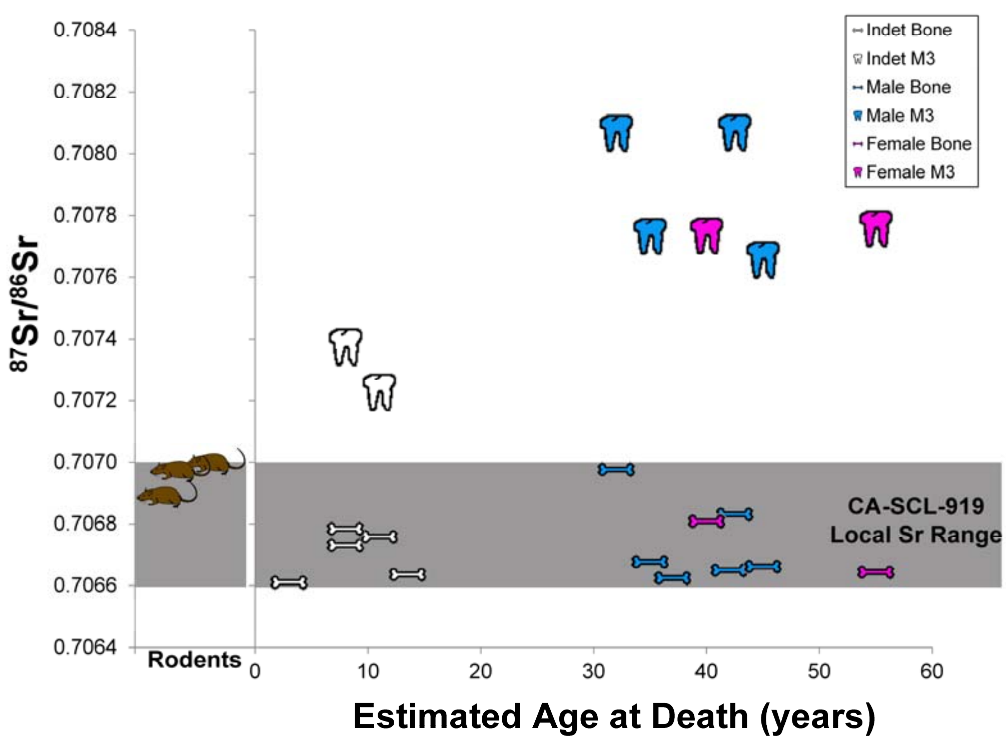

Figure 3. $^{87}Sr/^{86}Sr$ *vs. Age at Death, for human third molars and bone at CA-SCL-919. Rodent Sr values are plotted on left.*

DISCUSSION AND CONCLUSIONS

The number of individuals from CA-SCL-928 is small; too small to make broad statements about migration patterns during the Middle Holocene. One female appears to be local, while one male is local and another is non-local. This may represent an ambilocal post-marital residence pattern, or may represent a more fluid and residentially mobile population that moved over a larger territory in Central California. That two of three rodent teeth display different strontium isotope values than the human bone, and different than expected for the Milpitas area, may support more wide-ranging foraging territories. These rodents were likely obtained at a distance from the camp and brought back to SCL-928 for consumption.

By contrast, strontium isotope evidence suggests that CA-SCL-919 is composed almost entirely of immigrants. Fully 80% of the individuals we evaluated display signatures consistent with late immigration. Although the sample size is small (n=10 individuals), this rate of immigration is much higher than any other pre-contact period site we have analyzed to date in Central California (Eerkens et al. 2014a, 2015; Harold et al. 2016; Jorgenson 2012).

Radiocarbon dates on six of the eight immigrants are nearly identical, suggesting they may be contemporaries. These six radiocarbon dates are also the oldest among the human burials, suggesting they represent the “founders” of the village. Although there are a handful of older dates on pits and plant-processing features, it is possible that the site was initially used intermittently as a temporary camp for gathering and processing various resources. No human burials date to this phase of site use because people did not stay long enough at CA-SCL-919. The placement of human graves around 500 cal BP suggests a transition to a more permanent village. A marked increase in dated pit and resource processing features also supports the notion of a larger and more permanent occupation. Perhaps the six dated immigrants came together at the site to found a new more permanent village. If so, it follows that one of the two isotopic locals, Burial 10, has a median calibrated radiocarbon date that is some 70-80 years younger than the other dated burials (the other local, Burial 8, was not dated). These individuals may represent a subsequent generation or two at the site.

If CA-SCL-919 is comprised mainly of immigrants, it provides insight into how a new village forms in Central California. Little is known about this process either ethnographically or archaeologically. We are currently undertaking analyses of ancient DNA to further evaluate how these people were related, and are measuring additional stable isotopic signatures (e.g., carbon, sulfur, oxygen) to try to pinpoint their geographic origin(s). Based on the strontium isotope data alone, it appears that the immigrants are from at least two or three geographic areas with different underlying strontium isotope signatures. This is unlike the pattern we would expect if an existing village fissioned, for example due to internal social conflicts, and a subgroup of individuals split off to start a new village. In such a case, the immigrants would be from a single isotopic source.

In sum, the strontium isotope analyses provide a unique window into the migration behaviors of individuals in Middle and Late Holocene times in the San Francisco Bay region. Such information complements analyses of midden materials, features, and ecofacts, providing a richer picture of ancient lifeways and life histories.

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REFERENCES CITED

Bartelink, Eric J.

2009 Late Holocene Dietary Change in the San Francisco Bay Area: Stable Isotope Evidence for an Expansion in Diet Breadth. *California Archaeology* 1:227-52.

Budd, P., J. Montgomery, B. Barreiro, and R.G. Thomas

2000 Differential diagenesis of strontium in archaeological human dental tissues. *Applied Geochemistry* 15, 687-694.

Capo, R.C., B.W. Stewart, and O.A. Chadwick

1998 Strontium isotopes as tracers of ecosystem processes: theory and methods. *Geoderma* 82:197-225.

Eerkens, J.W., and E.J. Bartelink.

2013 Sex-Biased Weaning and Early Childhood Diet Among Middle Holocene Hunter–Gatherers in Central California. *American Journal of Physical Anthropology* 152:471-483.

Eerkens, J.W., A.G. Berget, and E.J. Bartelink

2011 Estimating weaning and early childhood diet from serial micro-samples of dentin collagen. *Journal of Archaeological Science* 38:3101-3111.

Eerkens, J.W., Madeline Mackie, and Eric J. Bartelink

2013 Brackish water foraging: isotopic landscapes and dietary reconstruction in Suisun Marsh, Central California. *Journal of Archaeological Science* 40:3270-3281.

Eerkens, J.W., G.H. Barfod, G.A. Jorgenson, C. Peske.

2014a Tracing the mobility of individuals using stable isotope signatures in biological tissues: “locals” and “non-locals” in an ancient case of violent death from Central California. *Journal of Archaeological Science* 41:474-481.

Eerkens, J.W., G.H. Barfod, A. Leventhal, G.A. Jorgenson, and R. Cambra.

2014b Matrilocality in the Middle Period in San Francisco Bay? New Evidence from Strontium Isotopes at CA-SCL-287. *Journal of California and Great Basin Anthropology* 34: 205–221.

Eerkens, J.W., J. Goodman, and S. Talcott.

2015 Using Stable Isotopes at Two Pre-Contact Sites in Yolo County. *Proceedings of the Society for California Archaeology* 29:172-179.

Eerkens, J.W., T. Carlson, R.S. Malhi, J. Blake, E.J. Bartelink, G.H. Barfod, E. Estes, R. Garibay, J. Glessner, A.M. Greenwald, K. Lentz, H. Hi, and C.K. Marshall

2016 Isotopic and genetic analyses of a mass grave in central California: Implications for precontact hunter-gatherer warfare. *American Journal of Physical Anthropology* 159:116-125.

Faure, G.

1986 *Principles of Isotope Geology*, 2nd rev. Wiley, New York.

Greenwald, A.M., and G.R. Burns (editors)

2016 *Reconstructing Lifeways in Ancient California: Stable Isotope Evidence of Foraging Behavior, Life History Strategies, and Kinship Patterns*. Center for Archaeological Research at Davis, Davis, CA.

Greenwald, A.M., J.W. Eerkens, and E.J. Bartelink

2016 Stable isotope evidence of juvenile foraging in prehistoric Central California. *Journal of Archaeological Science: Reports* 7:146–154.

Harold, L.B., J.W. Eerkens, and C. Ralston

2016 Patrilocal post-marital residence and bride service in the Early Period: Strontium isotope evidence from CA-SJO-112. In *Reconstructing Lifeways in Ancient California: Stable Isotope Evidence of Foraging Behavior, Life History Strategies, and Kinship Patterns*, ed. by A.M. Greenwald and G.R. Burns, pp. 33-46. Center for Archaeological Research at Davis, Davis, California.

Hedges, R.E.M, J.G., Clement, C.D.L. Thomas, and T.C. O'Connell

2007 Collagen turnover in the adult femoral mid-shaft: modeled from anthropogenic radiocarbon tracer measurements. *American Journal of Physical Anthropology* 133:808-816.

Hillson, S.

2005 *Teeth*. Second edition. Cambridge University Press, Cambridge.

Jorgenson, G.A.

2012 Human Ecology and Social Organization in the Prehistoric California Delta: An Examination of 87Sr/86Sr Isotope Ratios in the Human Burial Population at CA-CCO-548. Doctoral dissertation, University of California, Davis, CA. University Microfilms, Ann Arbor.

Jorgenson G.A., J.W. Eerkens, G. Barford, and E.J. Bartelink

2009 Migration Patterns in the Prehistoric California Delta: Analysis of Strontium Isotopes. *Proceedings of the Society for California Archaeology* 23:1-7.

Knudson, K.J., T.A. Tung, K.C. Nystrom, T.D. Price, and P.D. Fullagar

2005 The origin of the Juch'uypampa Cave mummies: strontium isotope analysis of archaeological human remains from Bolivia. *Journal of Archaeological Science* 32: 903-913.

Manolagas, S.

2000 Birth and death of bone cells: basic regulatory mechanisms and implications for the pathogenesis and treatment of osteoporosis. *Endocrinology Reviews* 21:115-137.

Martinez, M.C., J.W. Eerkens, A.M. Greenwald, and A. DeGeorgey

2015 Weaning and childhood diet at CA-CCO-297. *Proceedings of the Society for California Archaeology* 29:6-12.

Scharlotta, I., O.I. Goriunova, and A. Weber

2013 Micro-sampling of human bones for mobility studies: diagenetic impacts and potentials for elemental and isotopic research. *Journal of Archaeological Science* 40:4509-4527.