

Paleoindian Solar and Stellar Pictographic Trail in the Monte Alegre Hills of Brazil: Implications for Pioneering New Landscapes

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Introduction

In the last 50 years, archaeological finds from Amazonia have forced revision of some theories about human evolution. A common assumption had been that human evolution was restricted by environmental limitations which favored slow progression from simple, unspecialized, economically unproductive cultures to complex, specialized, and highly productive ones. This assumption has long influenced interpretations of human evolution in the humid tropics 1 4. It presumed that the first Americans would not have been broad spectrum foragers but instead big game hunters following herds from the Siberian steppes into similar American habitats 8. Only after those megafauna went extinct at the end of the Ice Age were people hypothesized to have developed agriculture in the dry, open vegetation valleys of the Central Andes and Mesoamerica, before finally migrating into the tropical forests and coastal lowlands 9. According to the environmental limitation theory, only cooler agricultural zones fostered conditions that gave rise to civilized achievements like math, astronomy, and calendars exhibited by the Maya, Aztec, and Inca. Hunter gatherers were not predicted to need, nor deemed capable of devising such cultural achievements.

In contradiction to this theory, recent research on Paleoindians shows that the first colonists ventured onto the marine coasts and into the tropical lowlands as soon as they spread through the hemisphere, living by hunting and foraging economies based on fishing and forest products just as early as the big game hunting cultures 4,10 14. However, few sites exhibit how Paleoindians presumably coming down from Beringia could move so quickly into starkly different environments. The Paleoindians at Monte Alegre represent one early culture that did so in the humid tropics of Amazonia by practicing broad spectrum foraging, painting notational symbols, and demarking astronomy alignments.

Paleoindian lifeways at Monte Alegre were first studied by Ana Roosevelt at Caverna da Pedra Pintada (Pedra Pintada) 15, a rock art site in the southernmost hill ridge called Serra da Paituna. According to the 56 radiocarbon dates on carbonized seeds and wood, and the 13 luminescence dates on burned lithics and sediment from Roosevelt's excavations, Paleoindians occupied the site between about 11,000 and 10,000 BP (uncalibrated) 15. From the carbonized plant remains, bones, and shells fine screened and floated from the sediment of these cultural layers from the cave, we learned that the early people relied heavily on oily palm fruits, starchy tree legume pods, other starchy and oily tree fruits, nuts, fish, turtles, tortoises, lizards, snakes, and small rodents 15. All 25 taxa identified in the Paleoindian cave deposit are still common in the area today. Among the c. 30,000 flaked lithic artifacts recovered with the food remains were 24 formal tools, including possible harpoons and fish arrow points of bifacial, triangular, and stemmed forms, and large and small unifacial cutting tools that could have been used to dig tubers, cut and shape wood, or chop starch out of palm trunks 15. No remains of big game were recovered from the cave; the subsistence evidence indicates broad spectrum foraging.

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Paleoindian Rock Art and Archaeoastronomy

Contemporary with late Pleistocene artists in Western Europe and Australia, the Eastern South American Paleoindians at Monte Alegre made numerous polychrome rock paintings, some of which were first documented by 19th century naturalists 16-18. Since then, the art has been studied in the 20th and 21st centuries by geologists and archaeologists 19-24. The prehistoric paintings at Monte Alegre are large geometric, zoomorphic, and anthropomorphic designs in mostly brilliant red, and sometimes yellow, colors. Pictographs were drawn in clustered panels on sandstone rocks exposed to the open sky or inside caves and rock shelters (Fig.1). Individual paintings were also drawn, some near the panels and others in isolation.

Fig. 1. Monte Alegre Rock Art Research Map, elevation is in meters. Sites depicted as various colored dots include Serra da Lua, Serra do Sol, Itatupaoca, Mirante, Pico da Raposa, Vista do Sol, Pedra do Pilão, Abrigo do Coruja, Gruta 15 de Março, Abrigo dos Ossos 1 and 2, Pedra Pintada do Paineiro do Pilão, Caverna Pequena, Caverna da Pedra Pintada, and Caverna do Diabo.

Fig. S1. Caverna da Pedra Pintada excavated plant remains show numerous carbonized sacuri and tucuma palm seeds dated from 11,145 to 10,250 (uncalibrated) years BP.

Preceramic Paleoindian, Caverna da Pedra Pintada, Monte Alegre, Para			
	Initial		
carbonized sacuri seed	11,145 +/- 135	-21.6 ^o /oo	-28.6 ^o /oo
carbonized tucuma seed	11,110 +/- 310	-23.2 ^o /oo	-30.2 ^o /oo
carbonized tucuma seed	10,905 +/- 295	-20.7 ^o /oo	-27.7 ^o /oo
carbonized tucuma seed	10,875 +/- 295	-22.5 ^o /oo	-29.5 ^o /oo
carbonized tucuma seed	10,655 +/- 285	-22.8 ^o /oo	-29.8 ^o /oo
carbonized sacuri seed	10,560 +/- 60	-21.2 ^o /oo	-28.2 ^o /oo
carbonized wood	10,450 +/- 60	-23.5 ^o /oo	
carbonized palm seed	10,470 +/- 70	-24.9 ^o /oo	-31.9 ^o /oo
carbonized sacuri seed	10,410 +/- 60	-24.3 ^o /oo	-31.3 ^o /oo
solutes from same	10,390 +/- 70	-24.9 ^o /oo	-31.9 ^o /oo
carbonized sacuri seed	10,392 +/- 78	-23.6 ^o /oo	-30.6 ^o /oo
carbonized sacuri seed	10,350 +/- 70	-25.4 ^o /oo	-32.7 ^o /oo
carbonized sacuri seed	10,305 +/- 275	-22.7 ^o /oo	-29.7 ^o /oo
carbonized sacuri seed	10,275 +/- 275	-21.7 ^o /oo	-28.7 ^o /oo
carbonized sacuri seed	10,250 +/- 70	-29.9 ^o /oo	-36.9 ^o /oo

The 19th century scholars hypothesized a number of geometrical designs to be mathematical symbols and representations of the sun, moon, planets, and stars, synthesizing a system of sun worship 16,18. Although several 20th century scholars have revealed the link of astronomy to cosmology in stratified societies 25-29, early hunter gatherers were not expected to have had such complex conceptual or observational systems. However, the excavations at Pedra Pintada 4,15, and a recent one at Paineiro do Pilão 30, uncovered abundant pigment and spilled paint radiocarbon dated to the earliest Paleoindian levels (ST Dating the rock art, Figs. S1-S15), not in more recent levels.

Fig. S15. Red ochre pigment as unearthed in-situ at 96 cm depth from surface of excavated sediment at the base of the Paineil do Pilão rock shelter. A charcoal sample 50 cm north of, and at a higher depth (~87 cm) to this pigment was ^{14}C dated to $11,148 \pm 71$ BP (13,226 - 12,779 calibrated BP).



At the site of Paineil do Pilão, just 426 meters from Pedra Pintada, Davis discovered several painted circles, discs, and lines positioned to face sunrises on the days of the June and December solstices, along with a large painted grid composition filled in with tally marks that both Roosevelt and Davis believe reflects a seasonal calendar³⁰. Davis further conducted rock art and archaeoastronomy research at 14 other sites (Fig 1) during a four year study³¹ to identify and count the different motifs, measure their astronomical orientations, and recover associated cultural artifacts in dateable contexts.

Paralleling the sunrise alignments of Paineil do Pilão, Davis discovered sunset alignments at Serra da Lua and Serra do Sol. The alignments fall within the azimuthal range that the sun traces in a solar year, as it sets each day from its northernmost position on the June solstice to its southernmost position on the December solstice, today spanning 293.4° to 246.5° azimuth respectively³². The difference 13,000 years ago would have been about 1° more in both directions. Such alignments serving as demarcations for the rock art was an important clue that the ancient people's attention was focused on elements of the sky. This is further substantiated by the personified concentric circle diving figure (ST Concentric diving figure), and the comet eclipse panel. We concluded that other paintings of cruciforms and zoomorphs might also have signified stars and constellations of the stellar zodiac as they are similarly associated in the ethnoastronomy myths and traditions of many South American Indians (ST Ethnoastronomy Lore). In many of those myths, frogs, turtles, fish, and other foods the Indians ate as they became seasonally abundant, were envisioned as the stellar constellations of the zodiac seen in the night sky for that period of the year^{33 48}.

Serra da Lua

The longest continuous sequence of rock art in Monte Alegre is at the site of Serra da Lua on the western edge of the Serra do Ereré hill ridge. There, 130 images (some in panels, others isolated) are positioned sequentially along 266 meters of vertical cliffs. Most paintings were drawn between 1.5 and 2.5 meters above their local ground level, although six images are positioned above 3.5 meters, with the highest painting placed on the wall ~5 meters above the present ground surface. Most paintings have dimensions between 20 to 30 cm long and wide, but the largest image (a personified concentric circle diving figure) is 96 cm long (Fig S16 S17). Out of 149 images at Serra da Lua, 49 were classified as circle or disc motifs (33%), including 7 simple circles, 8 simple discs, 10 concentric circles, 9 encircled discs, a concentric disc, and 3 half circles. Additionally, 8 more from this group have lines radiating from them like sunrays, and 3 have tails or streaks extending from one side of them, resembling comets or shooting stars.

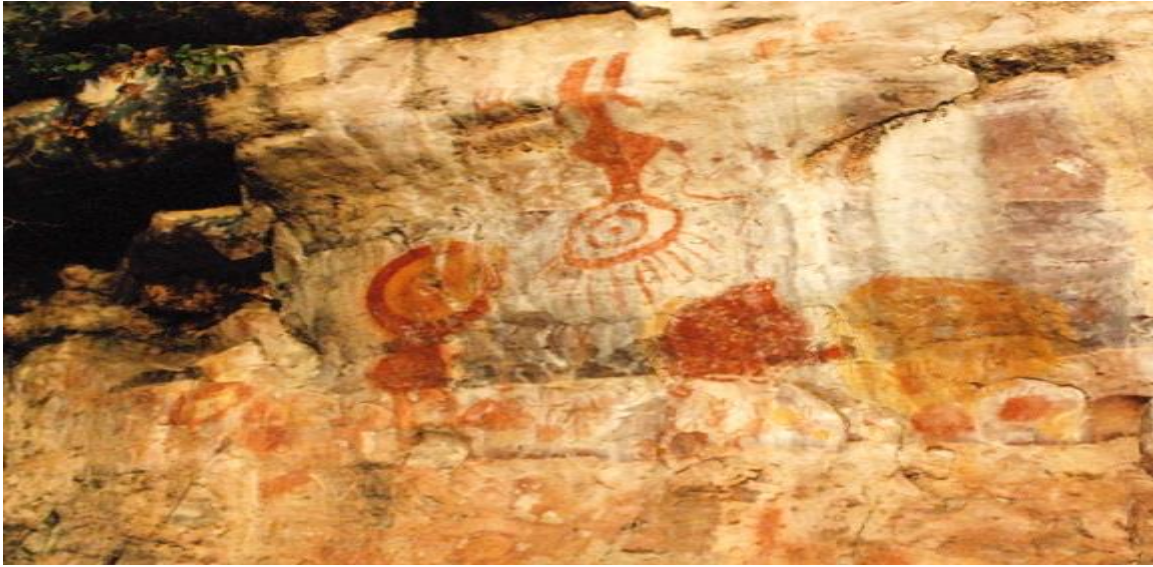


Fig. S16. Serra da Lua panel on the southwestern flank of the Serra do Ereré hill ridge. Left of center in the photo is a nearly 1 meter diameter red and yellow banded concentric disc on a red lobe, which resembles an upright humanoid figure. Right of center is an upside-down personified figure with a head formed of two concentric circles around its disc face and rays projecting down from the outer circle, an ellipsoid torso, linear down-curved waist, vertical bars for legs, and wavy lines for arms raised to its head. To the top left of this figure's is a smaller circle with central disc and rays emanating above and below (but not lateral to) the circle. Lower and to the right side of the head of the upside-down figure is another large red disc ~0.7 meters in diameter, with a yellow band circumscribing nearly half of its left border, and a red curved line extends from its right border to connect to a ~1 meter diameter (orange-ish) yellow disc. Many other discs, circles, and handprints are visible and some handprints superimpose a few large concentric images, suggesting a chronological sequence, and potentially a reverence or ritual associated with them.



Fig. S17. "Personified" disc pictographs at Serra da Lua— Left: red, yellow, red concentric disc with square-ish torso and two vertical lines for legs. Top center: Rayed encircled disc. Right of center: rayed concentric circle and disc center with upside-down humanoid torso and wavy lines for "arms". Right edge: red disc with partial yellow exterior band. Bottom edge center: Red right handprint with diminished middle finger. Bottom right corner: Red right handprint with faded pinky.

At Serra da Lua, in fact, the sequence of pictographic panels partly curves around the northwest edge of the hill, making the alignment of the images more tightly bound to the azimuthal horizon they face spanning the setting sun throughout the year (Fig. 2). Fig. 2. Serra da Lua horizon sunset alignments for concentric and encircled discs. True north is at the top of the photo. The map can not preserve true horizon distance and curvature at this scale, however, the position of rock art paintings, represented by green points along the red trail, correctly portrays the general orientations of the painted wall surfaces and the true distance ratios between paintings. Serra da Maxira (dark brown inset) is oriented in the correct direction but distance and size is not to scale. Caverna do Diabo, on the hill is shown by the red dot.

Fig. S2. Caverna da Pedra Pintada radiocarbon and Optically-stimulated luminescence dates, along with their weighted averages virtually overlapping.

Radiocarbon Dates		
8314	carbonized sacuri endocarp	11,145 +/- 135 (GX-17413) 13,143 cal
8231	carbonized tucuma endocarp	11,110 +/- 310 (GX-17406) 13,135 cal
8314	carbonized tucuma endocarp	10,905 +/- 295 (GX-17407) 12,950 cal
8314	carbonized tucuma endocarp	10,875 +/- 295 (GX-17414) 12,920 cal
Weighted average of four: 11,075 +/- 110 13,123, 13,088, 13,028 cal		
Luminescence Dates		
8231	burned chalcedony bifacial reduction flake	16,190 +/- 930
8346	burned chalcedony bifacial reduction flake	15,330 +/- 900
8231	sediment	13,106 +/- 1628
8231	heavy fraction of sediment	12,536 +/- 4125
8231	sediment	12,491 +/- 1409
8231	burned brecciated quartz flake,	11,880 +/- 760
Weighted average of six: 13,865 +/- 445 calendar years B.P.		

Test pit excavations did not uncover sufficiently deep soil deposits to excavate in association with the panels at Serra da Lua, but unifacial and bifacial lithic flakes, of similar Paleoindian manufacture, had been found on the surfacenext to painted panels (Figs. S10 S12).

Fig. S10. Lithic artifacts collected from the Pedra Pintada excavation. A: triangular stemmed quartz crystal biface point. B: triangular chalcedony biface point. C: triangular chalcedony biface point fragment. D: contracting stem fragment of a chalcedony biface point. E: chalcedony biface fragment. F: chalcedony blade fragment G: chalcedony unifacial graver H: chalcedony limace with graver tip and red pigment stain I: chalcedony unifacial scraper

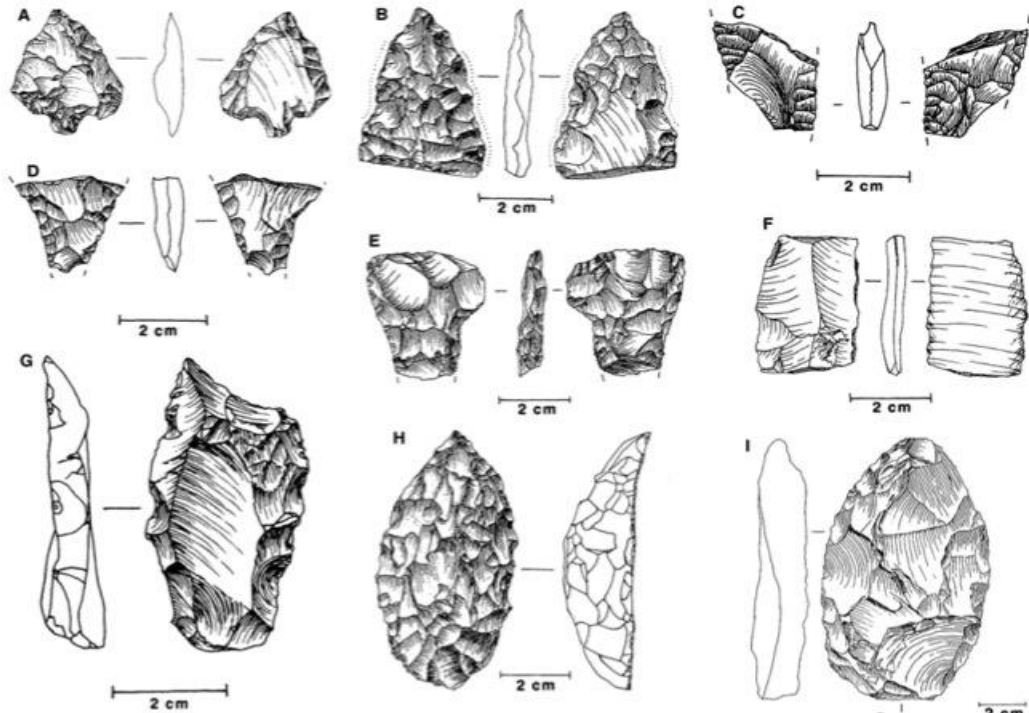


Fig. 6. Artifacts from excavations. (A) Triangular, bifacial, stemmed quartz crystal point, prov. 9272, 3.4 g. (B) Triangular bifacial chalcedony point tip with red pigment, prov. 9203, 18 g. (C) Bifacial chalcedony point fragment, prov. 8209, 2.5 g. (D) Contracting stem of bifacial chalcedony point, prov. 9248, 2.5 g. (E) Chalcedony biface fragment, prov. 9206, 12.5 g. (F) Chalcedony blade fragment, prov. 9290, 5.5 g. (G) Chalcedony unifacial graver, prov. 9145, 18 g. (H) Chalcedony limace with graver tip and red pigment stain, prov. 9203, 18 g. (I) Chalcedony unifacial scraper, prov. 9290, 5.5 g.

Fig. S11. Silicified sandstone heavy cutting or digging tools from excavated Paleoindian layers at Caverna da Pedra Pintada



Fig. S12. Silicified sandstone surface collections (unwashed) from Serra da Lua. Left: triangular wedge flake with minimal retouch and chipped cutting edge. Right: prismatic core. Compare tool form to Fig. 10 and pink-colored raw material to Fig. 11.



The circle or disc images in the sequence align with the setting sun at different times of the year, beginning and ending with solstice alignments. The pictographic sequence begins with a smiling face inside a rayed concentric circle positioned 4.6 meters high on the wall and angled toward $\sim 244^\circ$ (Fig 3 left).

The high position of this image is important, since it directly mirrors the intense sun earlier on that day as it peaks out from behind the hill at a higher angle and at a wider azimuth in the sky, reaching 244° around 4:30 PM local time on the day of the December solstice 32. Below and to the left of the rayed smiling image on the wall is a disc pictograph encircled by two concentric circles above a painted hourglass shape (Fig. 3 left). This image faces the sunset at 246° on the day of the December solstice, where a less intense sun dips below the south (left) edge of Serra da Maxirá hill on the horizon (Fig. 3 right).

Fig. 3. Southern (December) solstice pictographs. Photos of the pedestal painting (left) at the southwest end of the rock art panel series at Serra da Lua faces 246° southwest while the rayed circle with a smiley face aligns to $\sim 244^\circ$ and is positioned higher on the wall, (right) just as the sun on this day passes through 244° at $\sim 4:30$ PM 32. These cardinal directions were corrected to true north ($18^\circ 01'$) and it appears to depict the sun setting on top of a flat portion of the rocky slope of Serra da Maxirá hill, in the horizon.

Fig. S3. Ochre manuports and lithics in Paleoindian levels at Ana Roosevelt's Pedra Pintada excavation.



The third circle or disc painting at Serra da Lua is further along the rock art trail, and it is an encircled disc located 4.4 meters high on the wall and facing $\sim 252^\circ$. Next on the trail is a clustered panel containing two personified disc paintings (STConcentric diving figure) which face $\sim 266^\circ$. The next solar themed images after this panel are two encircled discs separated from each other by 0.25 meters on the wall. They both face $\sim 270^\circ$ sunset on the day of the equinox, the day of the year when the sun sets on the horizon just to the right of the base of Maxirá hill's north flank.

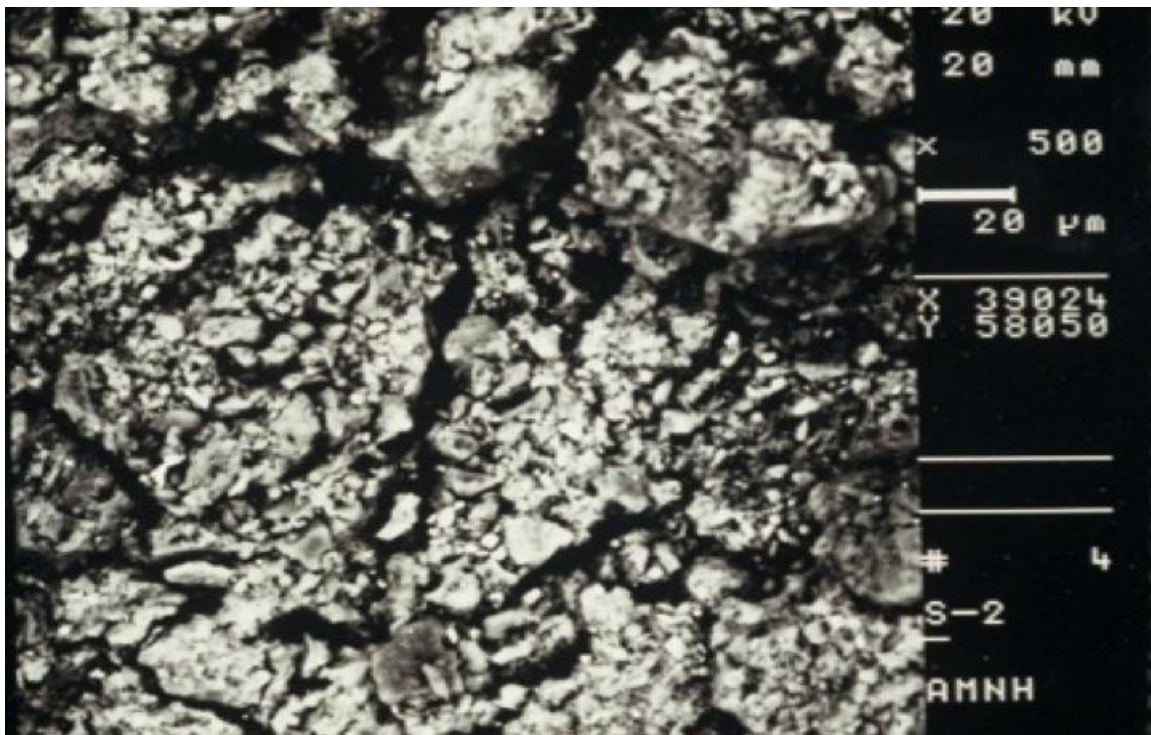
Sequentially, another encircled disc faces $\sim 276^\circ$, followed by another two encircled discs that are 0.37 meters apart on the wall and face $\sim 253^\circ$ and $\sim 291^\circ$. After a long distance along the trail, a rayed concentric circle faces 252° again. The last concentric circle image at Serra da Lua is on a stone tower in an alcove that faces $\sim 293^\circ$, the June solstice sunset. Due to the curvature of the trail around the cliff walls, the December solstice sunset is not visible from this location, just as the June solstice sunset is not observable from the painting facing the December solstice. Effectively, the full experience requires a journey along the rock art trail as though one is journeying through a solar year.

Possible Comet+ Eclipse Panel

A unique spoked wheel painting is in Serra da Lua's rock art sequence about 12.5 meters before the trail terminates at the rock tower. This painting is part of a panel (Fig. 4left) depicting a plus sign overlapping a circle, a spoked encircled dot (wheel) with two extended rays beneath it and encroaching arcs to either side of it, and a disembodied human head with four lines extending from underneath it. Handprints frame and overlap parts of the panel, and a bird like zoomorph pictograph intersects the panel between the wheel and the head (Fig. 4right).

Fig.4. The comet + eclipse panel at Serra da Lua just 12.5 meters away from the Ereré rock tower aligns between 302° and 309° azimuth. Left: raw color photo. Right: photo enhanced by Lab A contrast (for red colors) as black and white image that was then given cepia tone.

Fig. S4. Electron photo of a pigment sample from Pedra Pintada by William Barnett



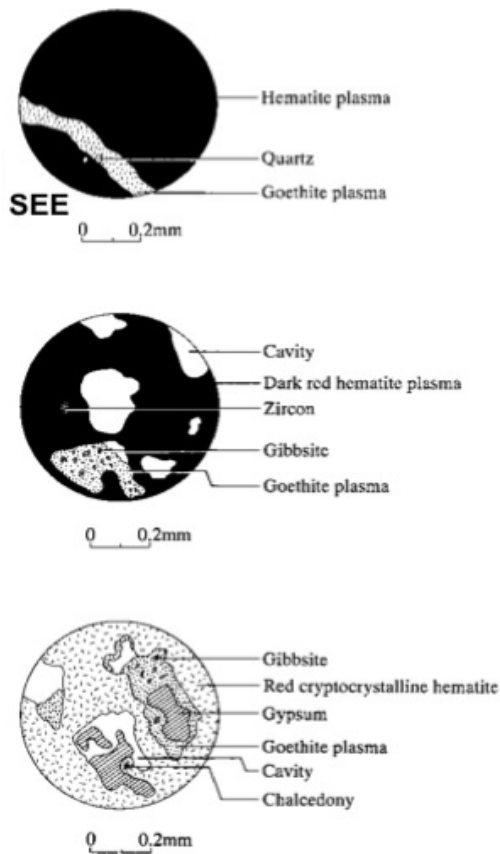
The overall impression of the panel is a representation of the sky featuring a bright star above a solar eclipse above an anthropomorphized comet. The panel faces a local azimuth between 302° and 309° , and the lowest image (the comet) is 4.46 meters above the foot trail on a sheer wall that slopes skyward at an altitude (inclination) between 42° to 54° . Maintaining consistency in motif interpretation, the encircled dot represents the sun, and the encroaching arcs and spokes represent the diminishment of its luminosity to the point that it is only as bright (by proportional size) as the star or planet (the circle and plus sign) above it.

Therefore, this appears to depict a solar eclipse. Beneath it, a face with four lines gives the impression of a comet, which at first was problematic because the painted "head" of the comet was right side up in relation to the horizon that the panel faces. Comets practically do not become visible until after the sun goes down due to comparative luminosities, therefore they would only appear in the western sky when the comet proceeds the sun, and because their tails nearly always point away from the sun, the comet's head should be pointing down toward the horizon after sunset. However, a comet preceding the sun would be facing right side up in the west if it were bright enough to be visible during the day, or if the daytime sun were vastly diminished. Such an orientation becomes observable during a solar eclipse when the sun's light no longer outshines the light of the comet.

Because paintings at Pedra Pintada and Painel do Pilão pinpoint a painting tradition ~13,000 years ago, StarryNight astronomy software was used to search for potential solar eclipses from that period. Because the panel faces the western sky near the northern solstice, the event it depicts must have occurred sometime after noon in the northwest sky circa 13,000 years ago. Although simulation software can not prove whether the event did happen, it can test the plausibility of such a conjunction. Astoundingly, the software revealed one such event very closely matching the painted panel (Fig. 5).

Fig.5. A StarryNight™ recreation of the sky at Serra da Lua during a solar eclipse at about 1:30 PM on July 28, 11,027 B.C., the eclipse during the daytime reveals a comet that would have otherwise been invisible due to relative daylight luminosity.

Fig. S5. Thin sections of red paint or pigment samples from Pedra Pintada, samples run by Marcondes Lima da Costa



According to StarryNight, which utilizes the known periodicities of observed comets to track their motions pro or retrograde, the A.D.

1910 Halley comet would have been close enough to the sun (if it had been orbiting the sun with its present trajectory so long ago (ST Recorded Comets) to produce a small tail viewable during the solar eclipse of July 28, 11,027 BC, between 1:30 and 2:30 PM. At Monte Alegre, 2° south of the equator, an eclipse occurred high in the sky at a local azimuth of 302° and an altitude (inclination) of 58°, and the comet was visible at 288° azimuth at an altitude (inclination) of 35°. Additionally, the planet Venus would have been visible just above the eclipse, just as the painted panel depicts a star above the spokedwheel. Furthermore, mercury and mars are just beneath Venus and to the right of the eclipse just as two concentric dots are positioned to the right side of the encroached circle in the painting. Considering that ancient artists would not have had paint in hand to draw such an unexpected event the moment it occurred, the panel nearly mirrors an extremely rare conjunction that mathematically could have occurred 13,000 years ago suggesting these pictographs might be the oldest representation for such a phenomenon in the world. Although the Serra da Lua pictographic sequence is considered to terminate at the rock tower, 19 other isolated pictographs are dispersed along another 150 meters of Erere's northeast slope between the rock tower and the Serra do Sol panels. None of those 19 pictographs are solar themed, most instead depicting the humanoid and zoomorphic designs we hypothesize to represent constellations and other heavenly bodies.

Serra do Sol.

At Serra do Sol, Davis classified 26 (41%) of the 58 pictographs as circle or disc motifs (including 2 simple circles, 7 simple discs, 2 concentric circles, 2 encircled discs, 1 concentric disc, 1 rayed circle, 1 rayed disc, 1 rayed encircled disc, 5 circles and 2 discs with lines or cruciforms, one mirrored pair of S scroll spirals enclosing a small disc (a dot), and one mirrored pair of S scroll spirals enclosing a circle. Most painted images at Serra do Sol are located among one of its two art panels that are on two separate cliff walls. The first wall faces ~265°, nearly aligned to the equinox sunset (270°), but none of the 11 paintings there depict simple circle or disc motifs. Instead, they depict zoomorphic or humanoid figures, and geometric compositions, including a snake with four distinct bends (ST Celestial Snake), a sideways humanoid with "eyes" outside the boundary of the face, and a curvilinear design that might represent the milky way (Fig.S18). These drawings might specifically represent envisioned asterisms of the zodiac along the celestial equator. Another humanoid figure, also oriented on its side, has a circular torso with a central dot, while another geometric design has a double line half circle arc, as part of a larger abstract composition. These circular compositions possibly have lunar rather than solar connotations.

The second wall at Serra do Sol, however, faces between 290° to 305° due to a slightly curved and irregular and fragmented surface. Here 24 of the circle/disc motifs all align very closely to ~294° the position of the setting sun on the June solstice, as does the largest overall painting at either site a concentric disc image with a diameter over 1 meter long (Fig.6 left).

Fig. 6. Northern (June) solstice pictographs. Left: photo of the ~1.5 meter diameter concentric disc image at the north end of the two main panels at Serra do Sol. This final image in the panel sequence there faces 294° northwest, which is the position of the path of the sun at dusk on the day of the June solstice 13,000 years ago (correcting for obliquity). Right: The 293.4° position of the northern solstice sunset on June 21, 2011.

Fig. S6. Wall Fragment recovered at base of Serra da Lua painted wall for pXRF analysis. Top photo: reverse side is black. Middle photo: obverse side has red pigment and white coloration. 2 OCT 2009, performed by JP Brown; Field Museum–Chicago, Illinois.



The fact that this painting faces 294° makes it more precise to the position the sun would have set on the solstice 13,000 years ago (ST Archaeoastronomy precision); today the sun sets at 293.4° (Fig. 6 right), though a $<1^\circ$ difference for naked eye sightings of the sun on an open horizon without a gnomon should not be expected to be so precise.

Nine other circular motifs here are small and have geometric lines or scrolls as part of their compositions, which theoretically could reflect visual aberrations or entoptics experienced when looking at the bright sun or a broad blue sky. However, we see no need to resort to shamanic trance or altered consciousness theory 49 51 because the painted circle and disc images at Serra do Sol and Serra da Lua seem to be contextual sky representations mirroring real heavenly bodies seen while standing underneath those paintings looking across the valley to the horizon, particularly on the days of the solstice and equinox. Thus, the sequence of western facing art panels from Serra da Lua to Serra do Sol constitute a series of locations marked for the sighting of the setting sun as it moved from solstice to solstice.

Fig. S7. Wall Fragment: reverse, no pigment (rock has black coloration). A little iron; small copper and zinc peaks seem to be internal to pXRF unit (compare sample 4). 40kV, 1.4 μ A, CuTiAl filter, no vacuum, 60 secs

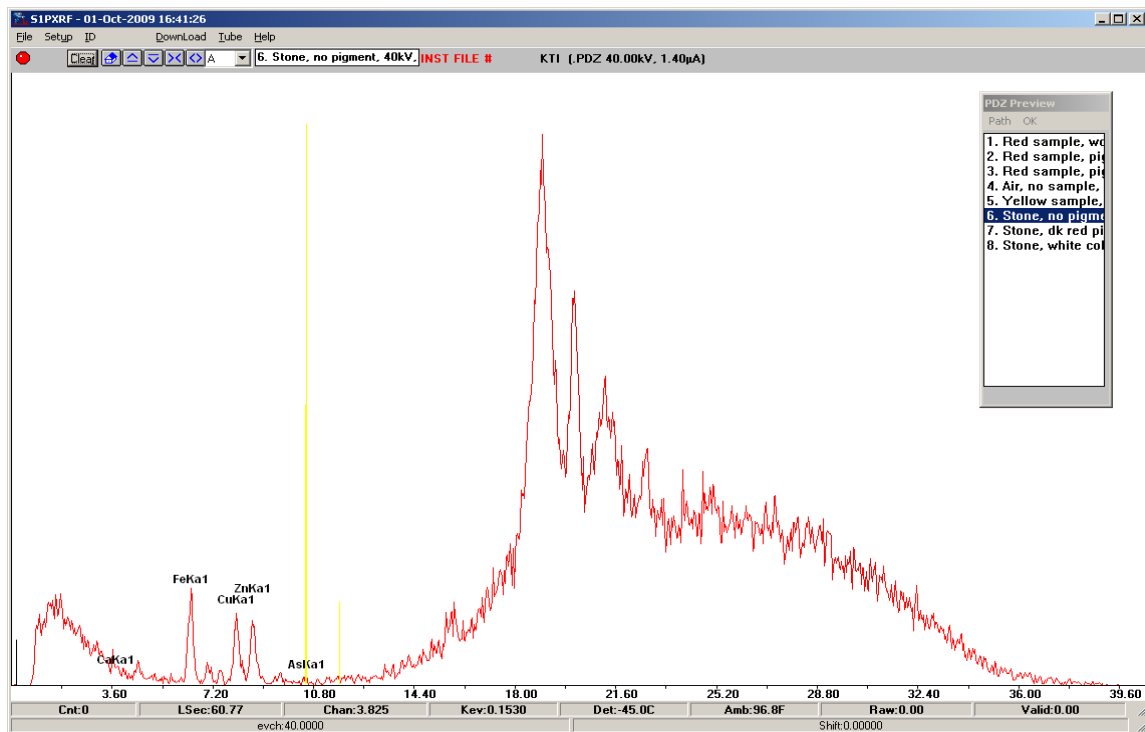


Fig. S8. Wall Fragment: obverse, dark red pigment. Strong iron response compared to Fig S14 and Fig S16; small copper and zinc peaks seem to be internal to pXRF unit (compare sample 4). 40kV, 1.4 μ A, CuTiAl filter, no vacuum, 60 secs.

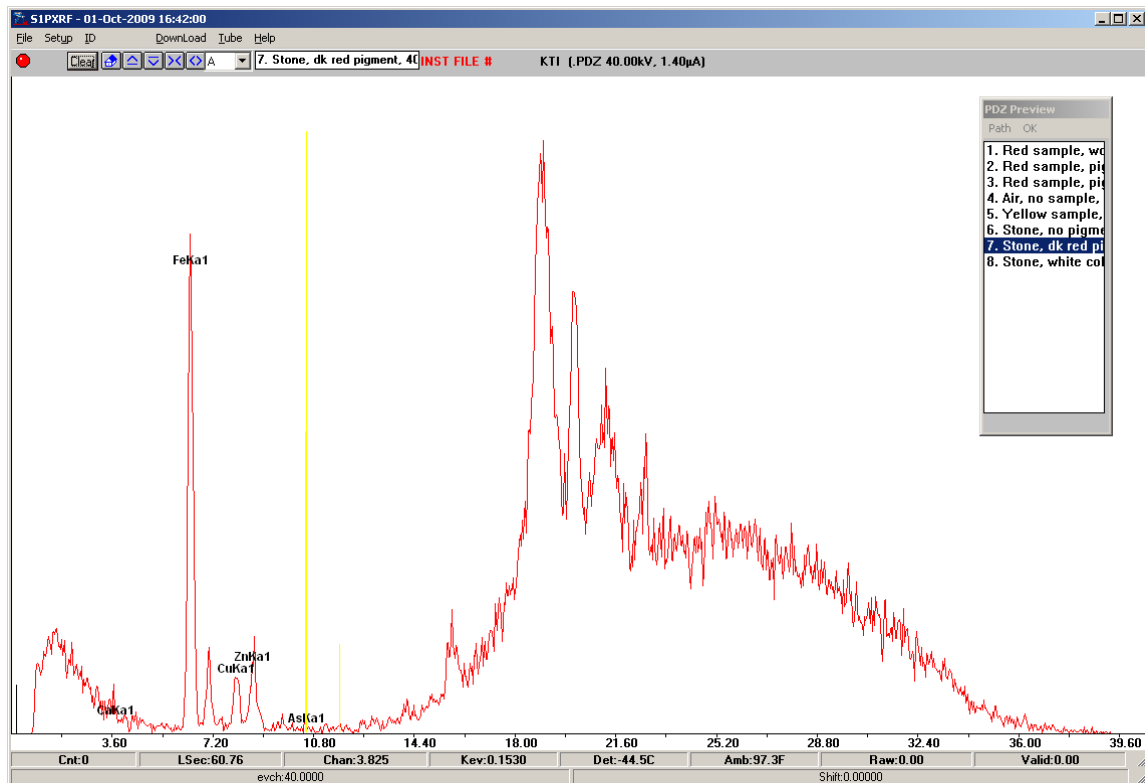


Fig. S9. Wall Fragment: obverse, white surface color. Essentially the same as Fig S14 with a slightly lower iron response; small copper and zinc peaks seem to be internal to pXRF unit (compare sample 4). 40kV, 1.4μA, CuTiAl filter, no vacuum, 60 secs

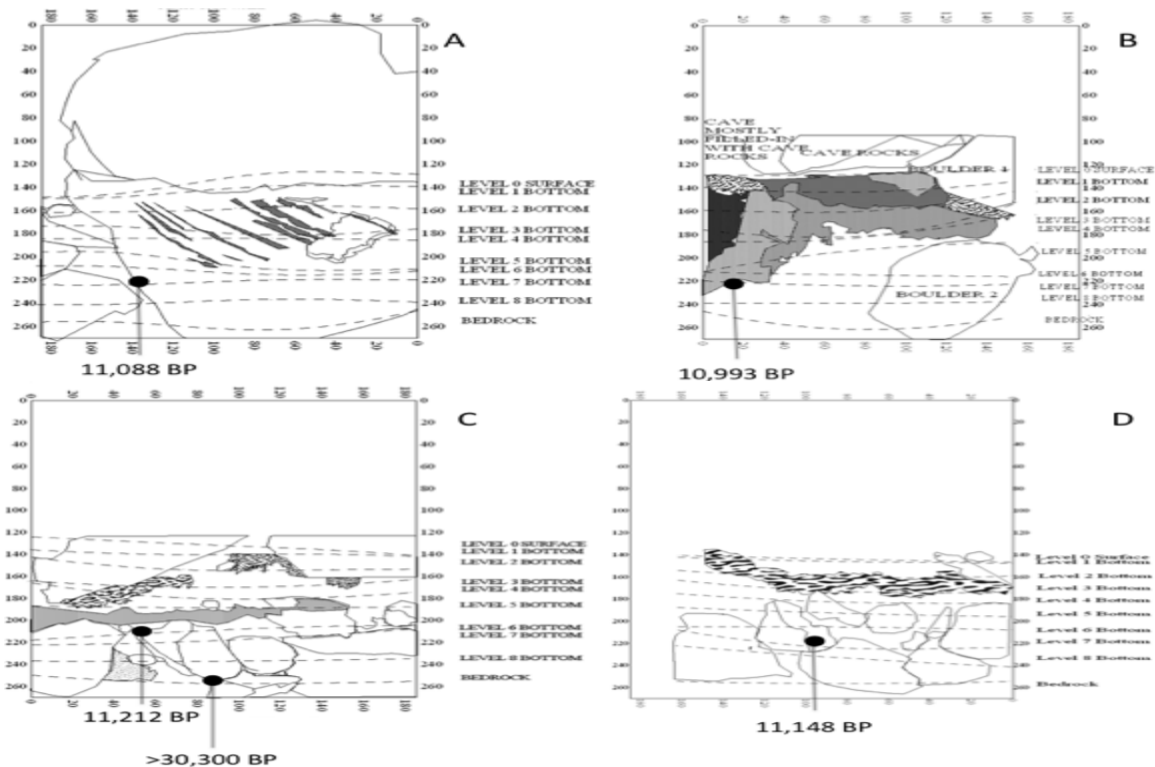
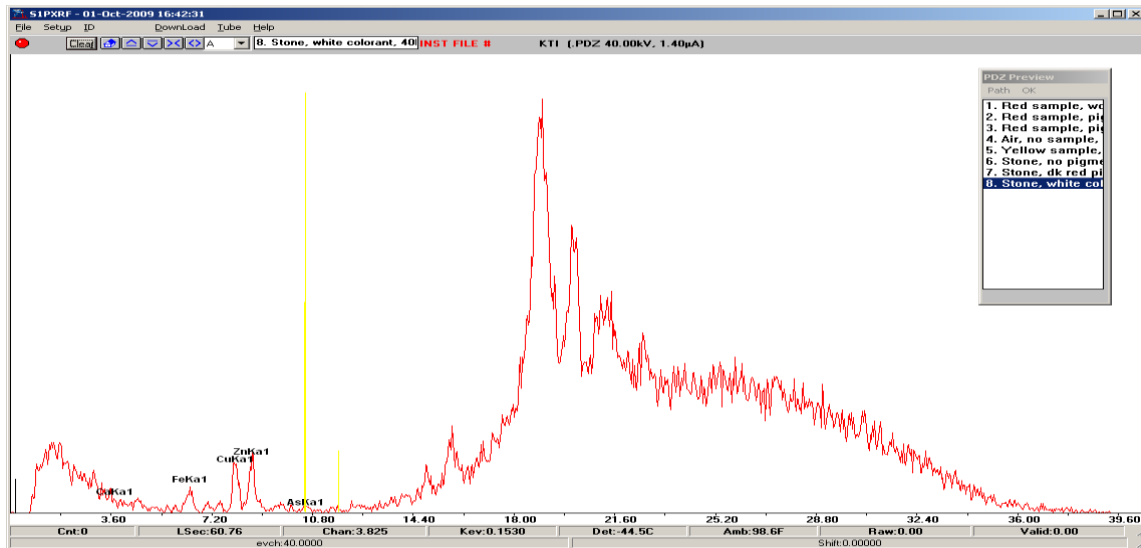


Fig. S13. Stratigraphic profiles of Paineil do Pilão excavation digitized with MapViewer version 7.2.1931 with excavation levels and radiocarbon samples (see Table 1) superimposed A): Northeast wall showing upraised platform base stage. All features here are cracks and crevices in rock, no soil forms part of this profile. The grey shaded-in features depict thirteen mostly parallel diagonal gouges of removed rock from the wall, which reach to excavation level 6 depths. Gouges to the right side terminate higher, at a dense rock jutting out from the surface. B): Southeast wall, which runs underneath the rocky outcrop with the rock art.

The upper left corner is where a narrow tunnel through loose sediment runs underneath the outcrop and through to the other side where the tunnel opens into a small cave. The features of this profile depict different soil strata which had filled into the tunnel vertically and horizontally over time. The mottled layer represents an ancient root and vegetation mat, probably from trees and vines. C): Southwest wall profile is formed mostly from bedrock boulders that provide much of the foundation for the side and overhang of this rock shelter. A similar vegetation mat forms the mottled fragments in excavation levels 2-4. There is also a narrow sediment layer that coincides with the top of excavation level 6, which is the level that caps the cultural layers of intense lithic activity dated to the paleoindian period. D): Northwest wall and ground exit from the rock shelter. The mottled layer seen here, partly extends to the Southwest profile of an ancient vegetation mat. This layer rests on a bed of boulders at the bottom of level 3 and the top of level 4.

Fig. S14. In the southeast section of the unit, this round rock was found in Level 7 (102 cm depth). Dstretch (ImageJ version 1.46r software running the Dstretch applet created by Jon Harmon at prodigy.net) enhances the pigment found on its surface. Charcoal found next to its top edge (89-91 cm depth) was ^{14}C dated to 13,014 – 12,725 cal yr BP.



Fig. S18. Serra do Sol panel facing $\sim 270^\circ$ west, taken with a gigapan panoramic camera (some distortion at edges). Numbered pictographs display 1: snake zoomorph with 4 distinct torso bends and a curved tail. 2) sideways humanoid (presumably) with a down-turned triangle between splayed legs and a dot on both sides outside the boundary of the head, which itself has 4 short lines radiating from the top like a crown. 3) curvilinear design possibly representative of the Milky Way. 4) sideways double half arc. 5) sideways humanoid with circle torso and central dot.



Table 1. CdPP samples are radiocarbon dates for Paleoindian cultural layer associated with the painting period (Initial A stratum 17c) excavated by Roosevelt in 1996 at Caverna da Pedra Pintada (3). PdP samples are radiocarbon dates for Paleoindian cultural layers excavated by Davis in 2011 at Paineil do Pilão.

Sample ID	Exc Level	Depth from Surface	14C age BP	d14C age	Calibrated calendar range	OxCal yr BP
CdPP/GX17414	13 (unit 5 W)	102-109 cm	10875	±295	11,441 - 10,076 BC	13,391 - 12,026
CdPP/GX17413	13 (unit 5 W)	102-109 cm	11145	±135	11,303 - 10,787 BC	13,253 - 12,737
CdPP/GX17406	13W (unit 2 W)	114-127 cm	11110	±310	11,681 - 10,455 BC	13,631 - 12,405
CdPP/GX17407	13E (unit 2 E)	119-132 cm	10905	±295	11,462 - 10,123 BC	13,412 - 12,073
Caverna da Pedra Pintada Paleoindian weighted date of 11,075 ± 110 yr BP (6)						13,116 - 12,726 cal
PdP/20110106-17	6	~87 (85-89.5)cm	11,212	69	11,292 - 10950 BC	13,242 - 12,900
PdP/20110107-2	7	~90 (89-91)cm	10,993	62	11,064 - 10,775 BC	13,014 - 12,725
PdP/20110107-13	7	~82 (80-85)cm	11,088	64	11,134 - 10,842 BC	13,084 - 12,792
PdP/20110107-14	7	~87 (85-90)cm	11,148	71	11,185 - 10,860 BC	13,135 - 12,810
Paineil do Pilão weighted date of 11,140 ± 68 yr BP						13,121 - 12,811 cal

Conclusions

The new findings at Monte Alegre confirm that some of the pictographs served astronomical and apparently calendric functions. As such, they seem to be the earliest pictographs in the Americas, among the early uses of rock art as landscape delimiters, and they constitute the earliest evidence of an archaeoastronomy observatory currently known. The ancient paintings also provide a glimpse at the cosmology of a late Pleistocene culture, their associative and relational understanding of the world, and one of their strategies for adjusting to a new landscape. This was a period of time when humans were pioneering new habitats in the Americas. Here, near the equator, there is little seasonal variation in daylight hours, temperature, precipitation phases, and the shedding of foliage unlike at higher latitudes. However, the position of the sun, and the direction that it casts shadows do provide reliable seasonal indicators. By using rock art to track horizon sightings at several distinct sites, the painters show skill at complex pattern recognition. Through studying the things they depicted sun, stars, comets we can begin to understand how they may have utilized those occurrences to predictively organize economic and social activities around environmental resource oscillations during the initial human occupation of the Amazon.

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Supplementary Text:

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