STARCH GRAIN ANALYSIS IN CHOLAME VALLEY: CALIFORNIA FLATS SOLAR PROJECT

JUSTIN WISELY, CARDNO, INC.

The Cholame Valley lies within the interior of the South Coast Ranges, between the Central Coast and the San Joaquin Valley. These regions are culturally and materially diverse, with prehistoric adaptations in this transitional area likely influenced by one or both given its use as a travel and trade corridor. Through the analysis of micro-botanical residues extracted from ground stone artifacts and dental calculus, we can demonstrate aspects of prehistoric diet in this particular area. Given the results, we can also discuss the potential toolstone-dependent preservation variability of micro-botanical remains as compared to results from elsewhere in California.

Data Recovery efforts by Applied Earthworks Inc. (AE) for the California Flats solar project in Cholame Valley resulted in the recovery of a vast array of archaeological materials that have yielded significant information into the prehistoric lifeways in the interior of the South Coast Range. AE invited me to conduct starch grain analysis on ground stone and human dental calculus. The ground stone artifacts sampled were from CA-MNT-2308 and included the millingslabs from a possible storage feature comprised of 4 sandstone millingslabs capped by a fifth sandstone millingslab and covered in red ochre (Figure 1). This site dates to 9254 calibrated BP, and the dental calculus samples recovered from three burials in MNT-2328 ranging from 574 to 905 BP. The Salinan Tribe and the NAHC-designated Most Likely Descendant authorized AE to conduct the analysis and include the results in reports and other documentation.

STARCH GRAIN ANALYSIS

To provide some context for starch grain analysis, a brief overview is necessary which is summarized from Wisely (2017). Starch grains are semi-crystalline structures that are formed within the plant from two organic polymers, amylose and amylopectin. They are microscopic grains designed for long-term storage of energy that can be found in various parts of a plant, but primarily in the storage components such as roots, seeds, or nuts (Gott et al. 2006:36; Pearsall 2010:178). Many starches can be diagnostic to family, genus, or species while other plants do not produce diagnostic starches. The following methods are consistent with those used throughout California (Kaijankoski et al. 2016; Stevens et al. 2015; Wisely 2015, 2016, 2017; Wohlgemuth 2016; Wohlgemuth et al. 2017) and are adapted from the methods used in California and internationally (e.g., Cortella and Pochettino 1994; Pearsall 2010; Scholze 2011). For a more detailed reference list and discussion see Wisely (2016).

The extraction of starch residues was accomplished with distilled water and sonic cleaning of the ground stone milling surfaces. The dental calculus samples were removed from the human teeth (Burials #1, #2, and #4) by Jelmer Eerkens (University of California, Davis) and supplied to me in sterile, glass vials. Lab processing consisted of centrifugal distillation and heavy-liquid flotation with a sodium polytungstate solution prior to slide mounting. Initial transects of the slide were conducted under cross-polarized light at 100x magnification in order to make preliminary starch grain observations. Once a starch was observed, final identifications were made at 400–1,000x magnification under both cross-polarized light and transmitted light. The starch grains were measured, digitally photographed, and spun to examine and describe any morphology. Starches were identified to the highest degree possible with my modern comparative collection. When the grains were observed but wouldn't spin they remained unidentified due to the importance of their three-dimensional morphology in identification.

Figure 1. Ground Stone Artifacts Sampled from CA-MNT-2308.

Diagnostic Features

Diagnostic features of starch grains include those seen in cross-polarized light as well as transmitted light (Figure 2). Identifications were made based on morphological features and further refined based on measurements.

Cross-polarized Light

Under cross-polarized light, the extinction cross of the starch grain is the most diagnostic and is due to how light passes through the semi-crystalline structure of the grain. Identifying traits can be the arms of the cross, angle of the arms, as well as the level of birefringence. The shape and location of the extinction cross can help orient the three-dimensional view of the grain. Damage from crushing or heat can be ascertained from visible changes to the extinction cross, with crushing damage supported by visible fractures under transmitted light.

Transmitted Light (Normal Light)

Under transmitted light, features such the hilum, fissuring, surface morphology, and the overall shape can be diagnostic. The level of compounding and faceting can also be diagnostic, such as the facets that can be seen on the holly-leaf cherry pit starch. Starch grains can be further identified from archaeological contexts based on their size in conjunction with their morphological traits. Starch grains from small seeds, such as rice grass or brome grass, are typically on the smaller side. Starches of nuts

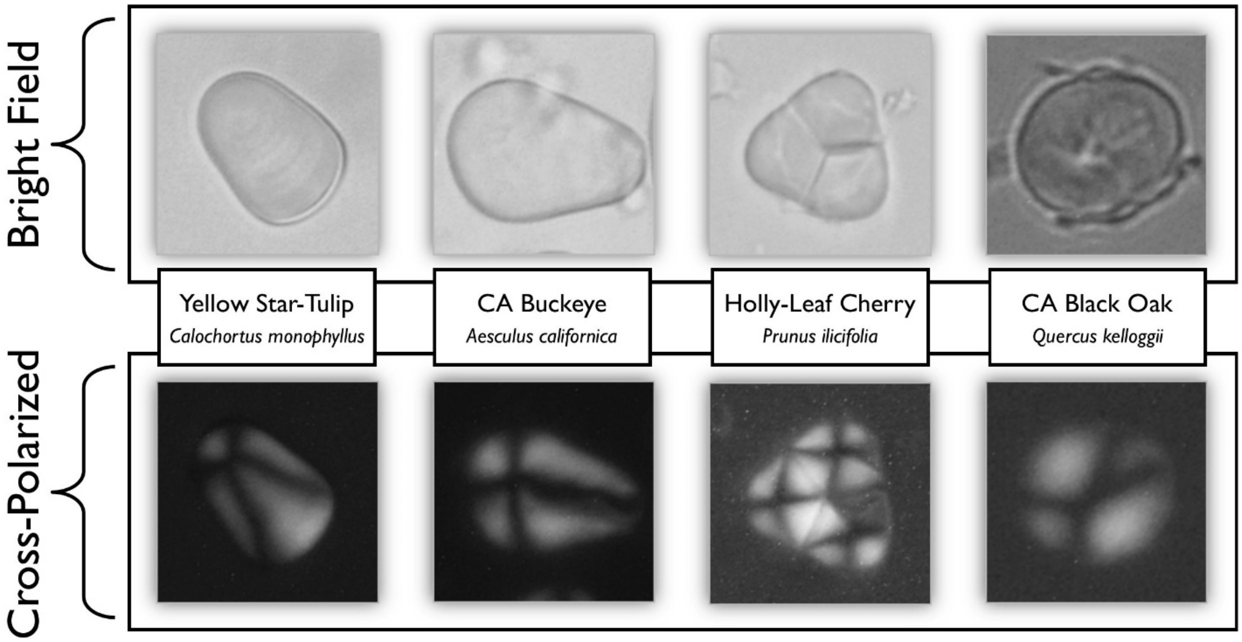

Figure 2. Diagnostic Features of Starch Grains Seen in Bright Field and Cross-Polarized Light.

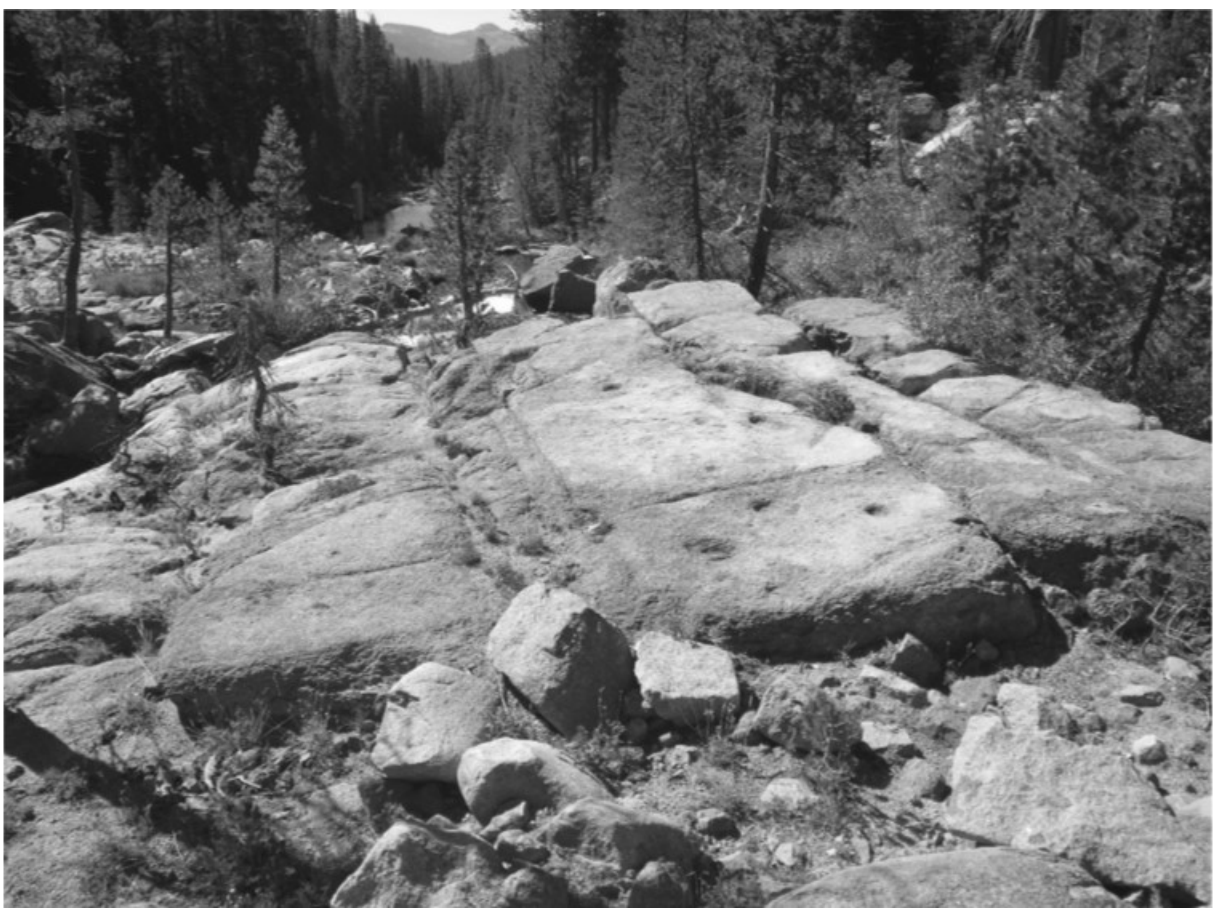

Figure 3. Granitic Outcrop showing Surfaces where Starch Grains can be Embedded.

such as acorns from black oak are larger. Geophytes starch grains, for example cattail rhizome, yampah, or blue dicks are larger yet. However, starch grains from some small seeds such as wild rye or rush vary greatly in size. This variation necessitates a preponderance of evidence be used to make a confident identification of starch grains within archaeological contexts.

Challenges of Starch Grain Analysis

There are several challenges in starch grain analysis, and are primarily contamination, preservation, and quantification, as summarized by Wisely (2017). Contamination is always a major concern, both natural contamination from duff, debris, rodent activity, etc. and modern contamination from modern food starch, industrial starches, etc. For natural contamination, research has shown that the artifact can provide a microenvironment that protects the anthropogenic residue adhering within the surface from taphonomic pressures (enzymes, organisms, etc.), while natural contaminants within soils are not protected by this microenvironment (Hart 2011; Haslam 2004). To address modern contamination several controls have been built into the methodology. These include wearing new powder-free gloves for each artifact sampled and identifying modern starch contaminants. In modern manufacturing, corn starch is used in the production of various plastics, including powder-free gloves (Crowther et al. 2014). As the potential for this modern contaminant cannot be fully controlled for, corn starch has been included in the comparative collection in order to better identify and account for contaminants. Banana starch is also included as a contaminant control given its popularity as a field food.

The second challenge is starch preservation. Thankfully starch grain structure is designed for long-term storage that is further protected by the artifact itself providing a micro-environment that aids in preservation. However, it has been shown that different stone types are more amenable to the preservation of starch than others through ongoing experimental research. So far the results have shown that granite provides for better preservation while sandstone is not as amenable to preservation, most likely due to differing surface attributes of the stone materials (i.e., cracks, crevices, etc.) where starch grains can be embedded, such as this granitic outcrop (Figure 3). It is important to keep in mind that not all plants produce starch, and different resources have varying levels starch (i.e., pine nut versus acorn).

For dental calculus, the rate of development of calculus is not well understood during pre-contact contexts. This means that any preserved starch can only confirm that certain resources were consumed due to the nature of calculus development, where the timing of consumption has the potential to play a major role in whether or not starch is encapsulated within the calculus and preserved.

RESULTS

The results presented here are for the ground stone artifacts sampled from MNT-2308 and the dental calculus recovered from three burials from MNT-2328 (Table 1). The number of starch grains recovered is not very high, but this is consistent with the expected recovery rates for the toolstone materials, i.e., primarily sandstone. The expected recovery rates are based on my previous experience with different toolstone materials on other projects (unpublished data). Of the 11 ground stone samples analyzed, 8 of these artifacts yielded starch grains. These grains are primarily grass seed (Indian rice grass and wild rye), but some acorn starch and geophyte starches were also identified. What I found particularly interesting was the results from Burial 1, where two starch grains were observed. One was unidentifiable but most likely a geophyte while the other was identified as *Aesculus californica* (buckeye). As far as I am aware, it is the first buckeye starch grain identified within dental calculus in California archaeology.

Table 1. Results from CA-MNT-2308 and CA-MNT-2328.

	ARTIFACT	IDENTIFICATION
	Feature 1, basin metate upside down *in situ*	80+ grass seed (Poaceae; Indian Rice Grass); 1 unidentified
	Feature 1, f-la slab metate	-
	Feature 1, f-1b, slab metate	1 *Elymus* sp.; 1 cf. *Quercus* sp.; 1 unidentified
	Feature 1, f-1c, slab metate	1 *Elymus* sp.; 1 cf. *Elymus* sp.; 1 cf. *Juncus* sp.; 1 unidentified (geophyte)
	Feature 1, f-1d, slab metate-Side 1	-
	Feature 1, f-1d, slab metate-Side 2	1 unidentified (damaged)
	Handstone-End	1 unidentified (could not spin)
	Handstone-Face	-
	Burial 1	1 *Aesculus californica*; 1 unidentified (geophyte)
	Burial 2	1 *Elymus* sp.
	Burial 4	1 *Elymus* sp.; cf. *Elymus* sp. (damaged)

DISCUSSION AND CONCLUSIONS

The results indicate that the millingslabs were used primarily for small grass seeds, but also to process acorn and geophytes. Given that the millingslabs were from a site that dated to approximately 9254 BP, while the dental calculus samples were from burials with dates ranging from 574 to 905 BP, this indicates that small grass seeds were an important resource during the early occupation of the Cholame Valley as well as during later times. Indian rice grass and wild rye seeds mature in late spring to summer, while buckeye and acorn are typically gathered during the late summer to fall seasons. Based on the lack of buckeye in the macro-botanical results as well as the ground stone starch residues, this resource was likely consumed elsewhere and preserved within the calculus at that time. However, given my experience with sandstone artifacts from other projects in the southern and east bay regions of California as well as our recent experimental archaeology analyses, these results should be viewed as confirming the consumption of certain resources rather than an indication of overall resource preference.

Starch grain results are supplemental to traditional macro-botanical research, as the two methods can identify different resources that have undergone different preservation pathways. This has been a common practice internationally, particularly in Asia, Australia, the Caribbean, and South America (e.g., Cortella and Pochettino 1994). Macro-botanical flotation results can yield plant remains that were not necessarily ground, are from plants that don't produce starch, or resources that were ground to such a degree that the starch grains are obliterated. For example, most pine nut, with the exception of single-leaf pinyon pine, is fairly low in starch and they are not always ground but are commonly found in flotation samples (Farris 1982). Geophytes, such as those in the agave family, typically produce high levels of fructans instead of starch. Small grass seeds contain high levels of starch and can have high levels of preservation on artifacts, dependent on the toolstone material.

With further analyses from different sites within the valley we will be better able to quantify any diachronic changes in diet within the South Coast Range. Of particular interest to me is the further examination of the importance of buckeye to their overall diet, as the seasonal availability of this resource and where it can be gathered has the potential to provide insights into seasonal occupation and mobility. I have identified this resource in several bedrock mortars in the Sierra Nevada and foothills (Wisely 2015, 2016, 2017; Wohlgemuth et al. 2017), but this is the first time I have identified it within dental calculus and subsequently demonstrated that this resource was in fact consumed. Given that the Cholame Valley was and remains a travel corridor between the coast and the central valley, the importance of the California Flats project to California Archaeology cannot be underestimated.

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REFERENCES CITED

Cortella, A. R., and M. L. Pochettino

1994 Starch Grain Analysis as a Microscopic Diagnostic Feature in the Identification of Plant Material. *Economic Botany* 48(2):171–181.

Crowther, Alison, Michael Haslam, Nikki Oakden, Dale Walde, and Julio Mercader

2014 Documenting Contamination in Ancient Starch Laboratories. *Journal of Archaeological Science* 49:90–104.

Farris, Glenn J.

1982 Pine Nuts as an Aboriginal Food Source in California and Nevada: Some Contrasts. *Journal of Ethnobiology* 2(2):114–122

Gott, Beth, Huw Barton, Delwen Samuel, and Robin Torrence

2006 Biology of Starch. In *Ancient Starch Research*, R. Torrence, and H. Barton (Eds.), pp. 35–46. Left Coast Press, Walnut Creek, California.

Hart, Thomas C.

2011 Evaluating the Usefulness of Phytoliths and Starch Grains Found on Survey Artifacts. *Journal of Archaeological Science* 38:3244–3253

Haslam, Michael

2004 The Decomposition of Starch Grains in Soil: Implications for Archaeological Residue Analyses. *Journal of Archaeological Science* 31:1715–1734.

Kaijankoski, Philip, Patricia Mikkelsen, William Hildebrandt, and Terry Joslin

2016 *Extended Phase I Explorations for the San Jose Creek Bridge Replacement Project, Goleta, Santa Barbara County, California*. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation District 5, San Luis Obispo.

Pearsall, Deborah M.

2010 *Paleoethnobotany: A Handbook of Procedures*. Second edition. Left Coast Press, Walnut Creek, California.

Scholze, Gary

2011 *The Application of Starch Grain Analysis to Late Prehistoric Subsistence in Northeastern California*. Master's thesis, Anthropology Department, California State University, Sacramento.

Stevens, Nathan, Mike Lenzi, and Vickie Clay

2015 *Testing of 21 Archaeological Sites on the Marine Corps Mountain Warfare Training Center near Bridgeport, Mono County, California*. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Naval Facilities Engineering Command Southwest Division, San Diego, California.

Wisely, Justin

2015 *Starch Grain Analysis for the Saddleback Ranch Project*. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Sonoma State University, Rohnert Park, California.

2016 *Starch Grain Analysis of Bedrock Mortars in the Sierra Nevada Mountains: Experimental Studies to Determine their Function*. Master's thesis, California State University, Chico.

2017 Starch Grain Analysis of Bedrock Milling Features: In Honor of Helen McCarthy. *Society for California Archaeology Proceedings* 31:104–113.

Wohlgemuth, Eric

2016 *Extended Phase I and Phase II Investigations for the Aspen Fales Shoulder Widening Project, Mono County, California*. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation District 5, San Luis Obispo.

Wohlgemuth, Eric, Angela Younie, and Adrian Whitaker

2017 *Data Recovery Excavations at CA-CAL-277/H for the Big Tree Creek Storm Water Compliance Project, State Route 4, Calaveras County, California*. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation District 10, Stockton.