DISCOVERY OF TWO NEW SOLAR MARKERS AT PAINT ROCK, A MAJOR SUN-WATCHING STATION

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Paint Rock is a pictograph site in the state of Texas, USA. The assemblage contains over 1500 pictographs. Between 1996 and 2002 there were six active solar markers discovered. These six solar markers make Paint Rock the most active archaeoastronomical site in the region. It was hypothesized that more solar markers existed. We report on the discovery of two new solar markers. One records the winter solstice and the second records the spring and summer cross-quarter days.

Introduction

The interaction of sunlight and shadow on rock art is referred to as a solar marker, which has become the third main area of the study of archaeoastronomy. This interaction records some of the astronomical knowledge of a culture. The astronomical knowledge recorded by solar markers is one of the most objective interpretations of rock art. Paint Rock is the largest assemblage of pictographs in Texas, USA containing over 1500 pictographs. They are located on the Campbell Ranch near San Angelo, Texas. Kay Sims Campbell's grandfather purchased the ranch in 1877, and she discovered the first solar interaction in 1994[1]. Subsequently, there were more solar markers discovered between 1995 and 2002, making a total of six solar interactions. These solar markers make the Paint Rock pictographs the most active archaeoastronomical rock art site in Texas.

Cliffs, rocky terrain, rock shelters, and caves have been used by cultures around the world, making rock art ubiquitous. The cliff containing the Paint Rock pictographs consists of broken layers of limestone created by a geologic uplift which runs northwest to southeast for over a kilometer. As a result of the uplift, much of the lower half of the cliff is a debris fall, with the upper portion exposed. The tallest layers are approximately one meter in height. The layers create panels and habitation areas that are protected from weather. There is only one section of the exposed cliff with these protected panels. This section is 300-meters long and is the highest section of the cliff. All the pictographs are in this section. Figure 1 is a site map of the location.

The archeological site number is 41CC1 for Paint Rock, based on the Smithsonian Trinomial Site Designation system in the United States. Forrest Kirkland and his wife recorded the site in 1934, painting the pictographs. The book, *The Rock Art of Texas Indians*[2], exhibits these paintings at Paint Rock as well as at all other sites in Texas that were recorded by the Kirkland's. In the book, it states, "there are no other sites in Texas that exhibit the same design characteristics as the pictographs of Paint Rock." The main archaeological study of Paint Rock found evidence of habitation dating back to the Middle Archaic period, an archaeological period in Texas dating from 6000 BCE to 4000 BCE[3,4].

The cliff is about 150 meters north of the Concho River. The river has a hard rock crossing at this location. The river is a primary water source, and there are springs at each end of the main cliff. There is evidence of large habitation sites located near each of these springs. The

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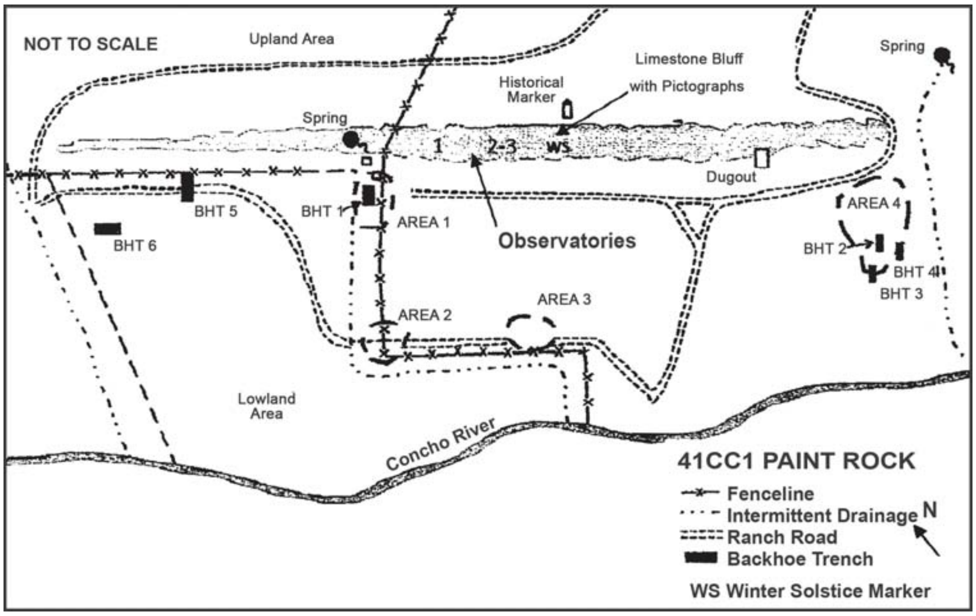

Figure 1. Site map of the Paint Rock Pictograph site. Adapted from Turpin et al[2]. Credit: Gordon L Houston

cliff provides weather protection in all seasons. The river crossing and the water mean that not only cultural trails in the landscape lead to this point, but wildlife trails as well. These attributes make the location an excellent nomadic site in an otherwise arid, barren and harsh environment. The cliff and the pictographs make the site a significant ritual site, and the numerous solar markers make it a major sun-watching station. All of these features make Paint Rock an excellent site for cultural diffusion.

The top layer of pictographs at Paint Rock is comprised monochrome-painted glyphs, and there is no evidence of petroglyphs at the site. Petroglyphs are designs pecked into the rock. There are all black pictographs and some that are multicolor, containing white, yellow, black and the maroon colors. Multi-color rock art is called polychrome. Most of the polychrome glyphs are behind the dark brown/maroon top layer of pictographs. Hematite is the main ingredient and color agent for the monochrome pictographs, as it produces the dark rusty reddish brown or maroon color. Hematite was found in context with Toyah Phase pottery. The Toyah Phase is a Texas archaeological period, with a timeframe of 1300-1700 A. D. Hence, the top layer of pictographs was scribed in this period.

The study of known solar markers at Paint Rock and in the American Southwest reveals that the sunlight and shadow interactions are brief and can occur at any time of the day. This quick fleeting interaction makes it hard to identify new solar makers. It had been over ten years since the discovery of the last solar marker identified at Paint Rock, before the beginning of our study. The sheer number of pictographs led us to hypothesize that there were more to be discovered. Thus, this was one of the primary research objectives. Two newly discovered solar markers at Paint Rock are presented herein.

Rock Art as Solar Markers

Prehistoric cultures developed various technologies to survive. In the Stone Age, making stone tools was one of the primary subsistence technologies. Solar markers, the interaction of sunlight and shadow with rock art, is another technology. Understanding the seasons is very important for both agricultural and nomadic cultures in their subsistence activities. It is important to know the changing of the seasons for planting and harvesting in agricultural cultures. Nomadic cultures must know the change in the seasons, which affect wildlife migration habits, wild plant cycles, and the necessity to change habitation locations. Placing a glyph to record a calendar day is an intentional act and an important subsistence activity.

The interaction with the rock art can be caused by a moving line of sunlight or shadow or by a unique design. Unique designs are usually a pointer or wedge, with the tip being the most common part to interact with the glyph. A line of sunlight overtaking and illuminating a shaded area is a sun line. A shaded line is when the shade is overtaking sunlight areas. These moving lines may also be crooked so that they line up and mimic the design elements in the glyph. These interactions are representatives of part of a culture's astronomical knowledge. They become mnemonic devices of this astronomical knowledge. McCluskey[5] states, "when a culture has not adopted the ability to write, knowledge is embedded into other material remains," hence the importance of solar markers to preliterate societies.

The location of these sites can be in public places, visible to all, or in "secretive places[6]," to be watched by a shaman or priest. Small sites containing a few glyphs are used by a single family or small band. One or two solar markers are all that is needed for calendrical purposes[6]. Large sites with many glyphs are public or ritual sites. The Paint Rock assemblage of pictographs is for public display and a ritual site.

Literature is abundant on rock art solar markers (Eddy[7], Fountain[6], Hudson et al.[8], Johnson[9], Murray[10], Preston & Preston[11], Sofaer[12], Sinclair[1], Whitley[13], Young[14], Zeilik[15], Zoll[16]), yet there is not a concise definition of a "solar marker." Numerous solar markers have been identified in the American Southwest, California and Baja California, with scattered reports worldwide. Based on a review of this literature and the observation and discoveries at Paint Rock, a definition of a solar marker was proposed in Houston & Simonia[17]: *"A 'solar marker' is an intentional rock art glyph or panel which records a significant component of the astronomical knowledge of a culture, preserving the interactions of light and shadows on the rock art at specific solar points."*

In any science, standard definitions of a subject help researchers, and this would be true for archaeoastronomical research as well. Solar points are the positions of the sun along the ecliptic. The most common solar points are the calendrical days known as equinoxes, solstices, and cross-quarter days. Outside of these eight major points, there may be solar points significant to local culture encoded in a glyph.

The number of solar markers reported in the American Southwest by various researchers is more than 300 [9]. Two paper discuss 109 solar markers at 46 sites[11], and a third paper reports 219 observed at 45 sites[6]. Hudson *et al*.[8] have a detailed list of astronomies in California, many of which contain solar markers. The number of solar markers and the number of different cultures scribing them establish a pattern of intentional behavior. The precision of solar interactions with the glyphs also makes coincidence extremely unlikely.

Rock art studies have multiple advantages over traditional archaeology. The solar markers tie the celestial sphere to the landscape. Rock art is in situ and is not changed by site formation processes[10], leaving the glyphs and panels undisturbed. The celestial sphere is unchanged from when the astronomical knowledge was embedded into the solar markers. The rise/set cycle of the sun from day-to-day remains constant over time. Hence the solar interactions remain unchanged. These facts make the embedded astronomy one of the most rigorous explanations for rock art. The study of rock art and solar interactions has moved from a posteriori to a priori[10].

Identifying Solar Markers

Solar markers have been identified throughout Native American lands in the American Southwest, but there is a paucity of identified markers worldwide. This fact may be a result of researchers who may not be aware of the potential interactions. The first solar marker at Paint Rock was discovered by chance on the winter solstice[2]. If a field survey does not occur on one of the eight primary solar points, and if the researcher is not observing for solar interactions, they can easily be missed. The first recommendation is to look for solar markers on the solar points discussed above. Identifying the full sequence of the interaction and time of the occurrence should be recorded. The interaction of a solar marker is typically brief and the moment of alignment may be a matter of seconds. The primary challenge is to avoid interactions that are coincidental.

Solar interaction can occur anytime during the day. The most common times are around sunrise, solar noon and sunset. Solar noon is when the sun culminates on the local meridian. If the culture who scribed the rock art is known, then a study of their customs may reveal significant anticipatory solar points which are not on one of the main solar points. These can either be a design element added to a calendrical glyph or be a separate glyph altogether. For example, Zoll identifies a *register mark* (3.2) added to a glyph that lines up with the sun wedge 30 days after the equinox, which marks the time to start the harvest of agave by the Sinagua culture.

Researchers should be aware of the variations in the sun's travel from season to season. The sun is highest in the sky in the summer and lowest in the winter in the northern hemisphere and the reverse for the southern hemisphere. The lower the sun is in the sky, the higher the projected interaction. So, when looking for potential solar markers, take note of shapes that may not be interacting at the first moment of observation, but a change in season or time of day may project the sun or shadow design onto a glyph.

The above discussion was basic information on how solar markers operate, when they operate, and the relationship between the sun's projection of sunlight or shadow. A guide to help identify and confirm solar markers will be discussed next. The guide formalizes some of these concepts.

Solar Marker Matrix of Intentionality

To bring this valuable tool to a broader audience, the "Solar Marker Matrix of Intentionality" is introduced, and

TABLE 1. Solar Marker Matrix of Intentionality

PTS.	1. Solar Points	A	PTS.	3. Interactive Characteristics	B
5	1.1Winter/Summer Solstice (WS, SS)		5	3.1 Focal Point(s)-Geometric Alignments	
4	1.2 Cross Quarter days (V, S, A, W)		4	3.2 Register Mark alignment	
3	1.3 Confirmed anticipatory points		3	3.3 Rapid Interactions	
2	1.4 Equinox (VE, AE)		2	3.4 Tangent align.	
1	1.5 Random days		1	3.5 Random	
PTS.	**2. Time of Day**		**PTS.**	**4. Supporting Evidence***	
5	2.1 Solar Noon		5	4.1 Horizon Astronomy#	
4	2.2 Sunrise		4	4.2 Geometric Conditions	
3	2.3 Sunset		3	4.3 Informed sources	
2	2.4 Random morning		2	4.4 Formal examination	
1	2.5 Random afternoon		1	4.5 Analogy/Symbolism	
	Point Values Total Column A			**Point Values Total Column B**	
	INTENTIONALITY FACTOR			**COLUMN A & B TOTALS**	
	VERY HIGH 19-20+			V-Vernal	
	HIGH 14-18			S- Summer	
	MEDIUM 9-13			A-Autumnal	
	LOW 4-8			W-Winter	

Table 1. Solar Marker Matrix of Intentionality. Astronomical Analysis in four categories are scored, and the final score determines the strength of a solar marker. * More than one category may be scored in section 4. Supporting Evidence. + The scores may exceed 20 if additional points are scored in section 4. Supporting Evidence. # The Horizon Astronomy category may include confirmation of any form of astronomical knowledge. Matrix Credit: Gordon L Houston.

referred to from now on, as the Matrix. Detailed explanations of the Matrix can be found in Houston and Simonia[17]. The Matrix, Table 1, is a guide to help identify new solar markers, and or verify solar interactions with rock art on reported solar markers. The necessity of a guide to help researchers identify and confirm solar interactions was realized over the course of 20 field survey trips and hours of observations at Paint Rock. The Matrix is the result of those observations. The Matrix will act as a guide for the archaeoastronomy, rock art and the archaeology communities. The Matrix was designed based on similar examples used in archaeology. The Harris Matrix[18] is a method of numbering and labeling stratigraphy in an archaeological excavation. The Parker Borderland Process Matrix[19] details the interaction between cultural groups.

The Matrix is divided into four categories. Category 1. *Solar Points[1]* scores points depending on the calendrical day of the interaction or lack thereof; the latter referred to as '*random days* (1.5).' Category 2, *Time of Day*, is when the interaction occurs, noting that *solar noon* (1.1) receives the highest score as an intentional step is required to determine when the sun culminates on the meridian. Category 3. *Interactive Characteristics* scores the actual operation of the sun and shadow interaction. A *focal point* (3.1) is a central aspect of a glyph. The final category, Category 4. *Supporting Evidence* is a combination of astronomy investigation and anthropological analysis. Confirming the *horizon astronomy* (4.1) at a site is essential, as it signals that a culture could determine with reasonable accuracy significant calendrical dates. The *horizon astronomy* (4.1) at Paint Rock has been established[17]. *Geometric conditions (4.2)* is an examination from an astronomical standpoint of the precision and accuracy of the solar markers operation. The final three points are forms of anthropological analysis of rock art.

Newly Discovered Solar Markers at Paint Rock

It has been more than ten years since the last solar marker was discovered at Paint Rock. During this time a variety of researchers had visited the site without reporting a new solar marker. The cumulative hours of observing the pictographs exceeded 200 hours. Cameras set to the correct local time were used to acquire photo documentation. The time was set using an atomic watch and a shortwave radio receiver. After each trip, the photographic data were studied for potential interactions, which identified new solar interactions. Two new solar markers, identified from the photographs, will be detailed in this section. The Matrix will be used to score these solar markers.

The first solar marker to be examined is known as the Feathered Shield. It operates on the Winter Solstice. The interactive sequence runs for 30 minutes and 12 seconds. It starts when a pointer begins to form, and then it proceeds to strike the focal point or center of the glyph. After the tip of the pointer interacts with the focal point, the sun gains altitude, and the pointer moves down, and the pointer shape disappears. Figures 2, 3, and 4 show this sequence.

Figure 2. The Feathered Shield has a pointer of sunlight that begins to form. Photo Credit: Gordon L. Houston

Figure 3. The light pointer is striking the focal point of the Feathered Shield glyph. Photo credit: Gordon L. Houston.

The score of the Feathered Shield Marker using the Matrix (Table 1): 1. Solar Point, *solstice* (1.1) 5 points;

Figure 4. The pointer moves down and outside the shield circle, losing the pointer shape. Photo credit: Gordon L. Houston.

2.Time of Day, *random morning* (2.4) 2 points; 3. Interactive Characteristics, the *focal point* (3.1) 5 points; and 4. Supporting Evidence, both *horizon astronomy* (4.1) 5 points, and *geometric conditions* (4.2) 4 points. The total points are 21, which places the "Intentionality Factor" in the "very high" category.

The second newly discovered solar marker is a large double circle rayed sun design. Figure 5 shows the summer cross-quarter day sequence of August 2013. Our photographic data show that this same interaction occurs on the spring cross-quarter day in May of each year. In this sequence, the pointer touches the base of the outer ring of the sun symbol at 2:44:22 PM CST. Proceeds to intersect the focal point or center of the sun at 2:57:25 PM CST, and then touches the outer ring at the top right at 3:20:19. The total interactive sequence is 35 minutes. This sequence is very similar to the Winter Solstice marker interaction, the first solar marker discovered at the site.

The Matrix score for this Spring/Summer cross-quarter panel would be as follows: 1. Solar Point, *cross-quarter* (1.2) 4 points; 2.Time of Day, *random afternoon* (2.5) 1 points; 3.Interactive Characteristics, the *focal point* (3.1) 5 points; and 4. Supporting Evidence, *horizon astronomy* (4.1) 5 points. The total points are 15, which places the Intentionality Factor in the "high" category.

Conclusions

The hypothesis and research question posited, "that more solar markers existed at Paint Rock," is confirmed by our discovery of the two previously unidentified solar markers. The number of active solar markers at Paint Rock makes it a major sun-watching station. This additional evidence supports the finding that Paint Rock is the most active archaeoastronomical site in the region. All of this recorded knowledge in a solar marker demonstrates the

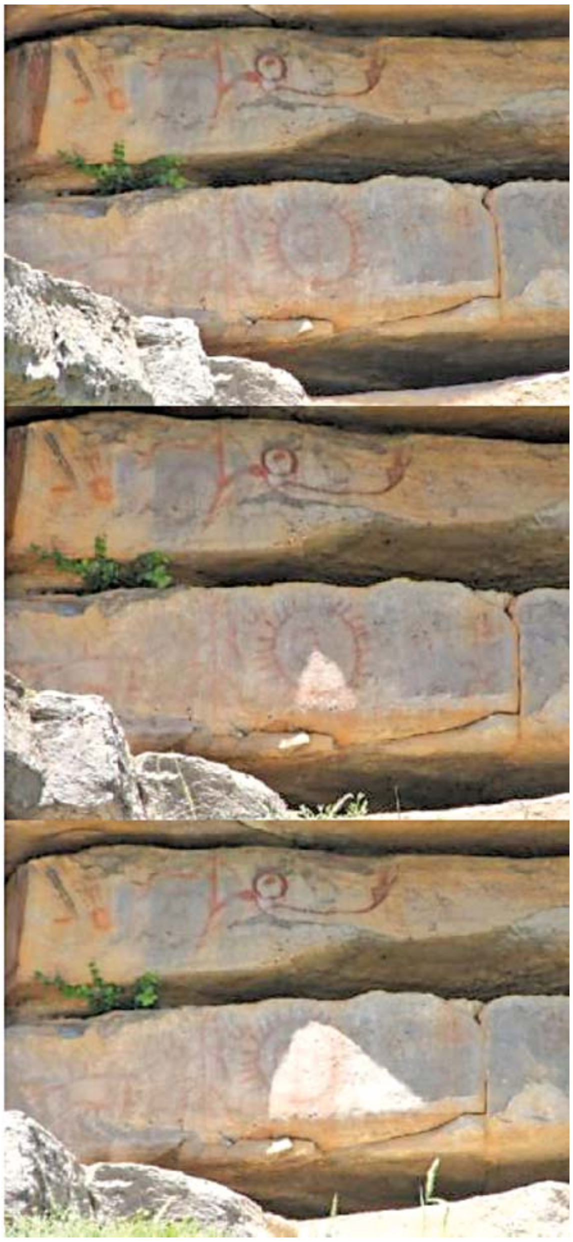

Figure 5. A three photo sequence is showing the spring and summer cross-quarter day interaction. Photo Credit: Gordon L. Houston.

effectiveness of it as a memory mechanism. Solar Markers provide a rigorous interpretation of the rock art and illuminate a portion of the embedded astronomical knowledge of a culture. The challenge for future studies of potential solar markers worldwide is the ability to conduct long-term observations at a given site and to rule out observer bias and coincidental interactions. The next step will be to create a database of solar markers to evaluate from a statistical stance.

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References

1. W.P. Yeates, F. Campbell, Concho Valley Archaeological Website. http://cvassanangelo.org/newsletters.html, (2002) accessed March 14, 2012, p. 8-
2. F. Kirkland, W.W. Newcomb Jr., The Rock Art of Texas Indians, University of Texas Press, Austin & London, p. 146-158, (1967).
3. S. Turpin, L. Riemenschneider, D.G. Robinson, *Current Archaeology in Texas*, Vol. **4**, No. 2, Texas Historical Commission, p. 8-19, (2002).
4. T.K. Pertulla, The Prehistory of Texas, Texas A and M University Anthropology Series, No. 9 p. 5-14, (2004).
5. S.C. McCluskey, Archaeoastronomy in the 1990's, p. 35, (1993).
6. J.A. Fountain, Current Studies in Archaeoastronomy, Carolina Academic Press, Durham, NC, p. 101-108, (2005).
7. J.A. Eddy, In Search of Ancient Astronomies, McGraw Hill Book Company, NY, p. 136, (1978).
8. T. Hudson, G. Lee, K. Hedges, *Journal of California and Great Basin Anthropology*, Vol. **1**, No. 1 (Summer 1979), by Malki Museum, Inc., p. 38-63, (1979).
9. C. Johnson, *Utah Rock Art.*, (12), p. 13, *(*1992).
10. W.B. Murray, *Journal for the History of Astronomy*, Archaeoastronomy Supplement, No 23, JHAS 29, p. S1-S6, (1998).
11. R.A. Preston, A.L. Preston, Astronomy and Ceremony in the Prehistoric Southwest, Papers of the Maxwell Museum of Anthropology, Number **2**, p. 191-204, (1983).
12. A.P. Sofaer, R.M. Sinclair, Astronomy and Ceremony in the Prehistoric Southwest, Papers of the Maxwell Museum of Anthropology, Number 2, p. 43-70, (1983).
13. D.S. Whitley, Introduction to Rock Art Research, Left Coast Press, Walnut Creek, CA, p. 101-136, 156, (2011).
14. M.J. Young, *Journal for the History of Astronomy*, Archaeoastronomy Supplement, JHAS 17, 43Y, p. S44, (1983).
15. M. Zeilik, World Archaeoastronomy, Selected Papers from the 2nd Oxford International Conference on Archaeoastronomy, Cambridge University Press, Cambridge, p. 143-166, (1989).
16. K.J. Zoll, Archaeoastronomy, *The Journal of Astronomy in Culture*, Volume XXIII, p. 154-164, (2010).
17. G.L. Houston, I. Simonia, *Journal for Astronomical History and Heritage*, Vol. **18**, No. 3, p. 3-17, (2015).
18. E. Harris, Principals of Archaeological Stratigraphy, Academic Press LTD. London, 2nd Ed., 3rd Printing (1997).
19. B.J. Parker, *American Antiquity*, (**71**), No. 1, p. 77-100, (2006).