Preliminary Results of a Study to Identify Archaeological Artifacts from San Salvador in Colton, CA, Using Ground Penetrating Radar

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ABSTRACT

We present the preliminary results of an ongoing archaeo-geophysical survey at Pellissier Ranch in Colton, CA. Historical archives suggest that the 200-acre vacant lot was home to a significant portion of San Salvador, the largest non-native settlement in the mid-1800s along the Old Spanish Trail between New Mexico and Los Angeles. An overwhelmed Santa Ana River (SAR) led to the Great Flood of 1862, which washed away or buried beneath a thick layer of sandy river deposits, all adobe structures and settlers' belongings. Artifacts are anticipated to be buried at a shallow depth of 1.5-4 meters, making them good targets for several different types of geophysical surveys.

Ground Penetrating Radar (GPR), Electro-Magnetic induction (EM), and ground-based magnetic gradiometry have proven successful in non-invasively identifying archaeological artifacts in a variety of different environments. In dry, southwestern sites, the most successful of these approaches has historically been GPR. Much work has been accomplished by researchers at other sites in identifying structural remains of buried adobe walls in the subsurface by their "adobe melt" signature in GPR profiles. We employ GPR using a 400 MHz antenna across this site and have imaged several anomalies that have a high probability of being related to San Salvador. The most noteworthy are a north-south trending canal signature buried at a depth of ~1.5 meters, an "adobe melt" signature at a depth of ~2.5 meters, and a feature that resembles a collapsed structure that is ~30 meters long in profile view. Significant hyperbolic signatures exist in the profiles that image the potential collapsed structure, located just below the strong reflector interface at a depth of 1-3 meters. We hypothesize that the strong reflections are caused by the significant difference in dielectric properties between the sandy river deposits and the adobe walls which would have dissolved quickly in the flood and been redeposited.

As GPR continues to locate potential San Salvador artifacts, concentrated surveys using magnetic gradiometry and EM are being planned for confirmation. Our goal is to aid the Spanish Town Heritage Foundation in proving the cultural importance of this site before the city of Colton's plans to develop the land are implemented.

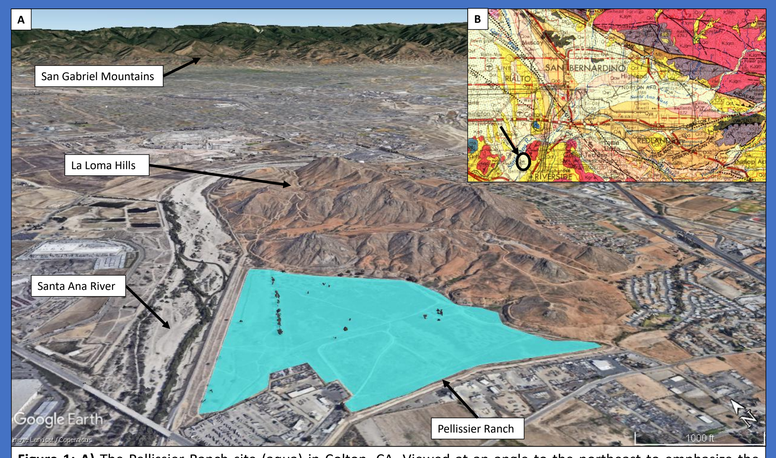

Figure 1: A) The Pellissier Ranch site (aqua) in Colton, CA. Viewed at an angle to the northeast to emphasize the absence of topography across the site and the San Gabriel Mountains. **B)** Geologic map of San Bernardino County, CA. Pellissier Ranch is circled. Quaternary wash deposits dominate the entire site. La Loma Hills are composed of Cretaceous quartz diorite. The San Gabriel Mountains, where the Santa Ana River originates, are composed of Cretaceous or Jurassic quartz monzonite.

INTRODUCTION

Pellissier Ranch is an approximately 200-acre plot of vacant land on the border of Colton and Riverside, CA (Figure 1). In February 2018, the Spanish Town Heritage Foundation (STHF) reached out with a request for an archaeological geophysics survey at Pellissier Ranch. Officers of the foundation are the descendants of high ranking settlers of the Agua Mansa/La Placita settlements (together known as San Salvador). San Salvador was the largest settlement between New Mexico and Los Angeles in the mid-1800s, populated by settlers from New Mexico.

In a single night, the entire settlements of Agua Mansa/La Placita were inundated by the SAR, with a peak flow of 9,000 m/s (Bainbridge, 1997). Efforts to farm the area post-flood were thwarted by the harsh, sandy deposits that the river had blanketed over the once fertile land (Vickery, 1984). Eventually, the settlers surrendered and moved to nearby communities, but the question remains: what became of the remains of San Salvador, the largest settlement between Los Angeles and New Mexico in the mid-1800s? Despite a brief period during which a vineyard was operated on the property, the land of Pellissier Ranch has remained undisturbed. The city of Colton has been looking to change that recently with plans of developing the land into a warehouse. Nancy Melendez, Darlene Elliot, and the rest of the STHF team seek to stop this development by proving the cultural importance of this land.

Archaeological geophysics has become a rapidly growing field in recent decades. The advancement of technology and computer processing has made the non-invasive techniques highly desired for their efficiency in determining the archaeological importance of sites. When the location is large and it is unknown where buried artifacts are located, invasive techniques are unfeasible. This study aims to identify subsurface anomalies with several different geophysical techniques at Pellissier Ranch that can be correlated with Agua Mansa/La Placita artifacts. Nancy Melendez and Darlene Elliot supplied us with images from historical recreations of the inside of an adobe home in the mid-1800s (Figure 2). Metallic and wooden artifacts will contrast greatly in material properties with the surrounding soil.

GEOLOGY AND SITE PROPERTIES

Historical archives claim the settlers were forced to abandon the land post-flood due to increased difficulty of farming given the new flood deposits. La Placita pre-flood was a fertile land, rich with agriculture, so we can assume that there must have been a more loamy soil at the surface pre-flood. We therefore infer there will be a measurable difference in material properties such as dielectric constant and conductivity between the previous ground surface that the canals were dug in and the sandy river deposits that filled them.

The modern surface soil of Pellissier Ranch had been classified by soil scientists from the United States Department of Agriculture as sandy loam (Natural Resources Conservation Service). Presently, it has been 156 years since the Great Flood of 1862, which has allowed for the deposition of this sandy loam atop what would have been the river deposits. A test dig at a location in the middle of the site found that the sandy loam extends ~0.5 meters deep. At this depth, the light colored sands, most probably deposited during the Great Flood of 1862, are reached (Figure 3).

Figure 2: Pictures supplied by the STHF, showing the likely possessions in the adobe homes. Settlers had no time to pack their belongings before the SAR inundated San Salvador and buried/washed away all possessions. Wooden and iron objects dominate both areas. **A)** A typical living area. Most homes are anticipated to have contained a kiln for cooking and heating during the winter months. **B)** A typical kitchen and cooking tools/utensils.

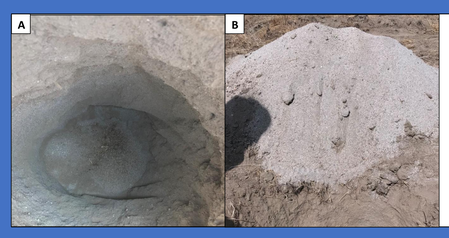

Figure 3: A) 1 meter deep, 0.5 meters diameter hole dug at Pellissier Ranch on 8/25/18. **B)** Unearthed sandy river deposits, encountered at approximately 0.5 meters depth. There is a distinct difference in grain sizes, cohesion, and color between the sandy river deposits and the sandy loam.

METHODS

Digital elevation models (DEMs) from the United States Geological Survey (USGS) show that in an overwhelmed river scenario, the flow on approach to Agua Mansa and La Placita would have been confined by two topographic highs (Figure 4). Also shown is that the Pellissier Ranch site has a slope of less than 1^{o} except in a few small areas, giving confidence that topography corrections for GPR will not be necessary.

Metallic and wooden artifacts would appear in GPR profiles as high amplitude, hyperbolic reflections. However, GPR can only image an object that is buried as deep as it is large. Artifacts are anticipated to be buried at a depth of 1.5-4 meters making relatively small artifacts difficult to image. However, previous research (Conyers, 2012) proved it possible to image "adobe melt" in the subsurface (Figure 5).

A GSSI Utility Scan Pro GPR with a SIR 4000 controller and 400 MHz antenna used to conduct several surveys in the last few months. With GPR, electromagnetic radar waves are emitted into the subsurface through a transmitter coil. When the wave encounters a change in dielectric properties, some of the energy is reflected up to the subsurface and recorded by the receiver coil. If there is a large difference in dielectric properties between the original material and the newly encountered material or artifact, the wave's reflection will be strong. When analyzing GPR traces, a strong reflection appears as either a bright white or dark black layer. If the materials do not differ greatly, the reflection will be less noticeable. From historical archives of San Salvador, materials and artifacts expected to be in the subsurface of Pellissier Ranch include: iron cookware, metallic utensils, wooden ladders/chairs/tables/fences, kilns, farming equipment, and adobe "melt" from the structures that were disintegrated in the flood waters.

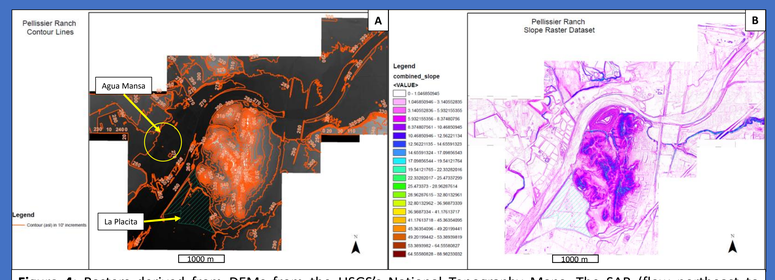

Figure 4: Rasters derived from DEMs from the USGS's National Topography Maps. The SAR (flow northeast to southwest) cuts diagonally across the figures. Pellissier Ranch, previously La Placita, is hashed in aqua, while Agua Mansa is circled in yellow. **A)** Map with 10' contour lines (ft. amsl). As the river approaches Pellissier Ranch, its flow is confined by topographic highs (La Loma Hills to the south and Mount Slover to the north). **B)** Showing 20 classes of slope (degrees). Pellissier Ranch is dominated by a less than 1^{o} slope.

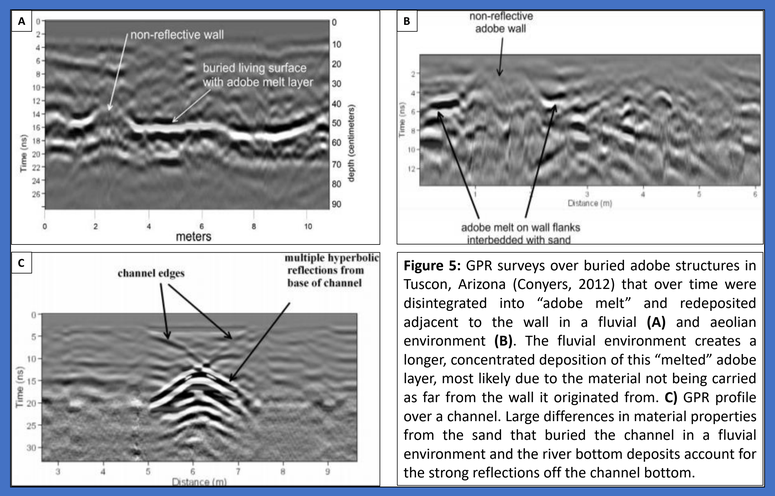

Figure 5: GPR surveys over buried adobe structures in Tuscon, Arizona (Conyers, 2012) that over time were disintegrated into "adobe melt" and redeposited adjacent to the wall in a fluvial **(A)** and aeolian environment **(B)**. The fluvial environment creates a longer, concentrated deposition of this "melted" adobe layer, most likely due to the material not being carried as far from the wall it originated from. **C)** GPR profile over a channel. Large differences in material properties from the sand that buried the channel in a fluvial environment and the river bottom deposits account for the strong reflections off the channel bottom.

PRELIMINARY RESULTS

60 GPR profiles have been completed at the site, 16 of which were collected along the dirt roads of the site. Areas furthest from the SAR did not contain significant anomalies. The highest amplitude anomalies within San Salvador artifact depth range came from profiles within 500 meters of the SAR and nearing La Loma Hills. We present 6 profiles that contain our most significant results to date. In GPR profiles (Figure 7), we have imaged an irrigation canal (Figure 6) and a potential collapsed structure (Figure 8). We strongly hypothesize that these objects are related to San Salvador, although this has not yet been confirmed by excavation. The GPR's depth of data collection was set to 7 meters. We performed a test dig in the middle of Line 8 (Figure 8). We dug through the sandy loam until we reached the river deposits at 0.5 meters, and dug another 0.5 meters until the excavation became too extensive and stopped (Figure 2). In Line 8, the strong reflection at 10 ns (nanoseconds) represents the air/ground interface. We next see a reflection at 15 ns. This layer change at 5 ns matches up with the sandy river deposits at 0.5 meters depth. After correlating this 5 ns reflection with the 0.5 meter layer, we can determine three things:

- The depth of data collection extended to 7 meters as expected
- The anomalous layer that returns a high amplitude reflection is buried at 40 ns, placing it at a depth of ~3 meters
- The contrast between the 40 ns layer and the river deposits is significantly stronger than that between between sandy loam and river deposits

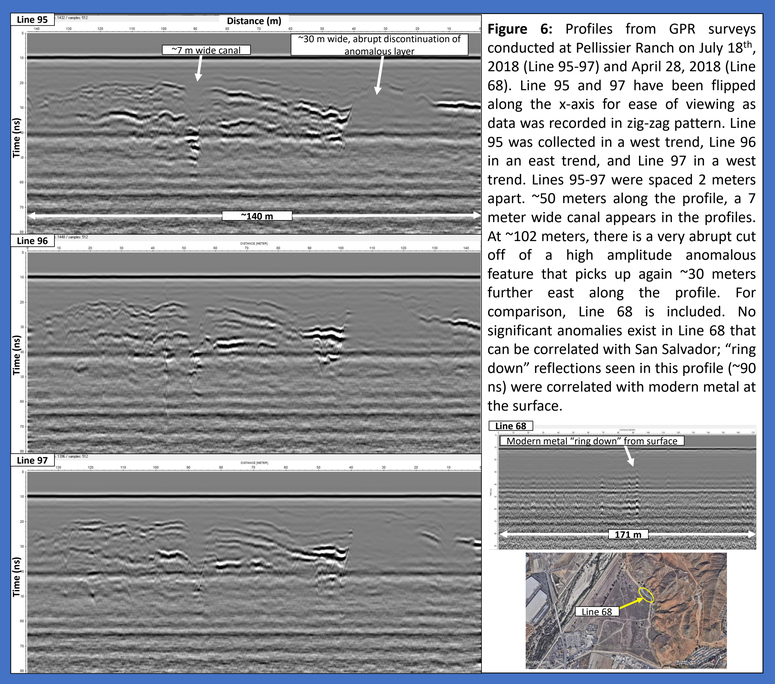

Figure 6: Profiles from GPR surveys conducted at Pellissier Ranch on July 18th, 2018 (Line 95-97) and April 28, 2018 (Line 68). Line 95 and 97 have been flipped along the x-axis for ease of viewing as data was recorded in zig-zag pattern. Line 95 was collected in a west trend, Line 96 in an east trend, and Line 97 in a west trend. Lines 95-97 were spaced 2 meters apart. ~50 meters along the profile, a 7 meter wide canal appears in the profiles. At ~102 meters, there is a very abrupt cut off of a high amplitude anomalous feature that picks up again ~30 meters further east along the profile. For comparison, Line 68 is included. No significant anomalies exist in Line 68 that can be correlated with San Salvador; "ring down" reflections seen in this profile (~90 ns) were correlated with modern metal at the surface.

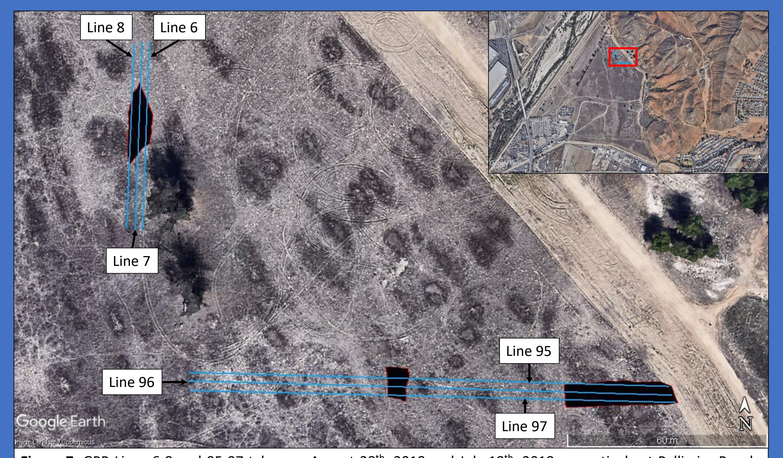

Figure 7: GPR Lines 6-8 and 95-97 taken on August 28th, 2018 and July 18th, 2018 respectively at Pellissier Ranch. Black shapes outlined in red denote locations of anomalies seen in profiles. The anomaly between Lines 6-8 represent a potential collapsed structure. Anomalies between Lines 95-97 represent (from west to east) a 7 meter wide canal and a 30 meter long, abruptly interrupted reflector.

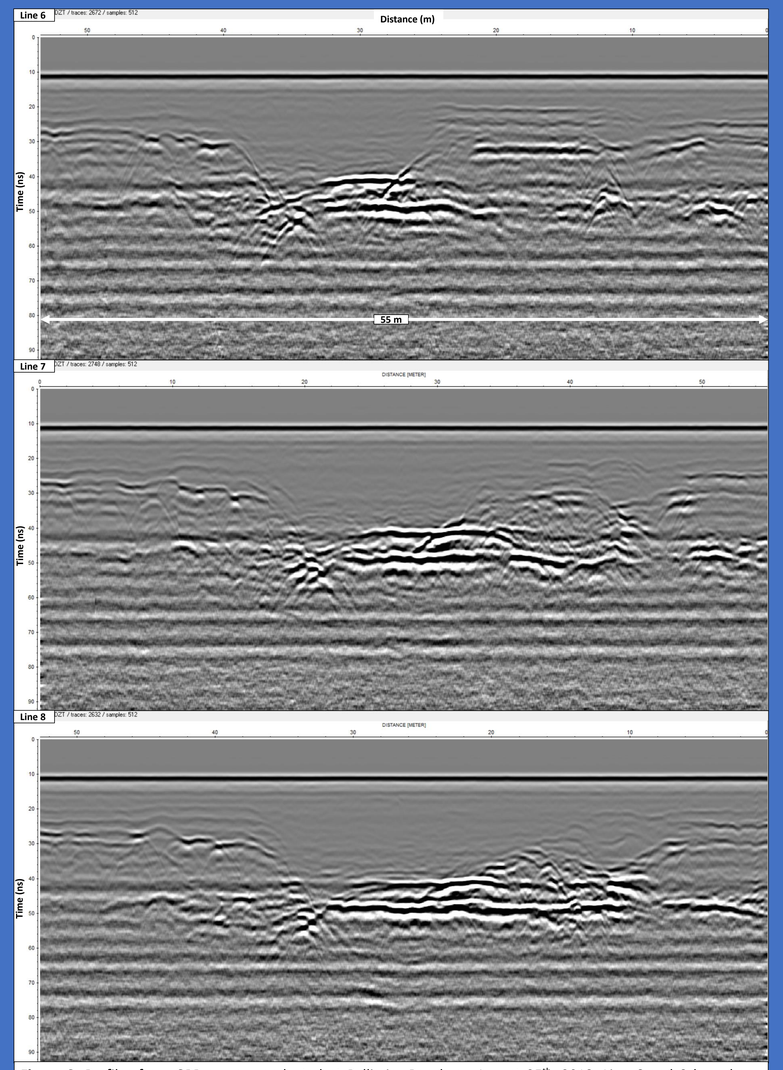

Figure 8: Profiles from GPR survey conducted at Pellissier Ranch on August 25th, 2018. Line 6 and 8 have been flipped along the x-axis for ease of viewing, as data was recorded in zig-zag pattern. Line 6 was collected in a southwest trend, Line 7 in a northeast trend, and Line 8 in a southwest trend. Each line was spaced 0.5 meters from the previous for a concentrated survey over this anomaly. ~18 meters along the profile, a large ditch feature appears in profile view with a high amplitude reflection at 40 ns. ~30 meters, a structural feature appears seemingly intact in Line 6 and progressively is collapsed from Line 6 to Line 7 and then Line 8.

CONCLUSIONS AND FUTURE WORK

Results from our GPR profiles show anomalies that can be correlated with San Salvador artifacts based on their large contrast from the soil matrix that they are buried in, and their depth of burial. Historical archives claimed at least one meter of sandy river deposits buried the settlement, but not deeper than four meters (Nancy Melendez, pers comm.). We imaged several high amplitude reflections in our profiles in this depth range. Future surveys will include more concentrated GPR profiles over additional anomalies and generation of 3-dimensional maps. To improve our interpretation of these anomalies, we intend to perform small scale, high resolution, electromagnetic induction and magnetic gradiometer surveys over these areas and combine the results from these different geophysical approaches.

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