

OBSERVING OCCUPATIONAL PATTERNS ACROSS A
PREHISTORIC ARCHAEOLOGICAL SITE (CA-BUT-3176) USING
METHODS OF SOIL ANALYSIS

by

RYAN GREEN

A THESIS

Presented to the Department of Geography,
Environment, and Planning at Sonoma State University

May 8, 2019

Observing Occupational Patterns Across a Prehistoric Archaeological Site (CA-BUT-3176) Using Methods of Soil Analysis

Ryan Green

Abstract: The occupational patterns of the prehistoric California archaeological site designated CA-BUT-3176 were investigated by using data from soil samples collected during excavations. The methods used were magnetic susceptibility and sequential loss on ignition (LOI). Four units of soil samples were analyzed and the data mapped across the site to give insight into its past occupation by the Konkow Maidu tribe. The purpose of this study is to provide preliminary soil analysis data on the archaeological site in question, and to make the soil data available for comparison with similar sites for future studies. This study also stands as a proof of concept for the use of these soil analysis methods on archaeological sites. Results show that measurements of magnetic susceptibility and soil organic content can be indicative of archaeological material.

Key words: Konkow Maidu, soil analysis, magnetic susceptibility, loss on ignition, prehistoric, archaeology

Introduction

This is an explorative study to investigate a prehistoric village site using methods of soil analysis. To date, these methods have not been used to study archaeological sites in this region. The purpose of this study is to make the soil analysis data available for comparison with similar sites, as well as to determine if these methods can be applied archaeologically. The methods used were magnetic susceptibility and loss on ignition (LOI).

The prehistoric village site designated CA-BUT-3176 is located in the Sierra Nevada foothills of Butte county, California. The site was first discovered in 2008 during the clearing of a corridor for the Woodleaf-Kanaka transmission line, which bisects the northern part of the site (Behrend et al. 2013). The site was then documented by archaeologists from HDR Engineering Inc., a company that specializes in infrastructure construction, on behalf of the transmission line's operator, Pacific Gas and Electric Company. Since 2008, there has been extensive damage to the site, by fire and by heavy machinery from maintenance crews working on the transmission line after the fires in October of 2017. The extent of the damage has been marked in Map 1, labeled as the contingency line, where fire crews bulldozed a fire break along the top of the ridge. Now only five of the original ten house pits remain undisturbed, and bulldozer tracks cover approximately 33% of the site (Triplett et al. 2017).

The presumed occupants of CA-BUT-3176 were the Konkow Maidu tribe, due to the site's location within the known Konkow territorial region in the Northern Sierra Nevada range, as defined by Shipley (1978) (Fig. 1). The Konkow Maidu are a subdivision of the Maidu tribe, first distinguished by Dixon (1905) on the basis of lingual dialect. The Maidu were hunter gatherers, relying on a staple of acorn flour, which was ground and processed using stone mortars, manos (flat grinding stone), and pestles. The Maidu also hunted game animals like deer and antelope.

The earliest meeting between European settlers and the Konkow was recorded by Padre Abella while exploring the San Joaquin and Sacramento Valleys for future mission locations, although he did not explore east of the Feather River. By the 1830's, European fur trappers had explored most of the Maidu territory (Dixon 1905:129). In 1833 much of the Maidu population was killed by an epidemic (possibly malaria) and their population swiftly declined. The Gold Rush in the 1850's led to even greater disruption of the Maidu and the theft of their land by prospectors (Pritzker 1998:177).

The Konkow Maidu typically settled in small village communities, some with designated dance halls and ceremonial structures. In hill settlements like CA-BUT-3176, the Maidu used bark-covered conical structures, no more than four meters in diameter. These dwellings were built over a shallow depression (<1m in size, recognized archaeologically as a house pit) and had a superstructure of wooden poles and layered bark, resembling a tipi. Earth was banked around the base of the dwelling, with a single entrance covered by a piece of bark or animal skin (Kowta 1988:14). Five house pits remain at CA-BUT-3176, and they are 273 centimeters in diameter on average (Triplett et al. 2017).

Excavations at the site were conducted in September 2017 by the USDA Forest Service, collecting and recording more than twenty artifacts as well as the characteristics of each site feature (house pits, milling stones, mortars) (Triplett et al. 2017). The site was revisited in June of 2018 by archaeologists from the Anthropological Studies Center (ASC) at Sonoma State University. During this visit, seven groups (units) of soil samples were taken from the site excavations. A total of forty-seven individual soil samples from four different sample units have been made available for use in this study.

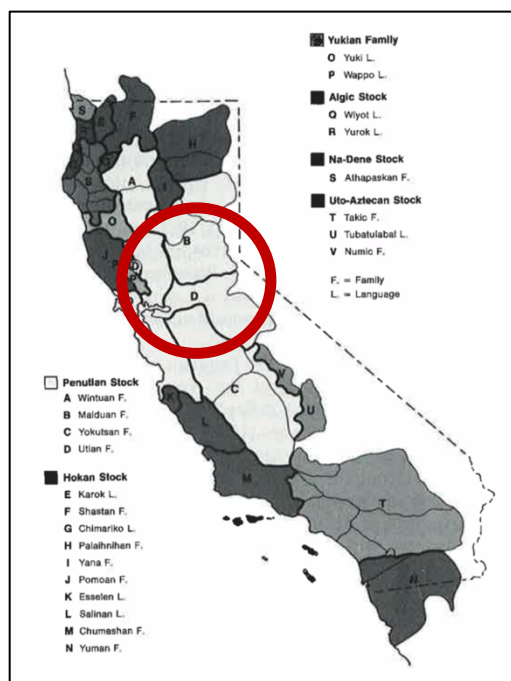
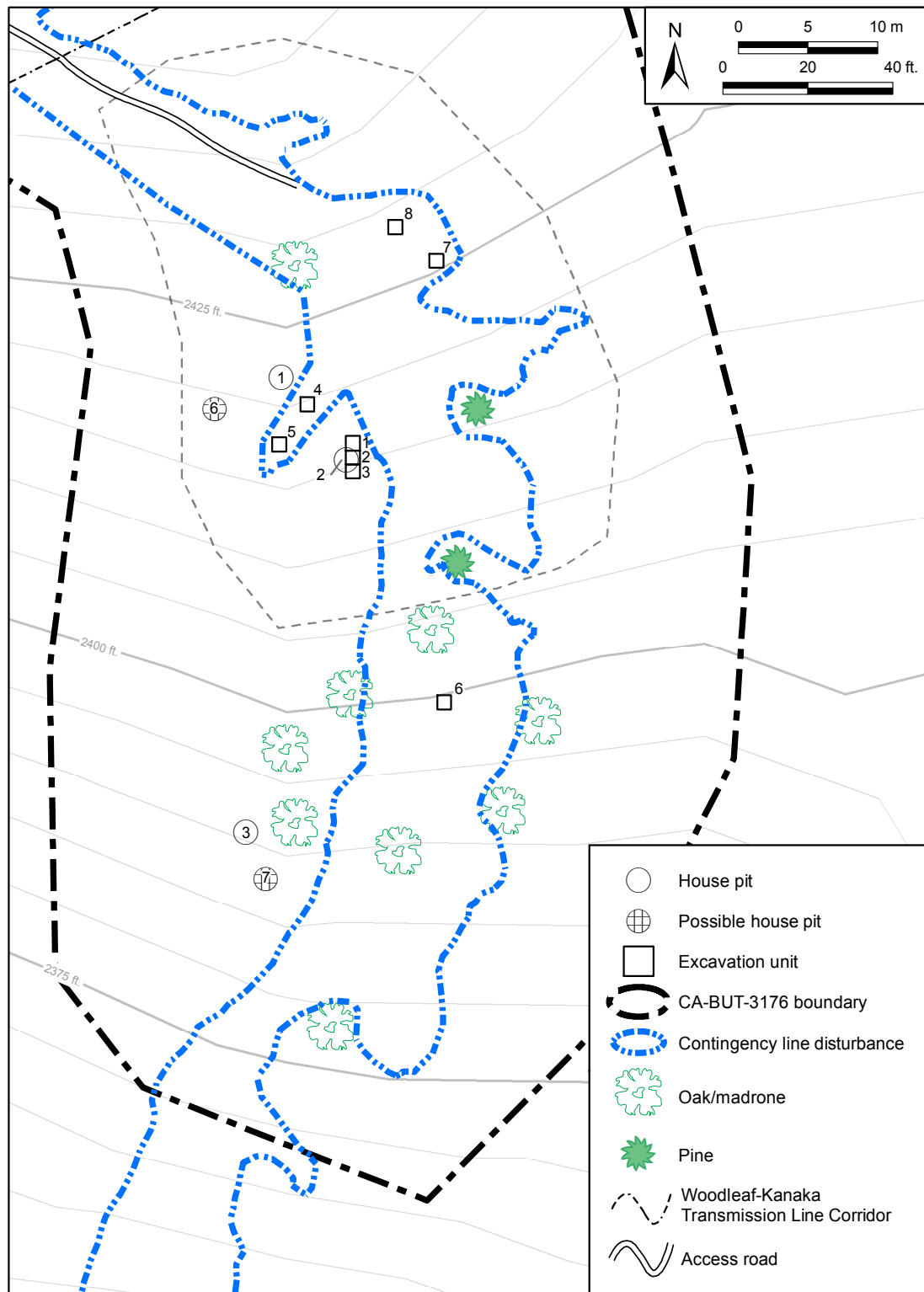


Figure 1: California language families and regions. Maidu family designated red circle (Shipley 1978)

Map 1: Site map of CA-BUT-3176.
 Courtesy of Anthropological Studies Center, Sonoma State University



Methods

While the exact location of CA-BUT-3176 is confidential for preservation purposes, the site is located north of the Feather River's South Fork, on a flat ridge top between two ephemeral drainages. The soil at the site is comprised of loamy colluvial deposits, and is covered in a thick layer of leaves and plant debris. Surrounding vegetation is dominated by an overstory of ponderosa pine, incense cedar, white fir, black oak, tanoak, and madrone. Understory vegetation includes manzanita, poison oak, and various grasses (Behrend et al. 2013).

The four excavation units used in this study were collected by the Sonoma State University ASC, during open pit excavations at the site in the summer of 2018. The units are column samples, referred to as Excavation Units 2, 4, 6, and 7 (Map 1). Each unit consists of bagged soil samples representative of each ten-centimeter excavation layer. Unit 2 consists of six samples representing six 10cm layers, to a depth of 60cm. Unit 4 is the deepest with 23 samples. Open pit excavations in Unit 4 reached a depth of 160cm, and the floor of the pit was drilled further to a depth of 230cm with an auger. Units 6 and 7 both consist of nine samples, and both reach a depth of 90cm. Individual samples are labeled according to their site number, excavation unit, depth, and type. For example, a surface sample from Unit 6 may be labeled with the following: CA-BUT-3176, Unit 6, 0-10cm, soil sample.

The four units were taken from a variety of locations across the site. Unit 2 was sampled from excavations within House Pit 2, fairly central to the site. Unit 4 was sampled about five meters away, between House Pit 1 and 2. Unit 6 was sampled further down the ridge, about ten meters from any house pits. Unit 7 was also sampled away from any site features (Map 1).

A discrepancy occurs in Unit 2, where there is no labeled sample to represent the 40-50cm soil layer. However there are two 0-10cm samples, a result of possible mislabeling upon collection in the field. The two samples have been labeled U2 0-10A and U2 0-10B. It is unclear which sample represents the 40-50cm layer. Both samples were included in soil analysis tests, but they are omitted from the results.

For this study, two soil analysis methods were used on each of the column samples. To begin, the magnetic susceptibility of each sample was recorded. Magnetic susceptibility quantifies the response of a substance to a magnetic field, to measure the degree to which that substance can be magnetized (Dalan et al. 1998). Magnetic susceptibility readings can therefore be used to determine the content of magnetic minerals in sediments (Nowaczyk 2002). Values in magnetic susceptibility are affected by the conversion of magnetic oxides and hydroxides to stronger magnetic forms on surface soil layers (Dalan et al. 1998). The increase in magnetic susceptibility on surface soil layers, as opposed to subsurface layers, was first explained by LeBorgne in 1960, who found that the anaerobic and high-temperature environment produced by fires was a

primary mechanism for the magnetic enrichment of soils (LeBorgne 1960, in Dalan et al. 1998).

Using LeBorgne's results, magnetic susceptibility measurements can be used to identify archaeological sites. Human settlements cause permanent magnetic enhancement of surface soil layers as a result of burning (Chianese et al. 2003). In some cases, buried cultural layers produced twice the magnetic signature than that of non-archaeological soil layers (Dalan 2006). For this study, magnetic susceptibility measurements from each sample may indicate human settlement activity among stratigraphic layers. The magnetic susceptibility of each soil sample was measured using a Bartington Magnetic Susceptibility discrete sampler. Three separate readings were taken per sample, and the results averaged. Readings are measured using the International System of Units (SI).

The second soil analysis method used was sequential Loss on Ignition (LOI). Measurements from LOI is used to evaluate the organic content and carbonate content of a soil sample. This method can be used to identify campfires through a link between levels of organic carbon and moderate cooking fire temperatures, as proposed by Werts and Jahren (2007). Their study found that the maximum isotopic organic carbon enrichment was achieved at temperatures between 200—400°C, covering mid-range fire temperatures. While these temperatures are too low for the flaming combustion of wood, they are hot enough to boil water and to provide a significant heat source. The authors suggest that the interpretation of these temperatures could be useful for reconstructing past human activity (Werts and Jahren 2007: 856).

Therefore, LOI may be used to identify human activity through their use of campfires. This method requires the burning of soil samples at 105°C, 550°C, and 950°C, cooling and weighing the samples between each burn. The 105°C burn removes moisture, the 550°C burn determines organic content, and the 950°C burn determines carbonate content. Content of organics and carbonate are determined by the difference in weight of each sample between burns (Heiri et al. 2001). Samples were burned using a Fisher Scientific Isotemp® Muffle Furnace.

Results

Data points for all units are arranged by excavation level midpoint: for example, the data point for a 50-60cm layer is displayed at 55cm. Site averages for magnetic susceptibility, organic content, and carbonate content are marked on each graph by vertical reference lines. Site averages were calculated using data from all 47 soil samples. The magnetic susceptibility site average is 198 SI (σ 65.52), organic content average is 7.87% (σ 4.69), and carbonate content average is 1.69% (σ .34).

Unit 2

After omitting the 0-10cm and the 40-50cm sample, Unit 2 provides only four viable data points. Magnetic susceptibility readings show a maximum of 312.5 SI in the 20-30cm layer, and a minimum of 219.1 SI in the 50-60cm layer (Fig. 2), showing a sharp decrease in magnetic susceptibility with depth. Organic content decreases with depth, from 10.4% in the 10-20cm layer to 5.4% in the 50-60cm layer. Carbonate levels are consistent as well, varying by $>0.5\%$.

Unit 4

This unit shows high variability in magnetic susceptibility across its 230cm depth. Its maximum magnetic susceptibility reading comes from the 110-120cm layer, at

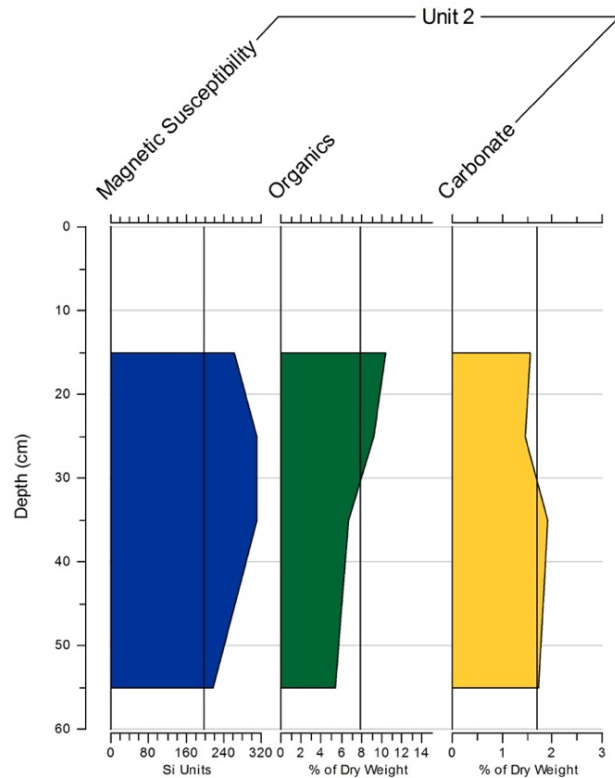


Figure 2: Magnetic susceptibility, organic and carbonate content for Unit 2.

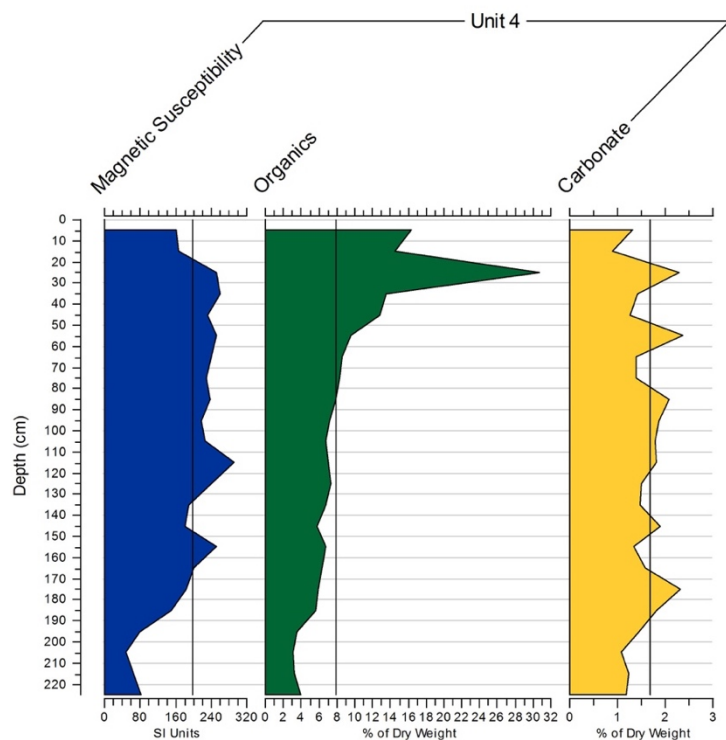


Figure 3: Magnetic susceptibility, organic and carbonate content for Unit 4.

290.6 SI. The minimum reading occurs in the 200-210cm layer at 47 SI. Readings show significant peaks at the 110-120cm layer and the 150-160cm layer (Fig. 3). A decrease in SI occurs after the 150-160cm layer to the minimum reading. Unit 4 shows a significant peak in organics and carbonate levels in the 20-30cm layer, followed by a drop in both between 30 and 50cm. Organic content decreases after 40cm, from 13.5% to 3.9% at 220cm. Carbonate levels are extremely variable compared to the other units, varying by $\sim 1.5\%$. Carbonates peak at the 25, 55, and 175cm midpoints. The minimum carbon content occurs in the 10-20cm layer, at 0.89%.

Unit 6

This unit shows a trend of decreasing magnetic susceptibility and has little variation. The 20-30cm layer has the maximum of 262.2 SI, and gently decreases to the minimum of 135.6 in the 80-90cm layer (Fig. 4). Organic content slowly decreases with depth from 9.2% in the 0-10cm layer to 4.8% in the 70-80cm layer, and rises to 5.25% in the final layer. Carbonate levels only by $\sim 0.8\%$, and shows its highest reading at 70-80cm of 2.26%.

Unit 7

Showing a similar trend to Unit 6, this unit has a maximum magnetic susceptibility reading of 227 SI in the 10-20cm layer, decreasing to a minimum of 134.7 SI in the 70-80cm layer (Fig. 5). Unit 7 shows nearly identical trends to

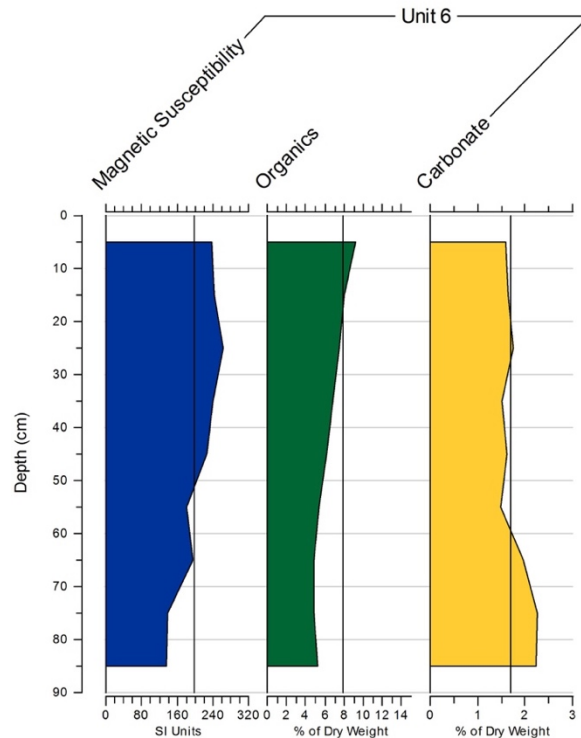


Figure 4: Magnetic susceptibility, organic and carbonate content for Unit 6

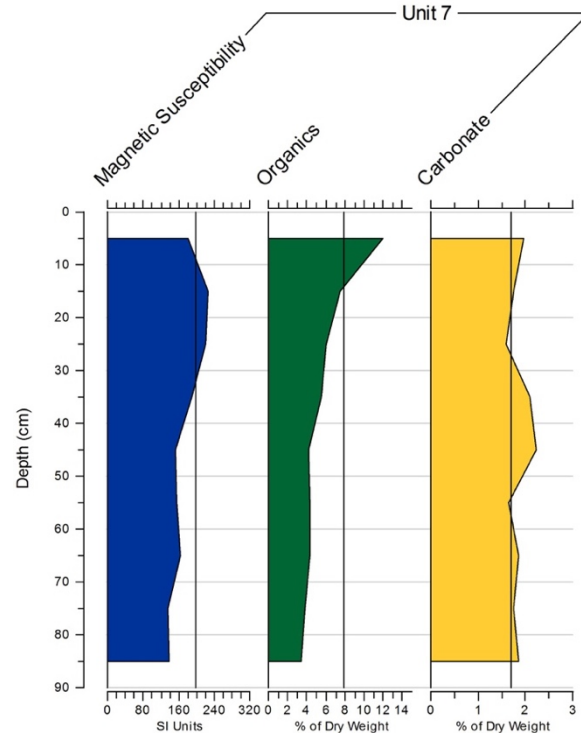


Figure 5: Magnetic susceptibility, organic and carbonate content for Unit 7

Unit 6, with organics decreasing with depth; however, organic levels are ~2% lower on average than Unit 6. Carbonate levels are between 1.6% and 2.2% throughout.

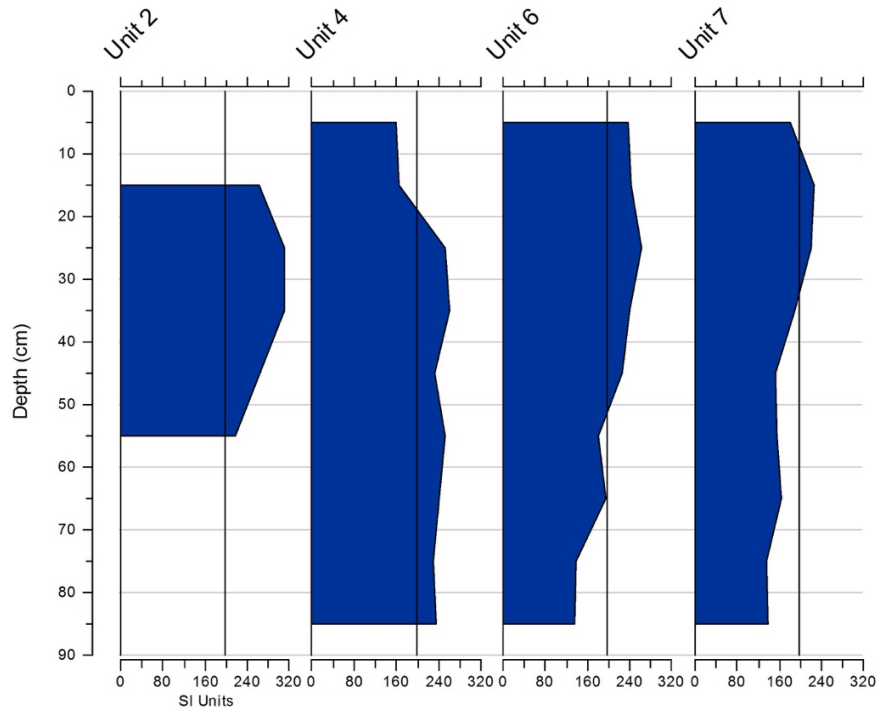


Figure 6: Magnetic susceptibility of all units to a depth of 90cm

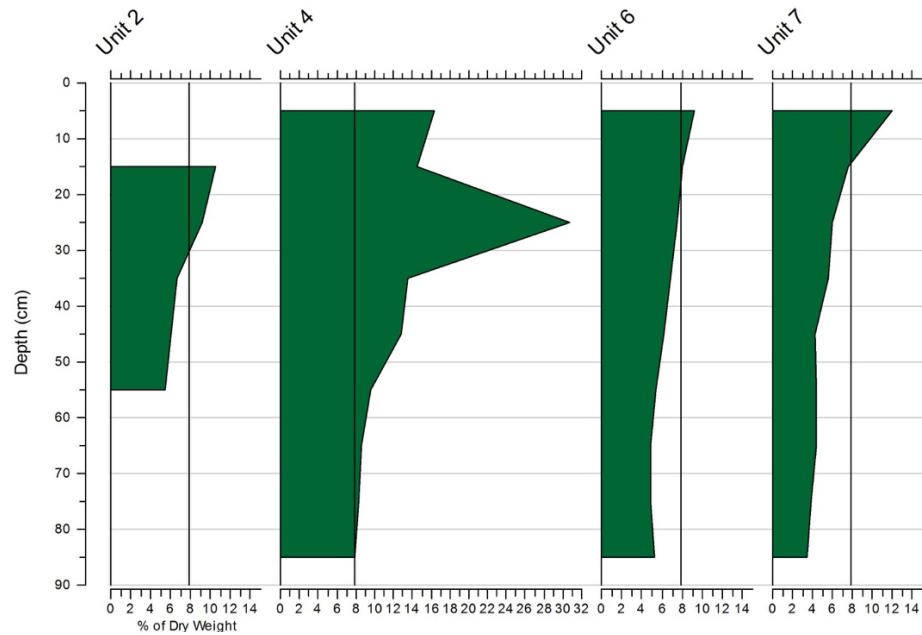


Figure 7: Organic content of all units to a depth of 90cm

Interpretation

All four column samples show an immediate increase in magnetic susceptibility units within the first three soil layers, to a depth of 30cm (Fig. 6). Units 6 and 7, both collected more than 10 meters away from a house pit (see Map 1), show more gradual increases in SI units with depth. Unit 4 shows the greatest increase in magnetic susceptibility above 30cm, increasing by 86 SI from the 15cm midpoint to the 25cm midpoint. The general increase in magnetic susceptibility across the site could be a result of past wildfires in the area, and therefore cannot be attributed to human occupation.

However, magnetic susceptibility readings relative to each unit suggest human occupation. Unit 2, taken from within one of the confirmed house pits (Map 1), shows significantly higher readings of SI units, up to 312.5 at 25cm below the surface. Although there are only four viable data points in this unit, all four have readings above the site average magnetic susceptibility (Fig. 2 and 6). The higher readings of magnetic susceptibility within the house pit is likely indicative of human occupation.

Unit 4, taken between House Pit 1 and 2, also shows above average magnetic susceptibility readings, but not as high as Unit 2. This may be a result of the unit's sample location, in an area that was likely a central workable space for the settlement (Map 1). Unit 4 also experiences a significant increase of organic content within the first 40cm, with a startling peak at 25cm (Fig. 3 and 7). This may suggest that this area was used for food preparation, although this is not confirmed. The discovery of a portable stone mortar at a depth of 52cm may be evidence of this hypothesis, however its depth is not consistent with the peak in organics at 25cm. Regardless, the stone mortar may indicate prolonged use of this location for food preparation, and the well above-average levels of organics are anomalous among the other units. It is also entirely possible that the increased organic levels were caused by root fragments within the sample that altered the data.

Conclusion

The soil analysis methods of magnetic susceptibility and LOI can be used to identify past human occupation, through analysis of magnetic and organic enrichment of soil due to campfire use and human presence. Although results from magnetic susceptibility readings were more conclusive than that of LOI, this study found significant differences in both factors in relation to archaeological site features. Notable increases in magnetic susceptibility readings correspond to areas of human occupation, especially nearby and within house pit features. This study stands as a proof of concept for the use of these methods on similar prehistoric settlement sites.

While these methods do not physically contribute to excavations, they may prove to be a less time consuming and less expensive method of identifying areas of interest across archaeological sites. The systematic coring of sediments across a site could therefore help archaeologists plan for future excavations.

In regards to future study, the further coring, excavation, and analysis of sediments from CA-BUT-3176 may further prove the efficacy of these methods. The sampling of sediment cores from other areas in the site may complete a picture of the site's occupation through time, and identify new unexcavated areas of interest.

Acknowledgements

This research could not have been possible without the assistance and cooperation of the Anthropological Studies Center at Sonoma State University, who conducted excavations on CA-BUT-3176 and allowed me to conduct tests on their soil samples. Special thanks goes to Michelle Goman and Jeff Baldwin of the Sonoma State GEP department, who supported and encouraged me throughout the writing process.

References

- Behrend M., D.R. Ford, K. Tippet, D. Simons, S.S. Flint. 2013. *Archaeological Survey and Site Boundary Delineation at Sites CA-BUT-3176 and CA-BUT-3255 for the Pacific Gas and Electric Company's Woodleaf-Kanaka Transmission Line Project, Butte County, California* (FERC No. 2281). Prepared by HDR Engineering, Inc., Sacramento. Submitted to Pacific Gas and Electric Company, Angels Camp, California.
- Chianese D., M. D'Emilio, S. D. Salvia, V. Lapenna, M Ragosta, E. Rizzo. 2003. "Magnetic mapping, ground penetrating radar surveys and magnetic susceptibility measurements for the study of the archaeological site of Serra di Vaglio (southern Italy). *Journal of Archaeological Science*; 31: 633-643.
- Dalan R.A., S.K. Banerjee. 1998. "Solving Archaeological Problems using Techniques of Soil Magnetism". *Geoarchaeology: An International Journal*; Vol. 13, No. 1, 3-36
- Dalan, R. A. 2006. "A geophysical approach to buried site detection using down-hole susceptibility and soil magnetic techniques". *Archaeological Prospection*; 13: 182-206.
- Dean W.E. 1974. "Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition; comparison with other methods". *Journal of Sedimentary Research*; 44: 242-248.

Heiri O., A.F. Lotter, G. Lemcke. 2001. "Loss on ignition as a method of estimating organic and carbonate content in sediments: reproducibility and comparability of results". *Journal of Paleolimnology*; 25: 101-110.

Heizer, R. F., A. B. Elsasser. 1953. "Some Archaeological Sites and Cultures of the Central Sierra Nevada". *University of California Archaeological Survey Reports* 21: 1-42.

Konzak, M., T. Whitley. 2019. "Archaeological Testing and Damage Assessment at CA-BUT-3176". Anthropological Studies Center, Sonoma State University, Rohnert Park, California. Prepared for California Department of Forestry and Fire Protection.

Kowta, M. 1988. "The Archaeology and Prehistory of Plumas and Butte Counties, California: An Introduction and Interpretive Model". California Archaeological Site Inventory, Northeast Information Center, California State University.

Nowaczyk N.R. 2002. "Logging of Magnetic Susceptibility. In: Last W.M., Smol J.P. (eds) Tracking Environmental Change Using Lake Sediments". *Developments in Paleoenvironmental Research*; Vol 1. Springer, Dordrecht

Pritzker B.M. 1998. Native Americans: An Encyclopedia of History, Culture, and Peoples. Vol. 1. Oxford, New York. Oxford University Press.

Shipley W.F. 1978. Native Languages of California. In R. F. Heizer, ed., The Handbook of North American Indians. Vol. 8, California: 80–90. (W. C. Sturtevant, general ed.) Smithsonian Institution, Washington D.C.

Triplett J., D. Gregory, C. Baricevic. 2017. Primary Site Record.

Werts S.P., A.H. Jahren. 2007. "Estimation of temperatures beneath archaeological campfires using carbon stable isotope composition of soil organic matter". *Journal of Archaeological Science*. 34. 850-857.