# Portable Instrumentation and Rock Art Analyses: A Simple Method for Creating Micro-Viewsheds from Pleito Cave

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*This Gordian Knot Project utilizes portable X-ray fluorescence, portable Raman spectroscopy, portable Fourier transform infrared spectroscopy, and various imaging on-site techniques such as photogrammetry, dStretch, reflectance transformation imaging, and laser scanning at the California rock art site known as Pleito. While these techniques have great worth, each technique has its own drawbacks and limitations. Laser scanner has shown to be a highly accurate, but cumbersome data set for geographic information science analyses. In this article, a simple but effective technique is presented showing how using standard portable total station equipment remains effective to create micro-viewsheds of rock art in relation to other archaeological features and its natural setting.*

With the proliferation of portable, non-destructive analytical equipment, we are entering a renaissance in researching rock art not only in California, but across the globe. The Gordian Knot Project focuses on the Main Cave of Pleito (CA-KER-77), one of the most complex painted localities in California. This project utilizes portable X-ray fluorescence, portable Raman spectroscopy, portable Fourier transform infrared spectroscopy, and various imaging on-site techniques such as photogrammetry, dStretch, reflectance transformation imaging, and laser scanning (Bedford et al. 2014, 2016, 2018; Kotoula et al. 2018; Robinson et al. 2015). All of these techniques have proven valuable, some for the creation of virtual reality immersive work (Cassidy et al. 2018, 2019). However, each technique has its own drawbacks and limitations. For instance, laser scanning is very good for documenting extant art, rock surfaces, and local topography in the most accurate detail, but the ensuing data set is so large that utilizing it for subsequent analyses typically exceeds the capabilities of even high-end computers. This is particularly a problem when trying to import such data into geographic information science (GIS) programs for traditional analyses such as least cost path or viewshed. In this article, a simple, low cost, but effective technique is presented illustrating how archaeologists, heritage experts, or conservationists may utilize standard portable total station equipment in the field to create data sets amenable to viewshed analyses on the local, or micro, scale.

## CREATING MICRO-VIEWSHEDS FROM ROCK ART LOCATIONS AND SHELTER OPENINGS

Pictographs are visual media. They exist on rock surfaces in four dimensions: x, y, z, plus time. While time remains more difficult to gauge, there are established techniques of examining the other three dimensions. Additionally, GIS is particularly useful to examine viewsheds because, given the proper data, it can calculate [illegible] remains also exist in these dimensions. Here it is shown that the question of the visual presence of pictographs on-site could be directly assessed using viewshed analysis to see the visual relationship between different archaeological components.



However, a 30-m DEM available from the USGS was not of sufficient resolution to be used in any meaningful manner for the fine-grained viewsheds, 1-m resolution Shuttle imagery was too expensive, and downloading a useable DEM would still necessitate mapping the archaeological components. Therefore, it was decided to map using a total station (Figure 1). This allowed detail of the edges of features that needed high accuracy for viewshed algorithms to determine line-of-sight. A basic outline of the procedures is as follows:

*Figure 1. Mapping Pleito using a Topcon total station.*

1. To perform this work, a standard intensive topographic electronic distance mapping (EDM) station survey of the site and its extended environs.
2. Detail EDM mapping of rock outcrops.
3. Detail EDM mapping of archaeological components and the natural features they occupy, including bedrock mortars (BRMs), middens, isolated finds, rock art panels, and shelter mouths.

In this case, a Topcon total station digital unit was utilized following the specific field procedures:

1. Establish datum(s), N/S orientation, GPS coordinates.
2. Establish a site perimeter extending into the local environs.
3. Topographic survey of site.
4. Survey of rock outcroppings and other pertinent natural features (springs, vegetation change, tree line, etc.).
5. Survey all rock art.
6. Survey all bedrock milling features.
7. Survey midden or individual finds.

A survey log was kept, sketching each site and making important notations. Over 4,000 individual points (Figure 2) were recorded with the Topcon total station. Following this fieldwork, the point data were transferred into ArcGIS as a "raw" DEM (Figure 3). This DEM was created in order to enable the ArcGIS program to calculate viewshed functions and create on-site visual envelopes from panels, shelter mouths, or rock features. It was found that the most accurate DEM for this purpose was a triangulated irregular network (TIN): a "vector representation of elevation that models the prototype in the form of triangular faces derived from the Delauney triangulation of spot-heights or survey points" (Wheatley and Gillings 2000:9).

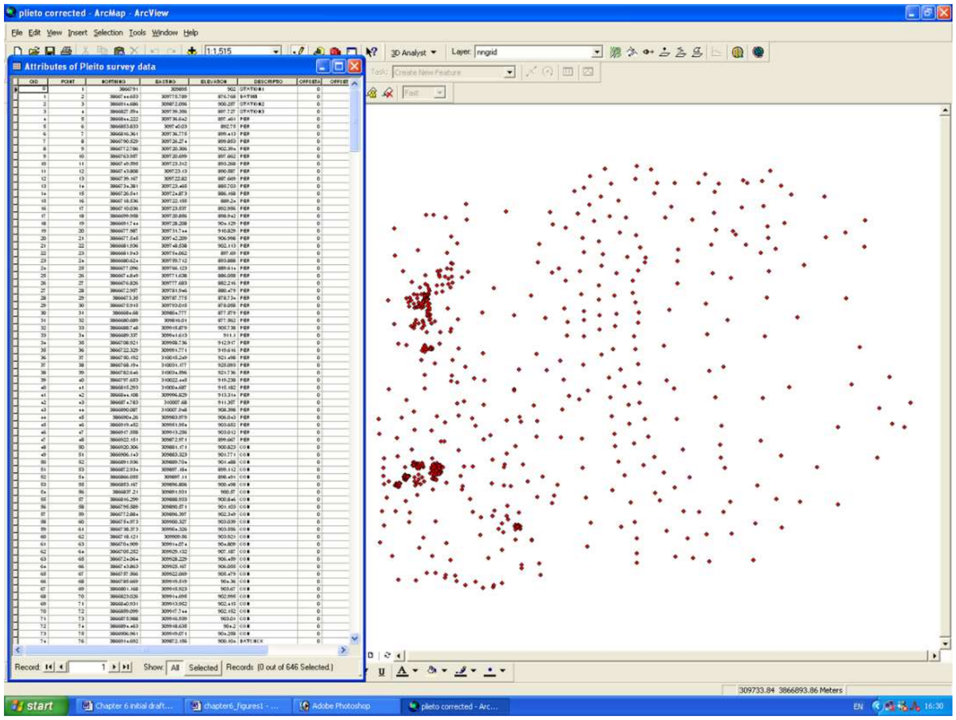



*Figure 2. Screen shot of total station points.*

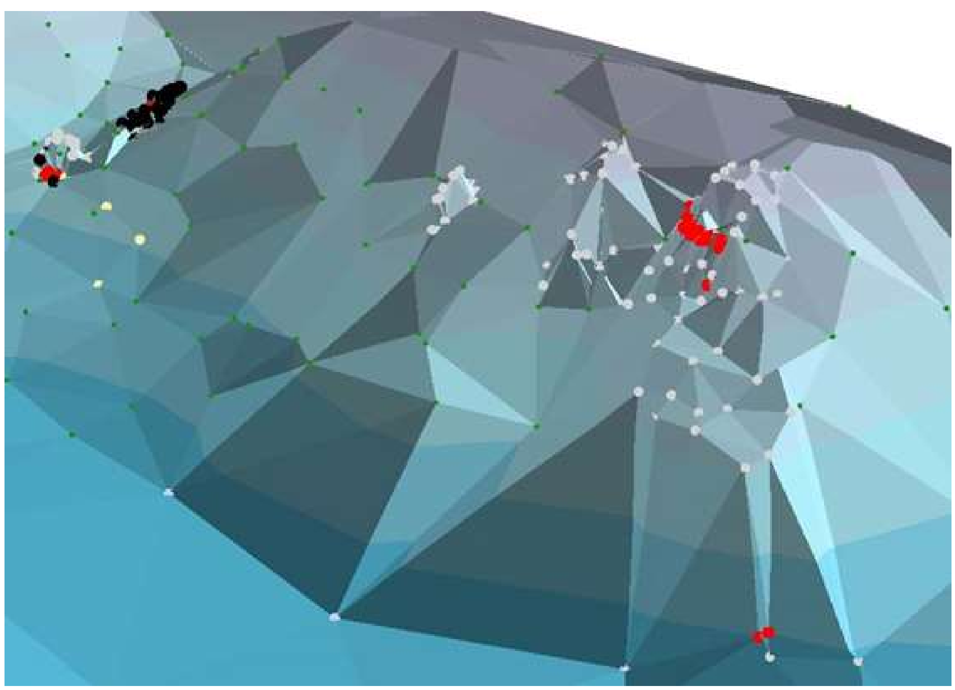


*Figure 3. Offset view of a portion of Pleito raw DEM, showing all survey points in the field (green = contour and perimeter points; red = pictograph features; black = BRMs; yellow = midden; grey = outcrops). The Main Cave is red concentration on top right. Boulder cave is far left.*

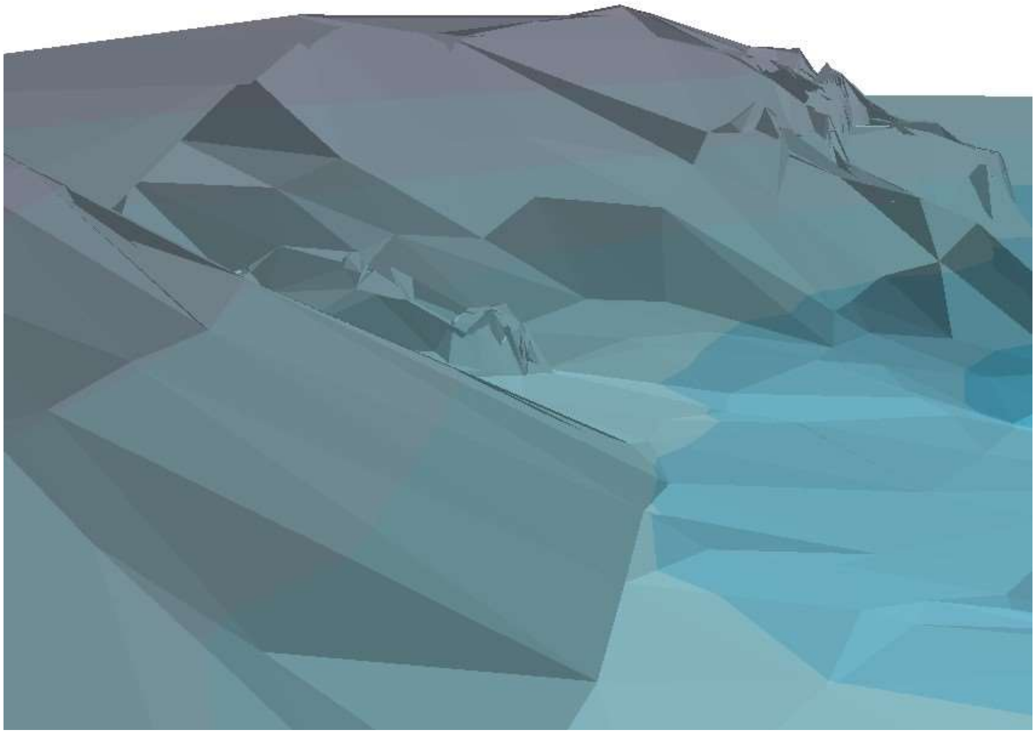
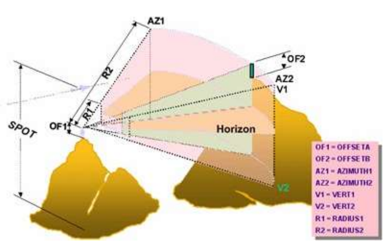


*Figure 4. View of raw DEM from upstream, Pleito. Note that the "V" declivity on the horizon is an error of triangulation.*

By raw, it is meant that the data has not been adjusted to compensate for minor errors within the triangulation calculations. Because of the calculation errors, the images produced often have "glitches" in the way that the GIS software triangulates surfaces; for instance, points within the interior of the main cave of Pleito connected with the top of the rock outcrop instead of the mouth, producing an erroneous "V" declivity to the top of the rock outcrop (Figure 4).

Another common error is for the linking of two points on opposite sides of a drainage and forming an imaginary vertical "wall" (Figure 5). These errors can be corrected by adding "dummy" points to create a more accurate DEM.

After correcting the DEM, viewsheds could be performed. The following is a synopsis of viewshed parameters from ArcGIS Help explaining how micro-viewsheds were created. There are nine characteristics of the viewshed that you can control:




1. The surface elevations for the observation points (Spot).
2. The vertical distance in surface units to be added to the z value of the observation points (OffsetA).

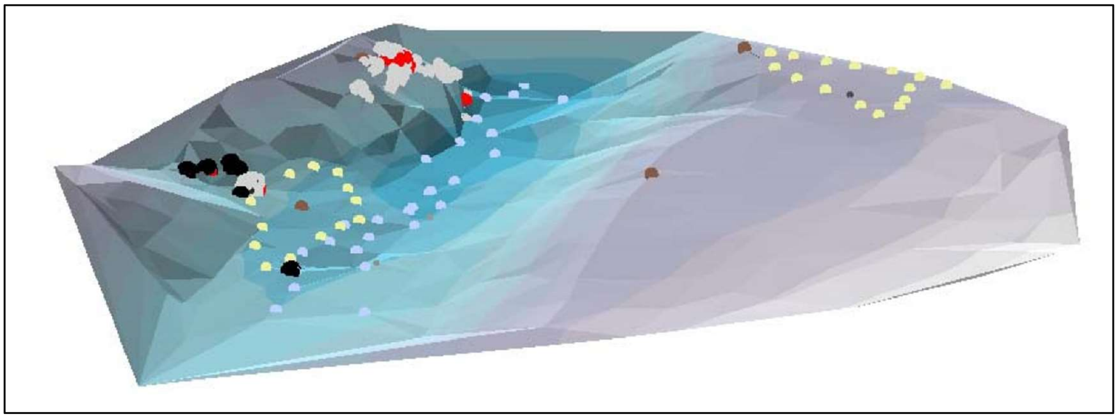
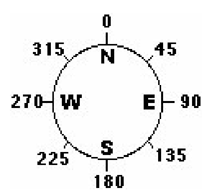


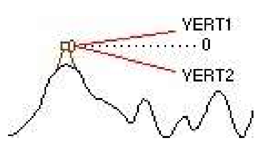
*Figure 5. A full, offset view of Pleito without survey points, looking north. Notice that the northern edge of the drainage has a false wall. Brown = stations; yellow = midden area; blue = creek bank; grey = rock outcrops; black = BRMs.*

3. The vertical distance in surface units to add to the z values of each cell as it is considered for visibility (OffsetB).


4. The start of the horizontal angle to limit the scan (Azimuth1).
5. The end of the horizontal angle to limit the scan (Azimuth2).

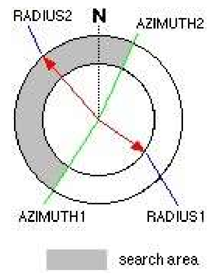



6. The top of the vertical angle to limit the scan (Vert1).
7. The bottom of the vertical angle to limit the scan (Vert2).




8. The inner radius that limits the search distance when identifying areas visible from each observation point (Radius1).

9. The outer radius that limits the search distance when identifying areas visible from each observation point (Radius2).




In the viewsheds here, it was necessary to determine where the pictographs (or the features they occupy such as a cave mouth) could be seen. In other words, Offset B is the viewer, not Offset A: this is a little different than typical viewsheds. However, since line-of-site works both ways, all that needs doing is to correctly establish the Offset heights. Since my EDM survey pinpointed the x-y-z location of the pictograph feature, its offset (Offset A) is 0. Since Offset B is the *eyes of humans anywhere on-site*, that offset needed to be raised to eye level. The typical human-height Offset was shaved to 1.5 meters (usually it is about 1.7 or 1.8) since many tasks on-site, such as pounding acorns, were performed sitting and to compensate slightly for hill wash. After setting Offset parameters, to perform viewsheds in ArcGIS the following steps were done:

1. Select pictograph point(s) in point file.
2. Go to Spatial Analyst>Surface Analysis>Viewshed.
3. Select Input Surface (DEM), Observer points (point file), leave Z-factor at 1, and set output cell size to 0.1 (Figure 6).

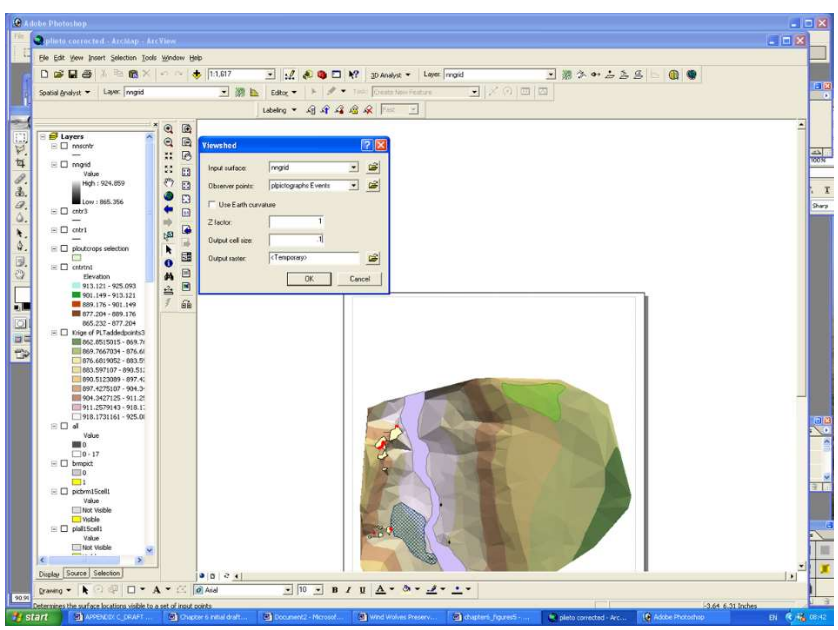


*Figure 6. Screenshot of the menu parameters in performing a viewshed from Pleito data.*

It was found that selecting 0.1 as the output cell size slightly restricted the edges of the viewshed. This was found to be the best parameter possible in better defining a realistic view envelope, since the more one is at an angle to a pictograph or feature, the less prominent it is. However, no compensation for viewshed distance (such as the Higuchi parameters, see Wheatley and Gillings [2000]) was needed since these are micro-viewsheds, performed at a site scale instead of landscape scale.

Before running viewsheds, a complete map of the site was produced, showing middens, BRMs, pictographs, topography, and natural features (Figure 7). Viewsheds were then performed from each pictograph location following the procedure outlined above (Figure 8). Importantly, each viewshed was printed and taken back on-site to double-check. It is crucial that viewsheds are not assumed to be correct but are double-checked in the field to ensure they accurately represent the actual viewshed on-site. Fortunately, since the total station work focused intently on rock outlines, the viewsheds were found to be highly accurate; however, one BRM boulder at Pleito needed minor corrections as a projection from that boulder was not accurately mapped, thus creating a minor variation in the lower viewshed; this was easily corrected by adding in dummy points to where the boulder outline should be. After verification, all viewsheds were combined into cumulative site viewsheds to demonstrate the rock art's total visual on-site envelope. The idea here is simple: to map out the visual areas where people would have been able to see the rock art or the feature it occupied.

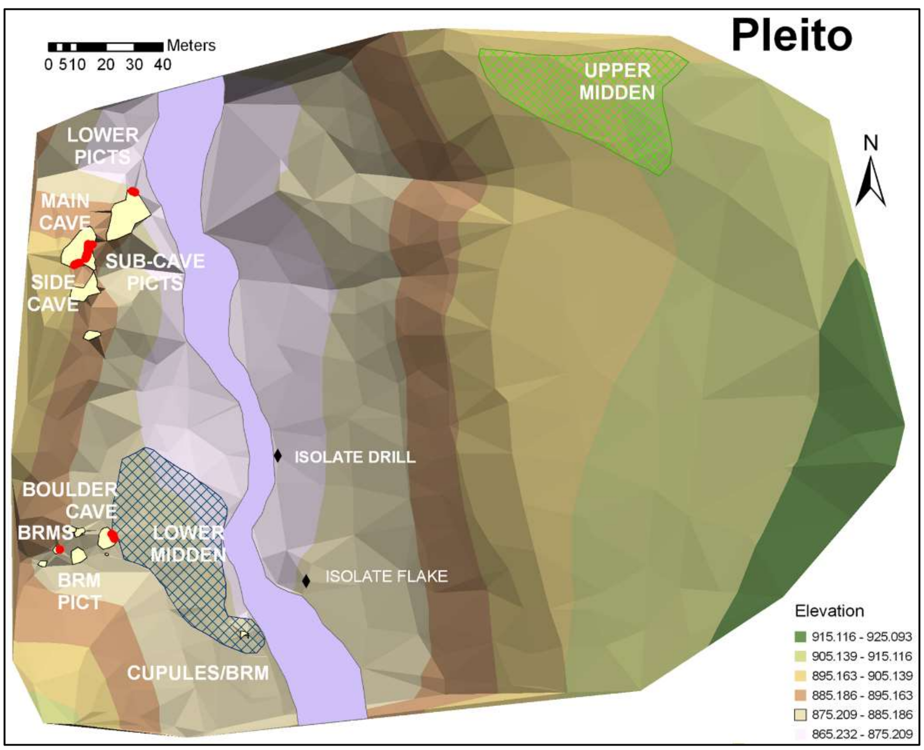



*Figure 7. Map of Pleito derived from total station data and DEM.*

## DESCRIPTION OF RESULTS

The site itself is bisected by a creek, with midden on the grassy eastern terrace overlooking the majority of the site on the west. This upper midden contains beads, chert and obsidian flakes, burned bone, *Anodonta* shell, and orange ochre (Sprague and Grasse 1999). On the west side, an extensive midden covers a lower terrace with similar components, as well as asphaltum-covered pebbles used for insulating basketry, and

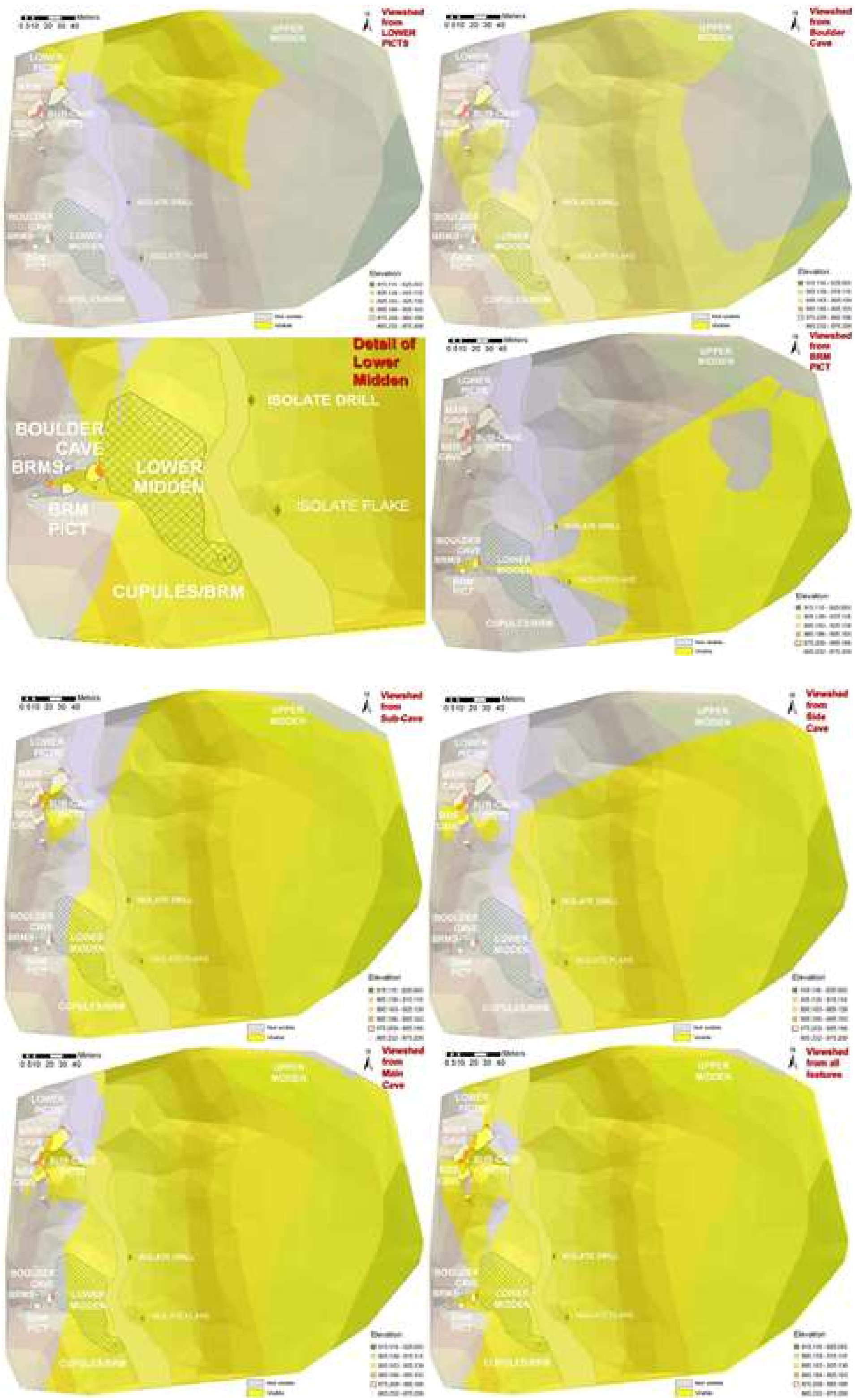



*Figure 8. Viewsheds from different pictograph locations. Yellow areas demarcate areas of intervisibility between a person and the rock paintings. The bottom right is the cumulative viewshed for all pictographs and landforms.*

*Table 1. Bedrock Milling Stations and Number of BRMs.*

| Station Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total |
|---|---|---|---|---|---|---|---|---|
| Total BRMs | 13 | 27 | 3 | 1 | 6 | 1 | 9 | 60 |

ground stone artifacts. Grasse (2005) had recently concluded excavations of this Lower Midden: finds include chert and some obsidian debitage; points, probably Later Period; a ground stone metate; a broken clam shell ornament; charcoal and animal bone; and late period and historic period beads. The site has nine bedrock milling stations, 60 BRMs, and over 100 cupules (see Table 1). There are also six different pictograph locations. Viewsheds were performed from each.

## Lower Pictographs

Approaching the site from the north, the first encounter is a large, honeycombed-weathered sandstone formation on the west bank of the creek. Two remnant red elements can be seen. Viewsheds demonstrated that these elements are intervisible with a small portion of the Upper Midden on the opposite side of the drainage, but no other archaeology.

## Boulder Cave

Continuing south along the creek, an open grassy terrace contains the Lower Midden. Here, a large boulder with two series of prominently carved steps winds up the side leading to the top of the boulder. On the east face of the boulder, a small shelter is outlined by dozens of patterned cupules. Within the shelter, cupules cluster in the rear, with red dots painted over many of them. There are numerous other pictographs—two panels with at least 11 anthropomorphic/zoomorphic figures; a red-abstract curvilinear element; cream-and-brown zigzag stripes; red, black, and orange dots; red-and-black aquatic motif; orange-and-black bird tracks; black traces; and an orange-and-red sun element. Viewsheds performed from the mouth of the shelter showed intervisibility with both middens, the two isolated finds, as well as two stations with 10 BRMs.

## BRM Pictograph

Upslope and west of Boulder Cave, the majority of the BRM stations cluster in a steep draw. Station 2 has the most BRMs of any on-site, and a hollow on its east face has a black-grid pictograph. The viewshed indicated that only Station 2, with its 27 BRMs, is intervisible with the pictograph.

## Sub-Cave

North from the Lower Midden, Boulder Cave, and BRM stations are large sandstone outcrops containing the remaining pictographs. Climbing up the rocks, an east-facing alcove lies directly below the Main Cave. Pictographs in this alcove include red and white fragments, a black grid, and a white stick figure. Viewshed analysis from the mouth showed that both middens, the isolates, and two stations with 10 BRMs are intervisible.

### Side-Cave

On the upper part of the sandstone formation, level with the Main Cave, a small south-facing shelter contains white, red, and black fragments; a white stick figure; and a composition with white patterned “v”-shaped figures bisecting between two red-black-white swirling elements. Viewshed analysis from the mouth showed intervisibility with the Upper Midden, a portion of the Lower Midden, and both isolates.

### Main Cave

On the upper portion of the sandstone outcrop, the Main Cave faces east. The most elaborate concentration of pictographs in California, and indeed perhaps North America, exists on the surviving portions of sandstone casing. There are multiple panels—elements range from simple black-linear to the most elaborate of polychrome compositions. Aquatic motifs, anthropomorphs, zoomorphs, geometrics (circles, zigzags, grids, meanders, curvilinear and linear abstracts), a few cupules, and compositional pieces make up the rock art. Colors include different shades of red, black, white, yellow, orange, green, and blue with multiple layers of superimposition. Highlights of the cave include two polychrome mandala-like discs with distinctive, elaborated “trailers” (Panels A, J, and K); a group of four highly embellished polychrome figures (Panel C); a circular composition with an assortment of aqua-blue-red-white figures overlain with orange plummet shapes (Panel E); and a panel with multiple images, densely applied and superimposed covering the northern wall of the cave (Panel H). A viewshed was performed from several points defining the cave mouth; it showed intervisibility with the majority of both middens, both isolates, and two stations with 10 BRMs.

### Cumulative

As shown in Table 2, a total of three stations with 37 BRMs, the Upper Midden, the Lower Midden, both isolates, and the vast majority of the site confines are intervisible with the pictographs.

*Table 2. Site Intervisibility Attributes Derived from Viewshed Analysis.*

| Features Tested | Total BRM Stations | Station Designations | Intervisible Taskscapes | | Isolates | Cupules | Path To Water |
|---|---|---|---|---|---|---|---|
| | | | Number of BRMs | Middens (Upper/Lower) | | | |
| Lower Pictograph | 0 | 0 | 0 | Yes/No | 0 | 0 | Yes |
| Sub-Cave | 2 | 6,7 | 10 | Yes/Yes | Yes | Yes | Yes |
| Side-Cave | 0 | 0 | 0 | Yes/Yes | 0 | No | Yes |
| BRM Pictograph | 1 | 2 | 27 | Yes/Yes | No | No | Yes |
| Main Cave | 2 | 6,7 | 10 | Yes/Yes | Yes | Yes | Yes |
| Boulder Cave | 2 | 6,7 | 19 | Yes/Yes | Yes | Yes | Yes |
| All | 3 | 2,6,7 | 37 | Yes/Yes | Yes | Yes | Yes |

## DISCUSSION

Clearly, Pleito is a site of extraordinary importance. The site could accommodate multiple family groups, but perhaps not an entire village population; certainly at least 14 women would be able to work at the BRM stations. However, the Grasse (2005) excavations in the Lower Midden in front of Boulder Cave indicate a full complement of activities reflecting both male and female tasks, and this is reiterated from surface finds from the Upper Midden. The visibility coverage of the overall rock art encompasses the majority of the habitable areas and extended site environs. The natural architecture of the locale influences spatial dynamics. The majority of the BRMs are excluded from the primary viewshed envelopes, but access to the water for acorn-leaching purposes would have taken one into the heart of the viewsheds. Boulder Cave, with its cupule patterning and polychrome elements, dominates the Lower Midden. The Main Cave also is dominant even on an angle as viewed from the Lower Midden and BRM Stations 6 and 7. From the Upper Midden, the mouth of the Main Cave looms large over the raised terrace. There is no doubt that the rock art of Pleito commands a dominant visual presence for anyone inhabiting the locale.

## CONCLUSION

The micro-viewsheds shown here reiterate what research over the past decade or more has shown, namely, that rock art paintings such as those found at Pleito were not exclusively visited or seen by male shamans alone, but were seen and experienced by all genders and ages, deeply embedded within the normal working space of all members of native society (Robinson 2007, 2010). Pleito is best seen as a site for the entire local community (Robinson 2013; Robinson and Wienhold 2016; Wienhold and Robinson 2017). The technique outlined here allows researchers the opportunity to continue testing the visual, spatial dynamics of localities that have rock art and other features. However, it also points out that this technique can be applied to any situation, archaeological or otherwise, where micro-viewsheds might help to better understand the visual characteristics of physical space.

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