Additional Information on the Willow Creek Observatory, Northern California.

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ABSTRACT

This paper provides additional information on an ancient observatory situated on the rim of Willow Creek Canyon in northeast California. Rudolf (1993, 1995, 1996) described the site and observed solar interactions. Two natural rock-roofed clefts in a basalt escarpment were utilized by placing various petroglyphs on the walls so that shafts of light formed by modified natural cracks and rock configurations produced light pointers that impinged upon specific parts of these petroglyphs at significant times of the year. The summer solstice is predicted by 59 days, i.e., two lunar cycles. The summer solstice is determined by a light pointer that lands on the sloping top of a standing stone at first sunlight. A light finger lands on the center mark of a seven-legged *Super-Pi Petroglyph* in the early afternoon. Only moonlight can reach the southernmost of the legs. Later, the sunlight lights only the top circle of the *Sun/Moon Gage*, the balance of the gage being illuminated only by moonlight, indicating knowledge of the 19-year lunar cycle. A computer program has been used to determine when the moon would be in a position to cast a beam of light on these two images. Near sunset, a light pointer moves around the outside line of concentric arcs to pull away at the top. At sunrise on the equinox, a light/shadow line runs exactly on the points of a stack of five chevrons. These and other interactions are dramatic indications that the site was used over a long period of time to mark the change of seasons with great accuracy, thus illustrating the importance of seasonal sky events to the early inhabitants of the area

INTRODUCTION

The Willow Creek Observatory is on northerly end of a basalt ridge, which is heavily embellished with petroglyphs. Many are invisible unless sunlight slopes across the rock face tangentially. Two natural "caves", i.e., fissures in the basalt are covered partially by large slabs and boulders, and are of particular interest. One, the *Sunrise Chamber* opens to the Northeast. The other, the *Sunset Chamber* opens to the southwest. The main events observed and the principle subjects of this paper are: a sunrise light triangle on a now removed target stone, 59 day summer solstice predictor light spear, the equinox light/shadow line on chevrons, and the late afternoon light-pointer on the *Sunset Mask*. Furthermore, the purpose and use of the mid-day light finger on the *Super-Pi Petroglyph*, along with the meaning of the five wavy parallel lines and the purpose and use of the *Sun/Moon Gage* are described below.[1]

DISCUSSION

During the 1995 summer solstice visit, I observed and photographed a light pointer shaped like a clenched fist with extended finger land on the S*uper-Pi Petroglyph* with the tip of the finger first touching a drilled hole then moving to the short center leg. (Rudolph 1995) It then moved off to the right (east). This light pointer never moved farther to the west on the petroglyph, either before or after the solstice. The only source of light that would project the light finger to reach the westward three legs is moonlight. About 60 feet southwest of the sunrise chamber is another "cave" formed by a six foot wide fissure capped by large slabs of rock creating a rough sort of cave. The roof rock and an outer ledge form a light pointer that lands on various petroglyphs at certain specific times of the year.

Figure 1 illustrates a section through the sunset chamber. From right to left the petroglyphs are: the one-eyed *Sunset Mask*, the parallel wavy lines, the double-lined serpentine, and the *Sun/Moon Gage*. A light spear strikes the center lobe of the double-lined serpentine, 59 days before the summer solstice (Rudolph 1995). The light pointer moves up and around the *Sunset Mask* outer arc on the afternoon of the summer solstice as shown in Figure 2. At the vernal equinox, this shadow profile works across the arcs of the *Sunset Mask* (Figure 3). The *Sun/Moon Gage* is shown in Figure 4.

The expedition of June17-23, 1996 was undertaken to measure azimuth and altitude angles of assumed sun and moon light pointers that I postulated would impinge upon the *Sun-Moon Gage*. These were taken by first stretching a string from aperture to petroglyph with the help of Dr. Bob Fortner and then measuring more accurately with an optical K&E "mountain transit", actually a theodolite. The sunlight, shaped by the narrow aperture, was observed to fully illuminate the upper offset circled dot only at its maximum.

Figure 5 shows the view looking up at the *Sun-Moon Gage* from below showing stretched string. The view looking down from above at the string stretched down through the aperture crevice is shown in Figure 6. Figure 7 is the view of the author taking a sight down the stretched string with a modified theodolite. This rather crude method gave remarkably accurate results and was used by Paul Middents (1966). The analysis worked up by Middents gave tantalizing "proof" that the hypothesis was correct, namely, that this was indeed a gage to compare the angles of elevation of the moon throughout its nineteen year cycle to that of the sun at its maximum elevation at the summer solstice.

Because these angles were measured with stretched string and a crude sighting device, I determined to return to the site with Paul Middents, equipped with a better instrument later that year. I modified the theodolite by mounting an inexpensive telescopic rifle sight atop the telescope barrel of the instrument. Offsetting this sight above the barrel of the instrument allowed vertical angles to be measured up to 75 degrees. We visited the site on September 5-9, 1996 and spent most of our time making careful measurements of azimuth and altitude of both the *Sun-Moon Gage* in the *Sunset Chamber*, and also the angles of sun and moonlight pointers at the *Super-Pi Petroglyph* in the *Sunrise Chamber*.

Figure 8 a, b, and c show the light finger sequence of the *Super-Pi Petroglyph* on the day of the summer solstice. We now had careful and accurate measurements at the *Sun-Moon Gage* and the *Super-Pi Petroglyph* so Paul Middents could do an analysis of both. The last part of this paper will be an abridged version of these analyses.

One fascinating "revelation" is worth noting before proceeding with Paul's part of the work. The parallel wavy lines in the *Sunset Chamber* had been an enigma to me. It looked as though it represented a river or a stream, but in this astronomic context, I thought that this might represent the Milky Way, the "river" of stars in the sky. This sort of wavy line petroglyph is found at sites elsewhere in the west, and is the sign for water in Egyptian hieroglyphs. But there was no proof. One especially puzzling aspect was that the right-hand line crossed over the other four and ended in a pecked hole in the rock face.

We were sleeping out under the brilliant stars on this trip, and I woke from a sound sleep to be perfectly awake, just as though someone had called my name. Without moving my head or eyes, I was looking at that part of the Milky Way that holds the constellation Perseus. I was looking at a great raveled rope of stars that led from the "right" side of the Milky Way across it in a great curve that led directly to the brilliant cluster of the Pleiades. This observation is, of course, subjective, but I offer it as a strong indication that the parallel wavy lines on the wall of the Sunset Chamber does indeed represent the Milky Way (Figure 9). The double-lined serpentine is in roughly the correct position to represent Cassiopeia. This suggests that one eye of the *Sunset Mask* represents Polaris.

AN ANALYSIS OF TWO PETROGLYPHS AT THE WILLOW CREEK SITE BY PAUL MIDDENTS

A set of data describing the alignment of the *Sun-Moon Gage* petroglyph has been analyzed for possible coincidences with celestial positions of the sun and the moon. On the summer solstice a shaft of sunlight was observed by John Rudolph to cross the upper three-inch diameter circle only. Middents and Rudolph's measurements of azimuth and altitude confirms the sunlight position at the summer solstice and supports a strong association between this petroglyph and the full moon on either side of the winter solstice. The alignments are such that the petroglyph is touched by a shaft of moonlight only at the full moon's nearest the winter solstice during about fifteen years of the nineteen-year lunar cycle.

The petroglyph seems to be recording the change in the lunar path as the lunar (Saros) cycle progresses. The data (Table 1) consists of the altitude and azimuth of 10 points on the petroglyph and the distance to these points to the tip of the crevice "aperture" that forms the shaft of light. The 11th point is a deep, 1/4" diameter hole located to the left of the petroglyph. Full moon declinations near the winter solstice range from about 18° N to 28° N during the 19-year lunar cycle. This produces meridinal transit altitudes from 67° to 78° at the latitude of the *Sunset Chamber* (40.4° N). The Lunar declination must be at least 23° N to produce a path across the sky of sufficient altitude to align with the crevice and the topmost part of the petroglyph.

The analysis was conducted using the planetarium software, "Dance of the Planets". Promising lunar alignments near the winter solstice in the years 2005, 2006 and 2007 were analyzed first. The calculated paths were plotted using "Mathematica", a computer algebra figure. The results for January 2007 are illustrated in Figure10. This figure confirms that the sun produces a path of light that crosses the upper part of the petroglyph each year. The lunar path appears to cross the petroglyph several inches below the top (#9). However, no indication of how closely the shaft of moonlight might pass to the rest of the petroglyph can be gleaned from this plot.

A three dimensional analysis was conducted next. Figure 10 shows a planar surface calculated and plotted by Mathematica, which is a best fit to the eleven measured points on the petroglyph. The plotted points are projections on the best-fit plane of the actual points. The actual points all lie within one inch of the best-fit plane so the computer provides a reasonable approximation of the rock surface on which the petroglyph is pecked. This surface bulges out slightly near the center of the petroglyph and runs almost due east and west (Figure 10). In Figure 10 the star symbols are the first nine points on the petroglyph from Table 1. The diamond symbols show the full moon nearest the winter solstice in 2006 crossing the petroglyph several inches below the top. The triangle symbols show the sun crossing the top of the petroglyph near the summer solstice. Figure 11 is looking up at a plane approximating the rock surface on which the Sun-Moon Gage is pecked. Ten points on the petroglyph are shown together with rays emanating from the tip of the crevice, which forms a shaft of sunlight or moonlight. The leftmost point (#11) is a 2" deep, 1/4" diameter hole. Figure 12 shows the computer replication of the summer solstice solar path observed by John Rudolph. In Figures 11 and 12 the point where each ray intersects the plane represents the predicted path of the right hand tip of the light shaft generated by sun or moon light passing through the crevice. Each ray represents the position of tip of the light shaft at 15-minute intervals. The paths pictured would take from two to three hours to complete and would progress from bottom to top and left to right.

The December and January moonlight paths travel up the full length of the petroglyph (Figure 13). Figure 14 illustrates the path of the full moon nearest the winter solstice plotted for 12 successive years. The variation in lunar path is due to the changing declination (altitude) of the moon from year to year. The pattern repeats every 19 years. At the point of the lunar cycle when the lunar declination approaches 23° N in 1999 a path similar to the summer solstice solar path results.
Each successive year the path starts lower on the petroglyph and proceeds upward toward the top. The moon reaches a maximum declination of about 28° N in 2006 and from that time on, the path starts higher up on the petroglyph until it no longer strikes the petroglyph at all. The winter solstice moonlight shaft will not strike the petroglyph again until 2019 when the entire cycle repeats.

No attempt has been made to analyze lunar positions in the distant past. The alignments will not be significantly affected by the very small changes in the inclinations of the ecliptic over the period the site might have been used (Figure 15 and 16).

A similar analysis has been applied to the *Super-Pi Petroglyph* in the *Sunrise*

Chamber. Altitudes and azimuths for eight points defining the tops of the legs and a hole are listed in Table 2. The hole, centered just above the petroglyph, is similar to the one associated with the *Sun-Moon Gage*. John Rudolph observed a summer solstice shaft of sunlight (the finger pointer) pass directly across this petroglyph from above, down and to the right with the point of the finger exactly crossing the drilled hole. The distance to the crevice forming the light shaft from the hole is 100 inches. Figure 17 shows the best-fit plane approximated by Mathematica with projections of the petroglyph points on this plane and rays emanating from the tip of the crevice. Figure 18 shows computer replication of the summer solstice solar path across the center of the petroglyph. The intersection of the rays with the plane represents the position of the tip of a shaft of sunlight at 15-minute intervals (Figure 18). Figure 18 shows the path of a shaft of light from the full moon nearest the winter solstice. As the declination of the moon approaches 23° N, the path approaches the petroglyph and crosses much like the summer solstice solar path. The lunar path remains below and to the left of the petroglyph for 6 years and then again crosses the petroglyph (Table 3). The moon replicates the summer solstice solar path when it is in the ecliptic; that is when its declination approaches 23.5°N. This also should indicate a period of potential lunar and/or solar eclipse activity.

The following eclipses (Table 3) will be visible near the winter solstice at the Willow Creek site during the period covered by Figure 18. Would our ancient observers have made this connection? If they observed five such startling coincidences in a 19-year period, I am sure they would. Not every 19-year cycle provides this many eclipses visible at the site, but 12 solar eclipses and 28 lunar eclipses will be visible during the next 100 years. I think this would provide enough evidence for our ancient observers to associate the return of the lunar shaft to the petroglyph with strong probability for eclipse activity.

CONCLUSIONS

Our investigations demonstrate that the Willow Creek site can confidently be called an ancient observatory. This site was used to note the summer solstice, the autumnal and vernal equinoxes, to predict the summer solstice by using two lunar months, to commemorate various asterisms, to compare both sun and moon cycles, to observe the 19 year lunar cycle, to mark the summer solstice with a second petroglyph that allows for a lunar observation, and to mark the summer solstice with a dramatic light pointer display. Recent observations made by Gordon Ponting also indicate winter solstice alignments.

It is now clear at this writing that not only was the sun being observed in its cyclic round during the year, but the moon's 19 year cycle was being both observed and measured with instruments of great ingenuity and precision. The native cultures who created and used this site over a long period of time were probably hunter-gatherers, attested by the many grinding holes and metates found in the area. They developed an elaborate and sophisticated method of noting, measuring and marking various celestial events. They found that this site lent itself to some unique alignments of the sun and moon so that with a little modification and embellishment, turned the natural rock "caves" into chambers to memorialize various events that they observed and determined to be important. The "little embellishment" is not meant to disparage the tremendous amount of work and many years of observation that resulted in the creation of these clever devices which still work today.

The oldest or "Classic" petroglyphs seem to be very old, as evidenced by the depth of the pecked carving, the similarity of patina to the untouched adjacent rock and by comparison with the other, fresher, newer looking inscriptions at the site. How old is yet to be determined, perhaps by one or more of the dating systems available today, or perhaps by systems yet to be devised. While certain affinities to Old World sites, symbols and observations suggest themselves; no definite conclusion can be drawn at this time as to any influence from other than indigenous cultures. It is hoped that funding to provide scientific dating of some of the petroglyphs can be found, as the question should be answered to add another clue to the origin of the creators of this remarkable facility.

This complex, with its natural happenings, may have made the event of the sunlight penetrating the womb of the earth more magical and more significant to the people who first witnessed them than if a man-made construction had been erected to accomplish the same practical ends, i.e., marking the changes of the seasons. This was the Cosmos itself involving mankind in its miracles. These people, immersed in nature and its processes, may have come to believe that they could play a part, to maintain the balance, to influence the outcome, to preserve not only their fragile culture, but also the cosmos itself. The Chumash tribes of southern California studied the heavens and conducted regular ceremonies in order to provide "ritual sustenance for the community and to supply meaning to life itself" (Hudson and Underhay 1978). They suggest that these beliefs were common to many if not all of the California tribes.

At the very least, this investigation, which is only beginning to reveal the information about the *Willow Creek Observatory*, should demonstrate that some of the enigmatic petroglyphs throughout the western United States, can be better understood and appreciated if it can be shown that their context is astronomical. This new perception of the purpose of the site and its petroglyphs can move our appreciation and understanding of this ancient work from merely "art" into the realm of functional astronomical symbolism and notation which in turn can give us better understanding of the concepts of the Cosmos in the minds of the ancient "astronomers".

FOOTNOTES

1. Note that certain petroglyphs are shown as rubbings. These were done before objections were raised to rubbings. I subscribe to the protection of petroglyphs wholeheartedly, however, the technique using Tyvek, has revealed detail that otherwise would remain invisible to either eye or camera. In some cases, these “tyvostats” may be the only record we have of petroglyphs that will completely disappear from erosion, development or vandalism. Some petroglyphs at this site are in such cramped, tight conditions that this recording system is the only way to obtain an accurate image of the petroglyph. With the technique used, nothing touches the bottom of the petroglyphs

themselves; thus there is no impact to future dating efforts.

ACKNOWLEDGMENTS

I wish to acknowledge my debt to Robert and Francis Connick who introduced me to the site and who have produced several excellent papers about it. Also, Nal Morris and Rollin Gillespie for their help, support and encouragement since being part of the expedition of 1992. Dr. Robert Fortner, who helped immeasurably on two solstice trips, 1995 and 1996. Paul Middents, co-author of this paper, who shared the "hardships" of the 1996 expedition and whose help in measuring azimuths and altitudes together with his skills in analysis of the data has given confirmation of the hypothesis that the *Sun-Moon Gage* and the *Super Pi Petroglyph* are indeed devices to measure and compare various positions of the sun and moon during the moon's 19 year cycle. Thanks also to the Battle Point Astronomical Association for its moral support and encouragement. I also thank the Oxford V organization for allowing me to present an earlier version of this paper at their conference in Santa Fe, New Mexico in 1996. Special appreciation to Don Gilmore and the New England Antiquities Association who helped make the first presentation of this site at the NEARA America Before Columbus Conference at Brown University in 1992 and subsequent publication possible.

BIBLIOGRAPHY

Hudson, Travis and Ernest Underhay
1978 *Crystals in the Sky: An Intellectual Odyssey involving Chumash Astronomy, Cosmology and Rock Art*. Ballena Press, Ramona, California.

Middents, Paul
1966 Preliminary computer analysis of Willow Creek Canyon Archaeoastronomy Site. Presented together with a poster display at the Oxford V conference on Cultural Aspects of Astronomy in Santa Fe, New Mexico, August 3-9.

Rudolph, John H.
1996 Poster display. Fifth Annual Conference on Archaeoastronomy, August 3-9, Santa Fe, New Mexico.
1995 Willow Creek Observatory, An Ancient Solar Observatory at Willow Creek, California. *Utah Rock Art*, Volume 13. Salt Lake City, Utah.
1993 NEARA Journal, Vol. XXVIII, No. 1 & 2, Summer/Fall.

1992 America before Columbus. New England Antiquities Research Association Conference, Brown University.

FIGURES

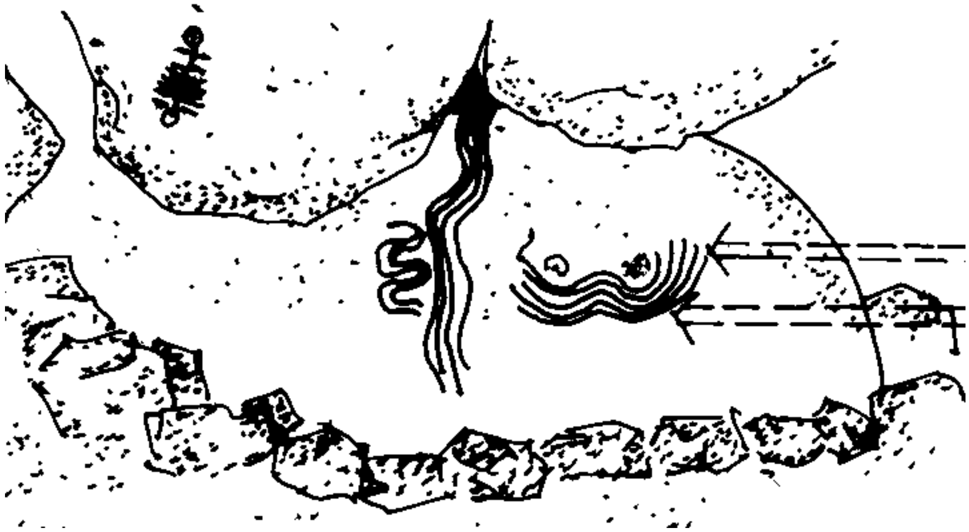


Figure 1. A section through the sunset chamber.

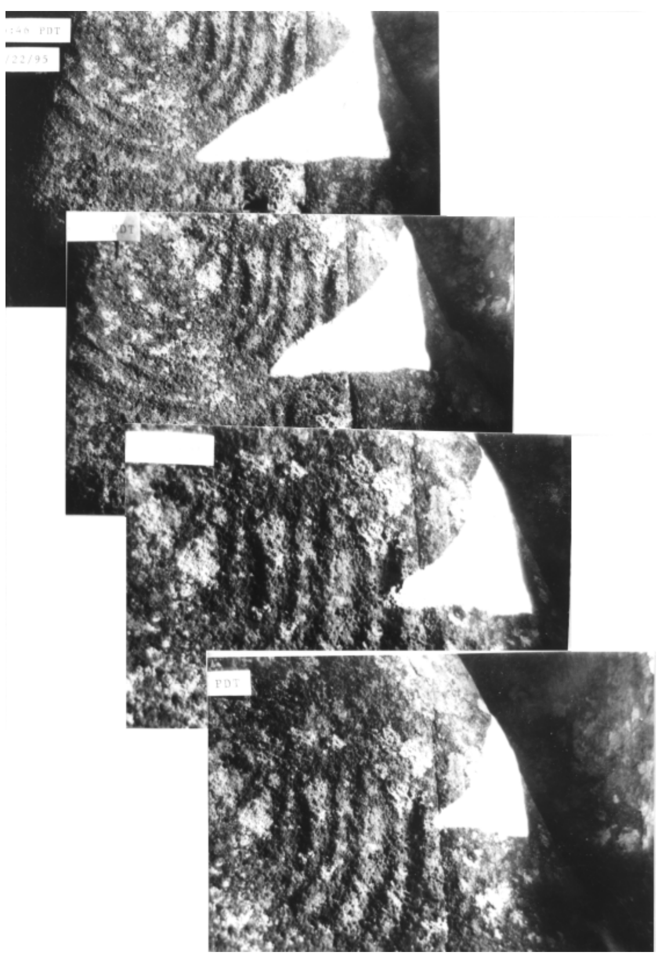


Figure 2. The light pointer moving up and around the *Sunset Mask* outer arc on the afternoon of the summer solstice.

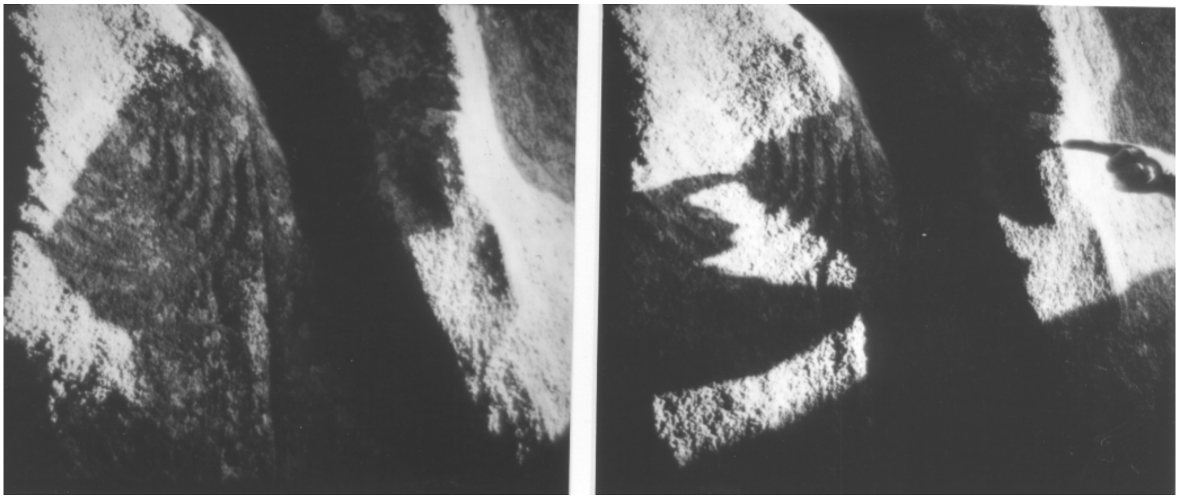
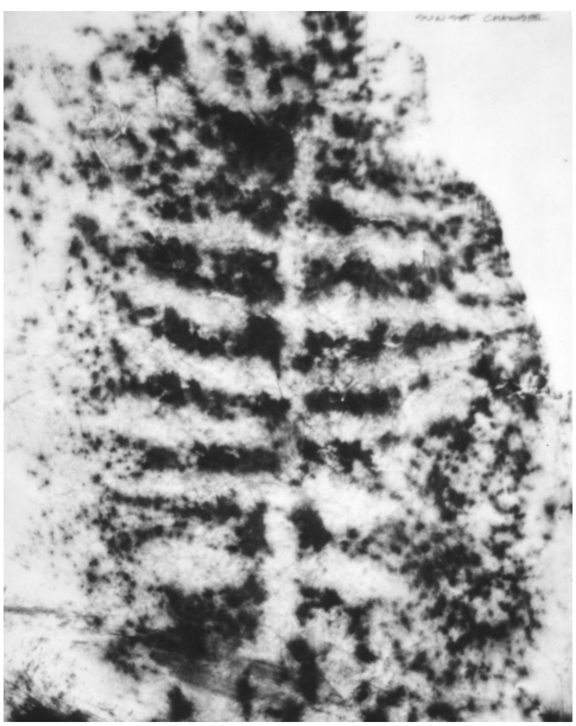


Figure 3. Shadow profile works across the arcs of the *Sunset Mask* at the vernal equinox.



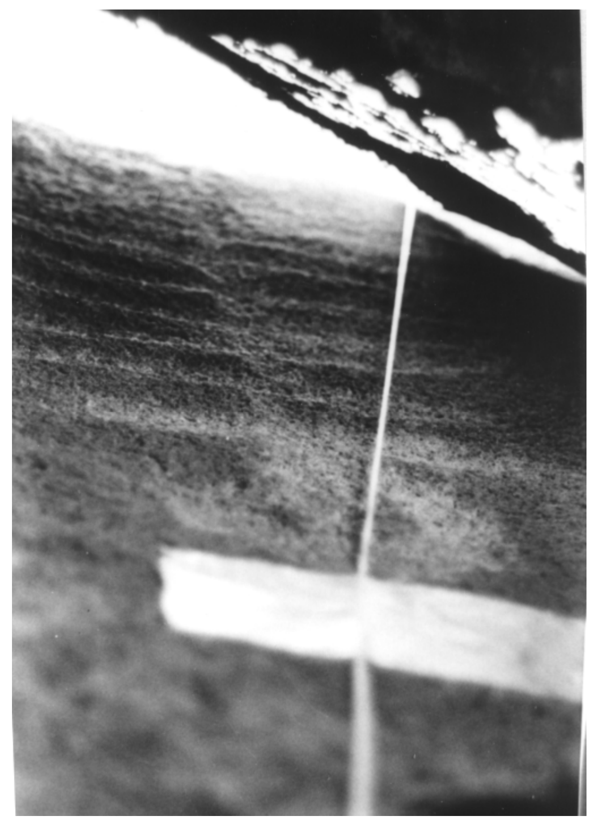


Figure 4 lower left. The *Sun/Moon Gage.* Figure 5, lower right. The view looking up at the *Sun-Moon Gage* from below showing stretched string.

Figure 6, left. The view looking down from above at the string stretched down through the aperture crevice. Figure 7, right. View of the author taking a sight down the stretched string with a modified theodolite.

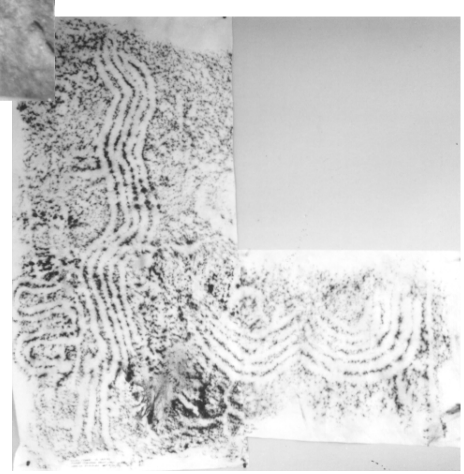
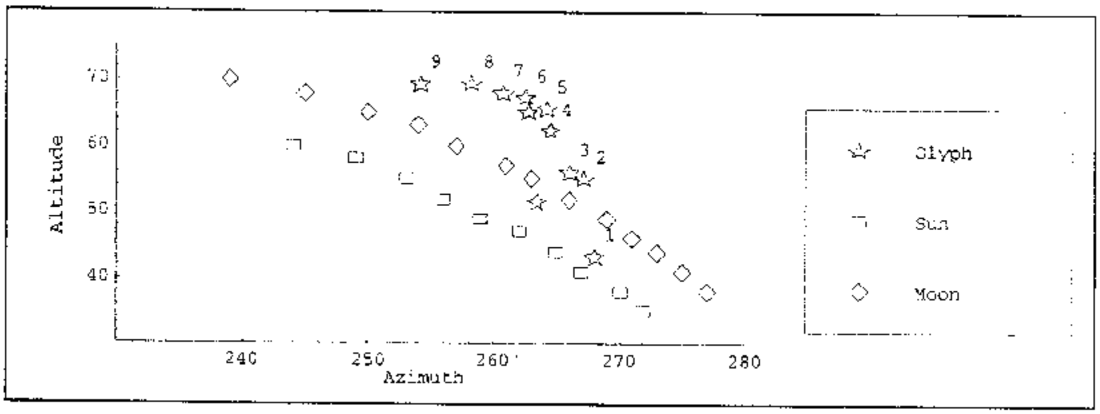
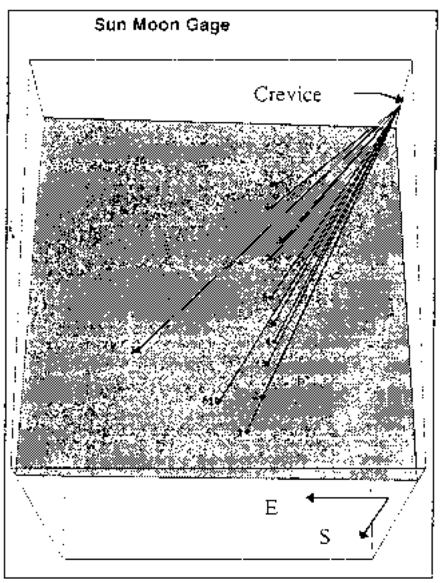


Figure 8a, b, and c left. The light finger sequence of the *super-pi* petroglyph on the day of the summer solstice. Figure 9, right. Parallel wavy lines on the wall of *the Sunset Chamber* representing the Milky Way.

Table 1

Point on the Glyph	Distance to the crevice inches	Altitude in degrees	azimuth in ° degrees
1 -	7.25	43.1	268
2	8.5	55	267.2
3	9.75	56	266
4	11.75	62.2	264.5
5	13.125	65.6	264.2
6	14	67.3	262.5
7	15.25	67.9	260.7
8	17	69.4	258
9	19	69.3	254.1
10	18	65.1	262.7
11 (Hole)	17.25	51.5	263.4





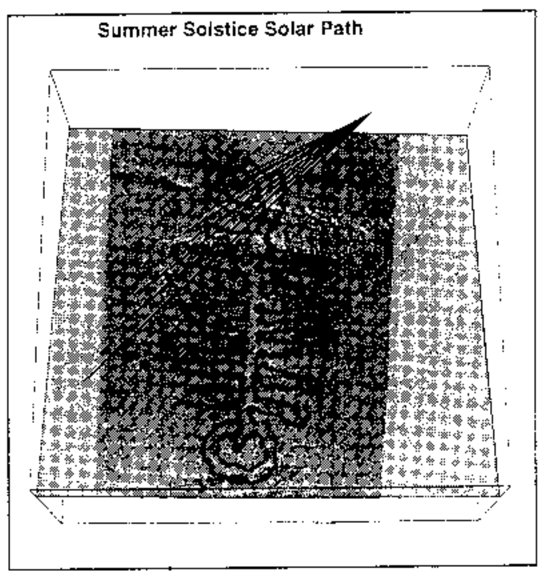
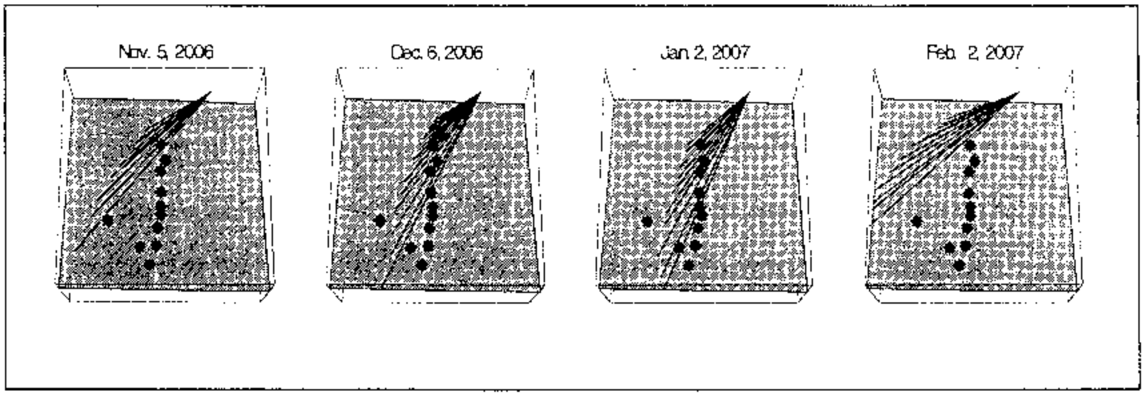


Table 1, top. Altitude and azimuth of 10 points on the petroglyph, and the distance to these points to the tip of the crevice "aperture" that forms the shaft of light. Figure 10, center, Lunar and solar alignments near the winter solstice for January 2007. Figure 11, lower left, and 12, lower right. The computer replication of the summer solstice solar path, looking up at a plane approximating the rock surface on which the *Sun-Moon Gage* is pecked.



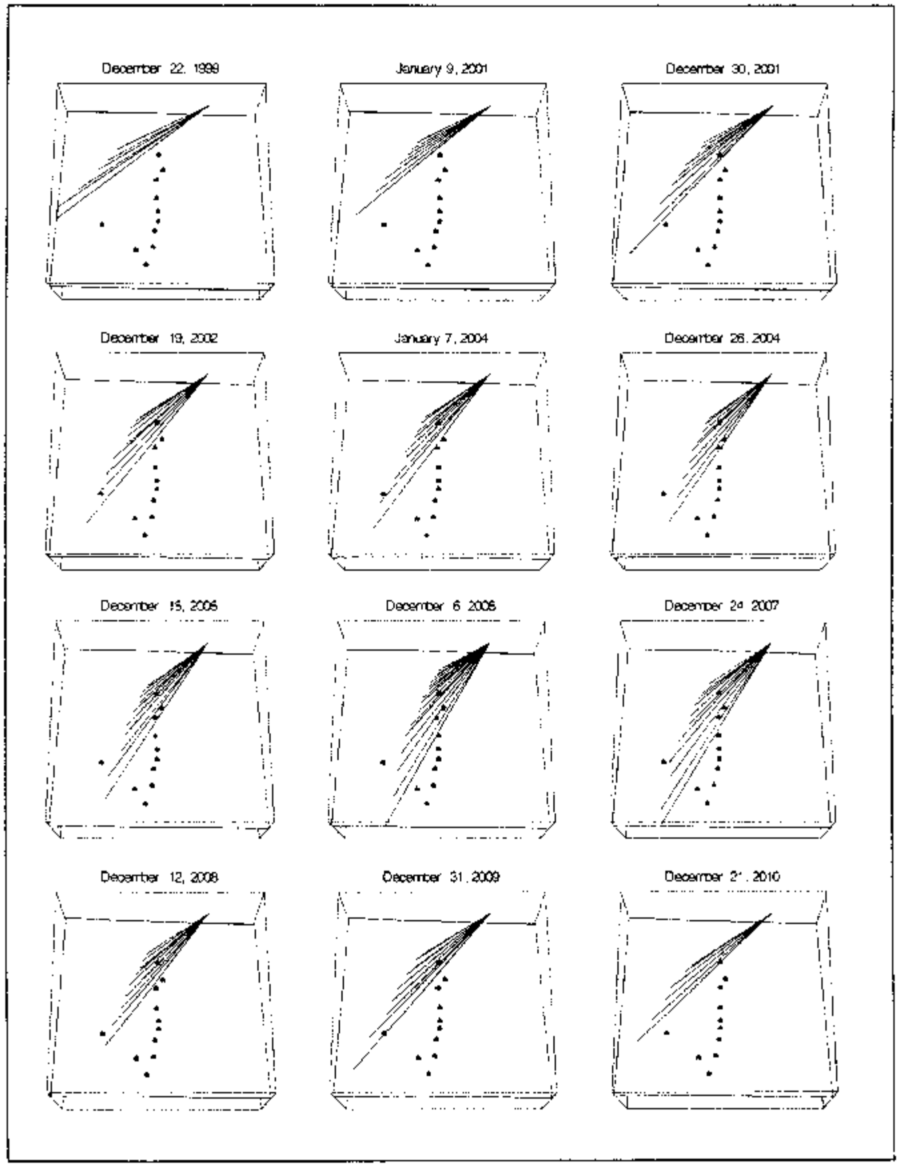
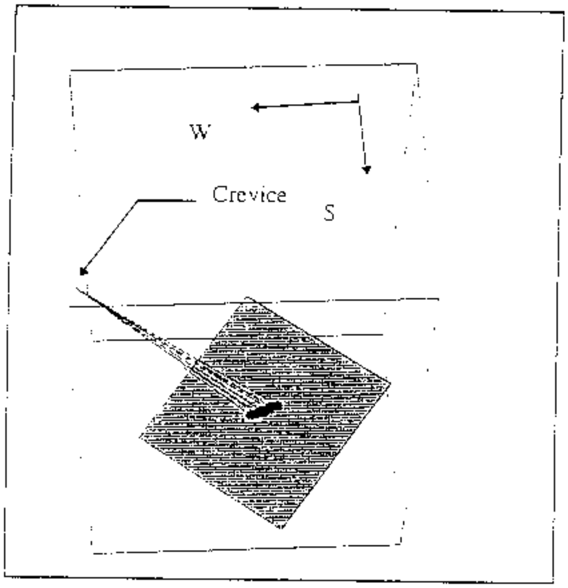
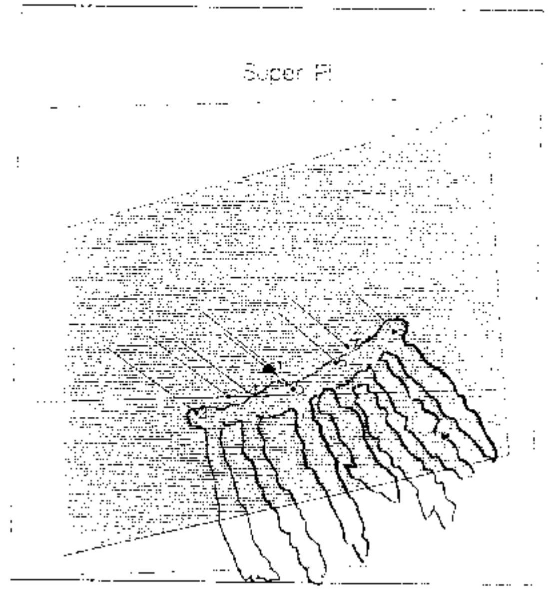


Figure 13, top. The December and January moonlight paths travel up the full length of the petroglyph. Figure 14, bottom. Illustrates the path of the full moon nearest the winter solstice plotted for 12 successive years.





Point	Altitude	Azimuth
1 (hole)	64.1	236.6
2	65.6	235.3
3	65.0	236.25
4	64.7	236.6
5	64.05	237.3
6	63.2	238.2
7	62.9	238.0
8	62.1	238.8

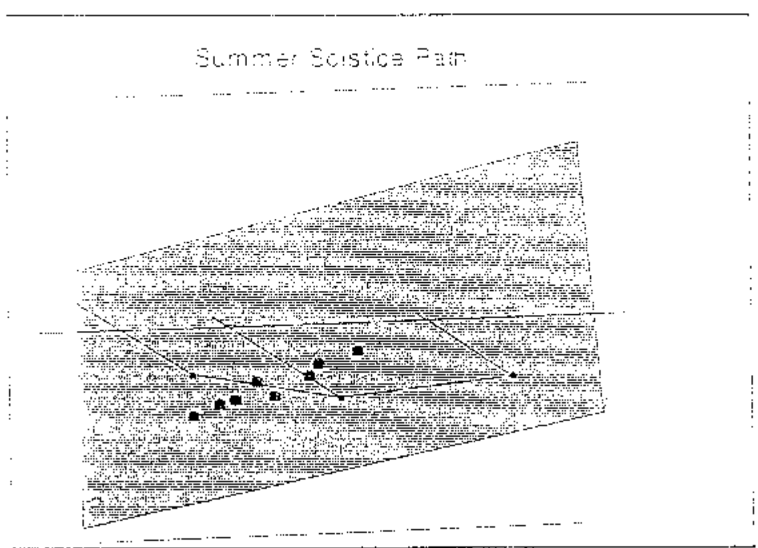
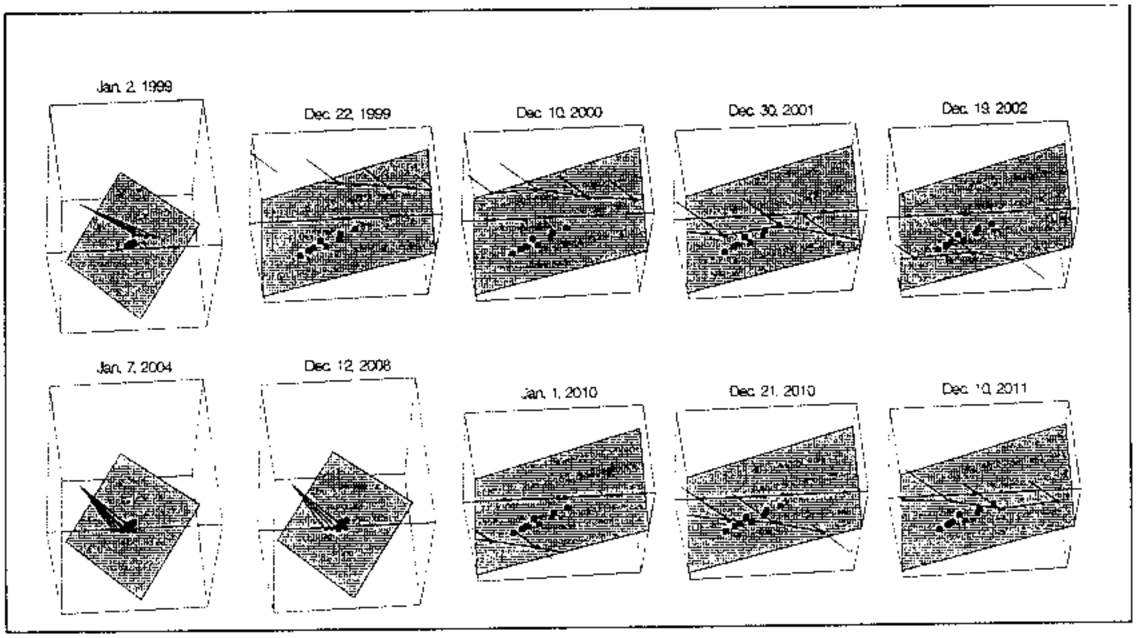


Figure 15 top left and 16 right. Show that the alignments will not be significantly affected by the very small changes in the inclinations of the ecliptic over the period the site might have been used. Table 2 center. Altitudes and azimuths for eight points defining the tops of the legs and a hole are listed in Table 2. Figure 17 bottom. Figure 17 shows computer replication of the summer solstice solar path across the center of the petroglyph.



January 21, 2000	Total lunar eclipse
December 25, 2000	Partial solar eclipse
December 14, 2001	Annular solar eclipse
December 21, 2010	Total lunar eclipse
December 16, 2011	Total lunar eclipse

Figure 18 Top. The path of a shaft of light from the full moon nearest the winter solstice. The intersection of the rays with the plane represents the position of the tip of a shaft of sunlight at 15-minute intervals. Table 3, bottom. The lunar path remains below and to the left of the petroglyph for 6 years and then again crosses the petroglyph.