

THE RECONSTRUCTION AND ARCHAEOASTRONOMY OF A HOPEWELL GEOMETRIC EARTHWORK IN OHIO

by

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Overview:

The Salisbury brothers authored a paper in 1862 describing several archaeological sites in Ohio. One was an “Ancient Symbolic Earth Works” in Northern Perry County. The paper included a narrative and plot map of a hill top earthwork and three associated features. They recorded linear measurements, angles of intersection, and mound elevations. They described five structures with flat tops which they termed “platforms” and another as an open “C” shaped structure (*Salisbury and Salisbury 1862*). State Archaeologist Warren K. Moorehead published a short article in 1896 describing the site naming it “Frank Yost’s Mounds” after the landowner. The only significant information he added to the Salisbury paper was finding ash in what he termed the “bird effigy” located inside a large circular enclosure. (*Moorehead 1896*). Moorehead’s report did not contain the detail or descriptions of the entire structure as described in the Salisbury document. This indicates erosion and intentional agricultural destruction began in the latter half of the 19th century. Until recently, the large circle with an internal crescent and a small nearby mound are the only features known to exist into modern times. It is obvious the site was a large geometric earthwork similar to other Hopewell sites in Ohio. However, some features and therefore functions are unlike any other known Hopewell site, making this a very unique and important site.

This paper encompasses the rediscovery of lost features, digital reconstruction of the site, and investigation into its functions. I will show how the site integrates distant terrestrial features and offer my research into the purpose of this three dimensional geometric earthwork. I will demonstrate how precise construction and spatial orientation of the structure provided alignments with celestial body rise and set points. I will describe the visual illusions created by celestial body rises and settings in relation to the earthwork and a distant terrestrial feature. I will also suggest hypothesizes for the cognitive precursors for these Native Americans to construct such an elaborate structure.

Site Reconstruction:

The geographic center of the site, **33Pe5** in the Ohio Site Registry, known today as the “**Yost Works**”, is located on a hill top at coordinates 35°54’02”N x 82°20’31”W in Northern Perry County, Ohio. To the south of site center is an intact large circular enclosure and a small nearby mound both covered by trees and brush. Inside the enclosure on the south interior perimeter is an earthen crescent with a central “bulge” which, when viewed from above resembles an effigy of a spread wing bird. Until recently, these are the only features of the geometric structure known to have survived. Construction of an accurate site plot map began with entering the linear measurements generated by the Salisbury’s into a Computer Aided Design Program, (CAD). Scale and orientation needed to be verified before an accurate reconstruction could be completed.

Dr. William F. Romain provided aerial LiDAR, images of the site. LiDAR is an acronym for Light Detection and Ranging. By filtering the digital LiDAR data in bare earth mode, foliage was eliminated and subtle terrain elevations were delineated. (2008a, 2008b. *Romain and Burks*).

Analysis of the LiDAR images revealed the large circle, the nearby mound, and remnants of the original structure. The additional remnants of the earthwork delineated were the ends and remnants of two long linear enclosures. A “platform” at each end is also revealed. (Figure 1). The CAD image was then sized and registered to the LiDAR imagery data points. This resulted in an accurate; two dimensional scaled aerial view primarily based on the LiDAR data. (Figure 2).

The Salisbury’s used magnetic compass readings to determine the orientation of the site. Since the angle of declination for this location in 1862 is not known, orientation was accomplished by registering the new plot on to an aerial image of the site in Google Earth™ computer program. Then azimuths, midlines and sight lines were measured and constructed to complete the final site plot map. (Figure 3). This new plot map was then registered to a current aerial image of the site. (Figure 4).

Dr. Jarrod Burks performed Geophysical Surveys of the site using magnetic and electrical resistance technologies. The surveys did not add to the data base because of extensive agricultural destruction. Also, the placement of an underground iron oil line through the center of the site in the middle 20th century skewed much of the data. The minimal data recovered supported known data.

Suppositions:

Without a carbon 14 date for the site and considering its advanced form and complexity, it is supposed that this site was constructed in the middle to late Hopewell cultural era. For this reason, a date of reference for all alignments of 250 AD was selected. A variation of ± 500 years is not a significant factor given the tolerances in this research. Solar and lunar alignments are not significantly affected by time variations less than ± 1000 years. Therefore, a reference date of 250 AD is well within the parameters for accurate testing.

The Salisbury’s described five features in the earthworks as “platforms”. These are noted as P1, P2, P3, P4, and P6 on the plot map. These five platforms were the same height as the linear earthwork walls of four feet. The flat upper surfaces provided a confined location for precise sightline viewing. P5 is a “C” shaped enclosure with the interior at terrain level. These six features are considered to be “observation platforms and viewing points” for celestial alignments. (Figure 3).

Site Analysis:

The Global Positioning System, GPS, was used to determine terrain elevations above mean sea level. It was then possible to render a three dimensional view of the geometric structure. This reveals the earthwork was built over the crest of a hill using terrain elevation to create a three dimensional structure having six different elevations at six

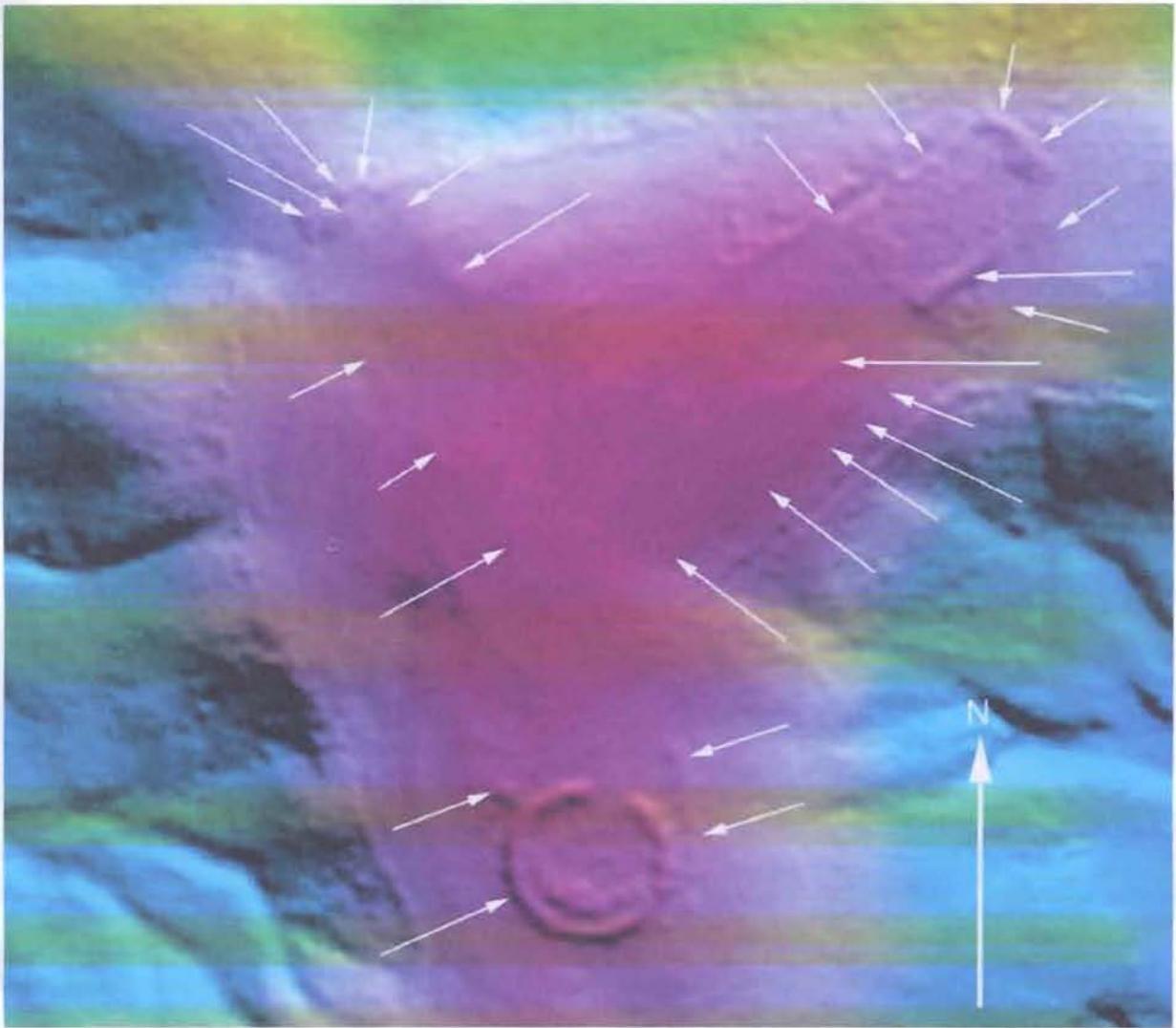


Figure 1 LiDAR image revealing earthwork features. *Image by W. F. Romain, Interpretation, R. Moats*

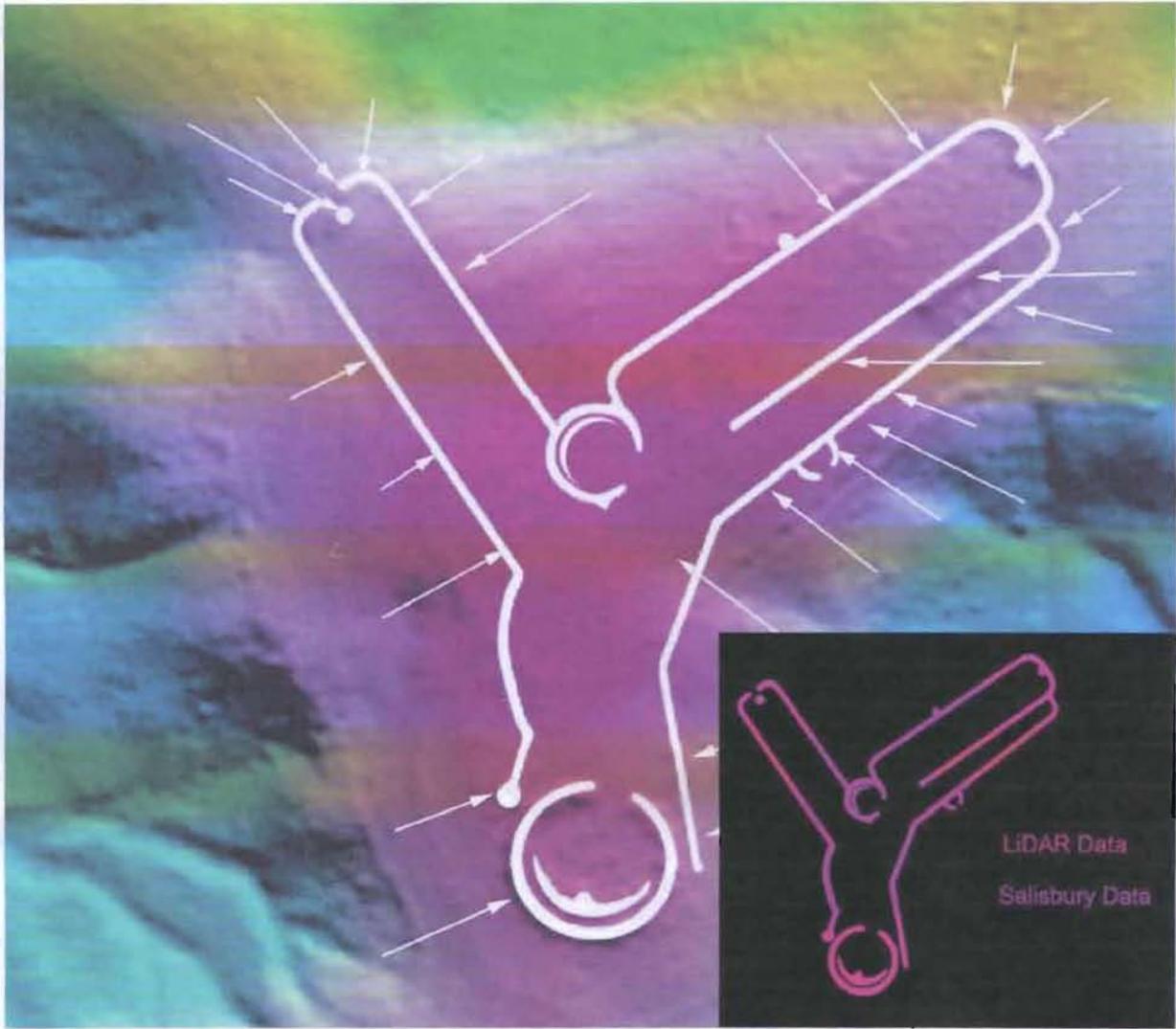


Figure 2 Computer Aided Design, CAD, plot of site registered to align with the LiDAR data points. *CAD Image, R. Moats and D. Hill*

The Yost Works

Site 33Pe5 Plot Map. Combined LiDAR & Salisbury Data
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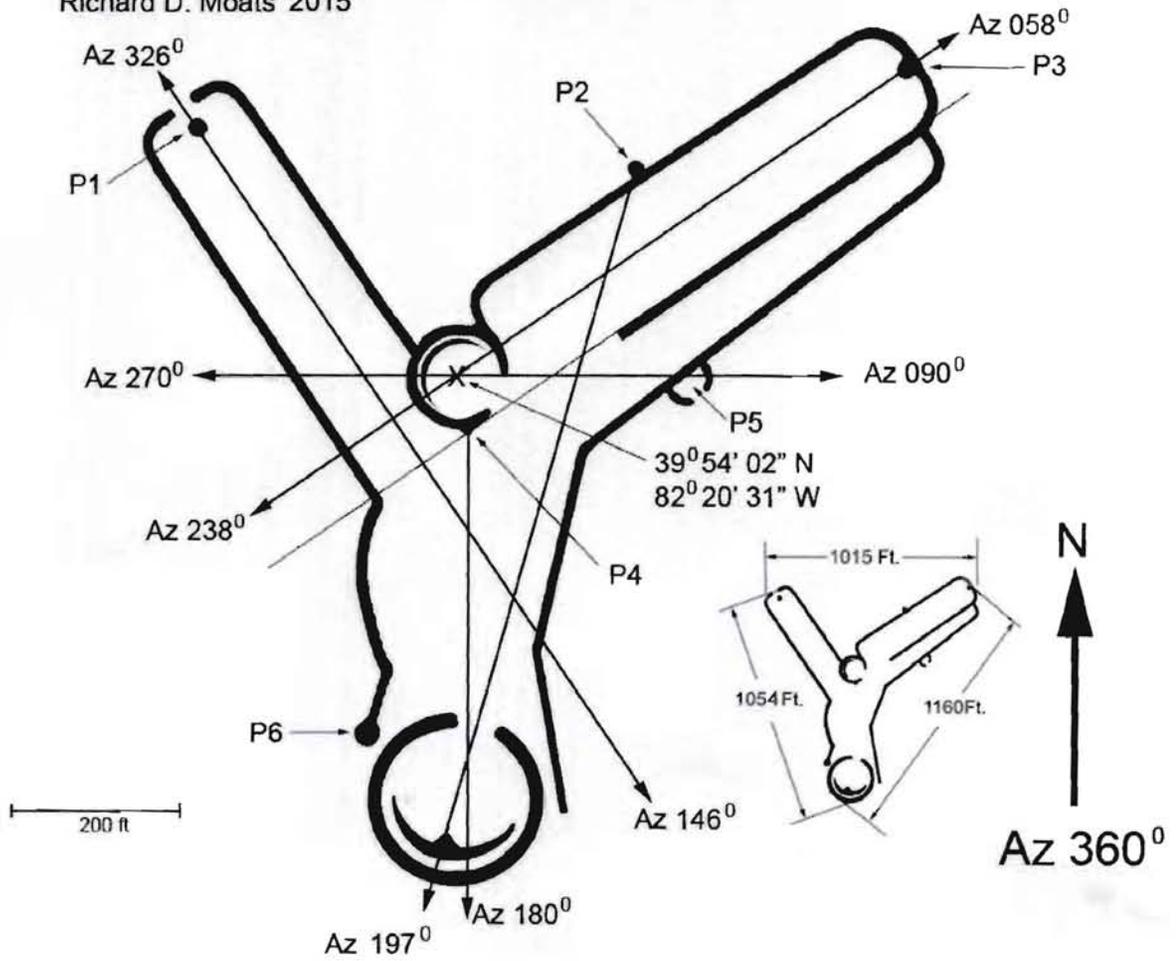


Figure 3 Completed site plot map. Image, R. Moats

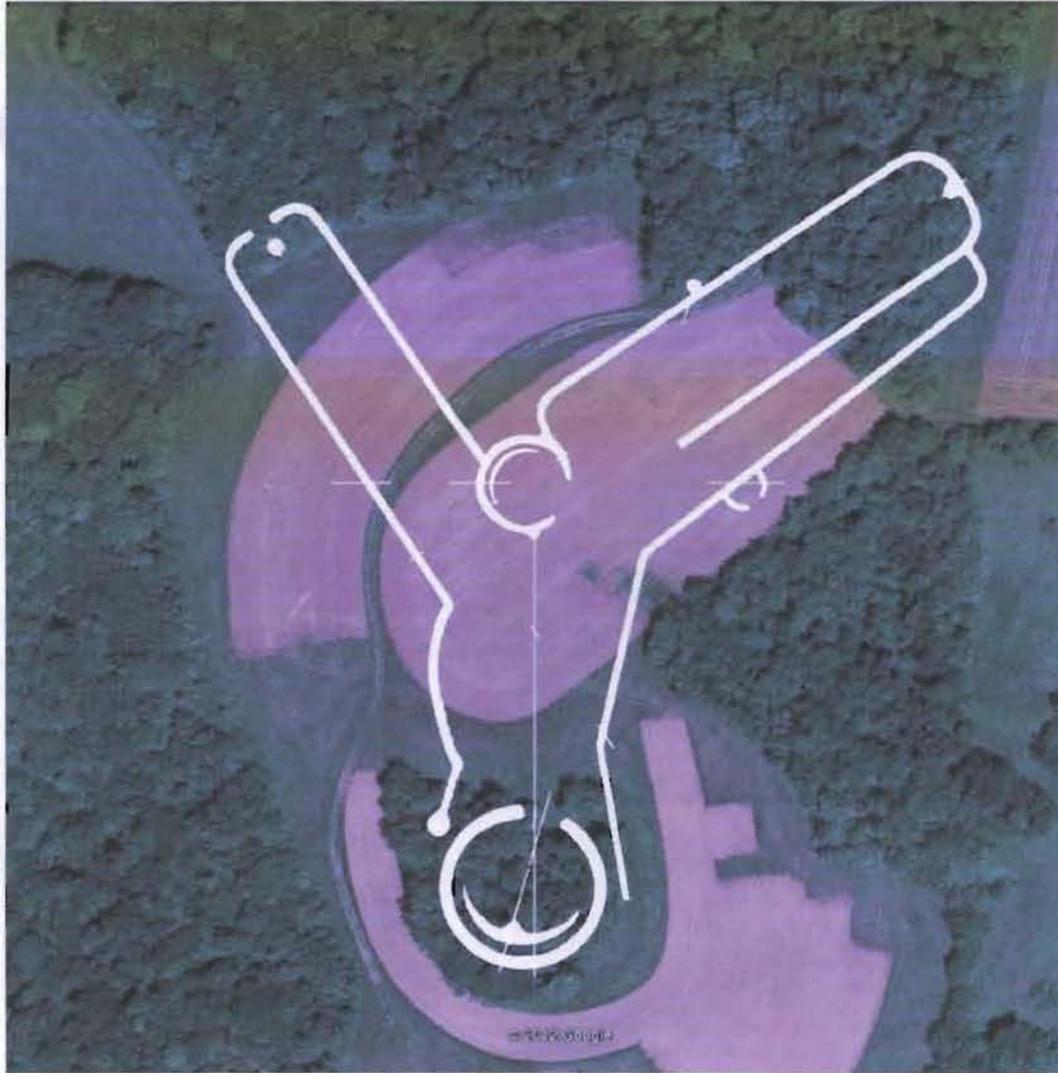


Figure 4 Site plot registered to 2012 aerial image. *Aerial image, Google Earth*

observation locations. (*Figure 5*). The earthwork was very large having an aggregate size of 1054 feet by 1180 feet by 1015 feet. These dimensions are found in other Hopewell geometric earthworks. This strongly suggests the builders of this site were of the Hopewell cultural era using a unit of measure common in other Hopewell earthworks. (*Romain, 2010*).

The center of the central circle is at the highest terrain elevation. The central circle at the crest of the hill was flat and level. Terrain variances were compensated for adjusting the earthwork height making the mean embankment elevations of the earthwork 4 feet above terrain elevation. An exception is the south east wall which was two to three feet above mean terrain elevation. The diameter of the central circle was 121 feet, ± 5 feet from crest to crest. The diameter of the large circle is 197 feet ± 2 feet from crest to crest. The ratio between these two earthen circles is $1:1.628 \pm 0.05$. This ratio is very close to the "Golden Ratio" of $1:1.618$. The Golden Ratio is found in earthen circle enclosures at several other Hopewell sites. (*Hamilton, 2012*).

The distance separating the two circles is 318 feet. This is the combined diameters of the central circle "A" and the large circle "B". This strongly suggests the use of Phi function at this site where diameters A + B is to A as A is to B = Phi. (*Figure 5*).

In a view from directly above the site, *figure 2*, the vertical dimension of the structure is eliminated. Analysis of this view reveals the angle of intersection of the midlines and walls of the two causeways intersect at a 90 degree angle. This was necessary to achieve the desired alignments on three dimensional terrain. This suggests the application of Pythagorean geometric principals used in the construction of the site.

A wider view LiDAR image delineated three distant features described by the Salisburys, the "North Mound", "Pool", and "T Mound". The image is a 90° overhead composite view which eliminates linear distortion. (*Figure 6*).

The "North Mound", (*figure 8*), is a 36 X 60 foot elliptical shaped mound oriented north/south through the long axis midline. The center of this mound on Az360/0 degrees $\pm 0.05^\circ$ north of platform, P3. (*Figure 7*).

A "Pool", (*figure 9*), formed by a low earthen dam holding water from run off and a spring, lies on an azimuth of $58^\circ \pm 2^\circ$ from the center of the central circle, through platform P3, and on the extended centerline axis of the north east enclosure. (*Figure 7*).

The "T Mound", (*figure 10*), or as the Salisburys named it "Human Shaped Symbolic Mound", lies east of platform P3. (*Figure 7*). Its shape is not well discerned because of agricultural destruction. Also, a modern dirt bike track was built through the mound which destroyed more of the structure. Based on the description in the Salisbury text and current observations, the "T" shaped mound was oriented to the cardinal directions. The longest midline, 80 feet, is in line with an east/west axis and the cross midline, 36 feet, is in line with a north/south axis with the top of the "T" being to the west.

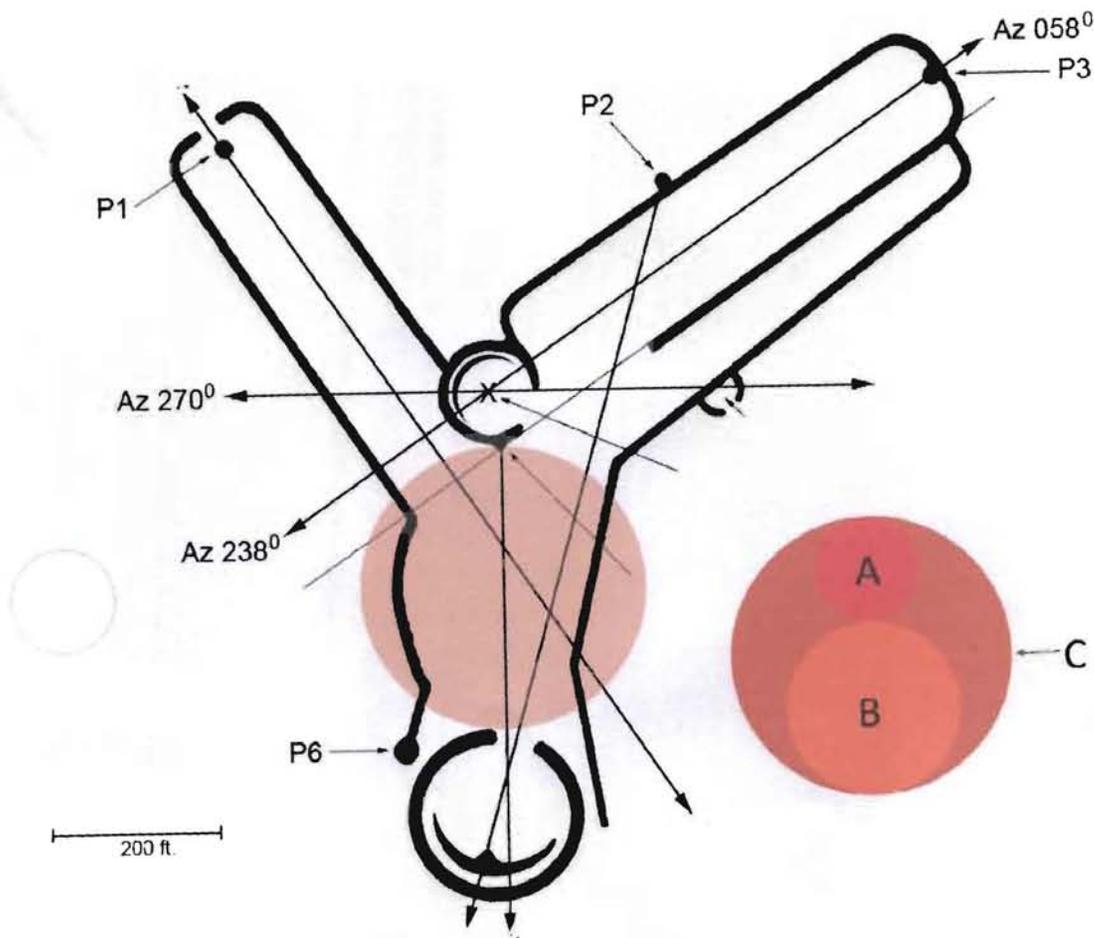


Figure 5 The golden ratio Phi integrated in the site geometry. *Discovery, Ross Hamilton*

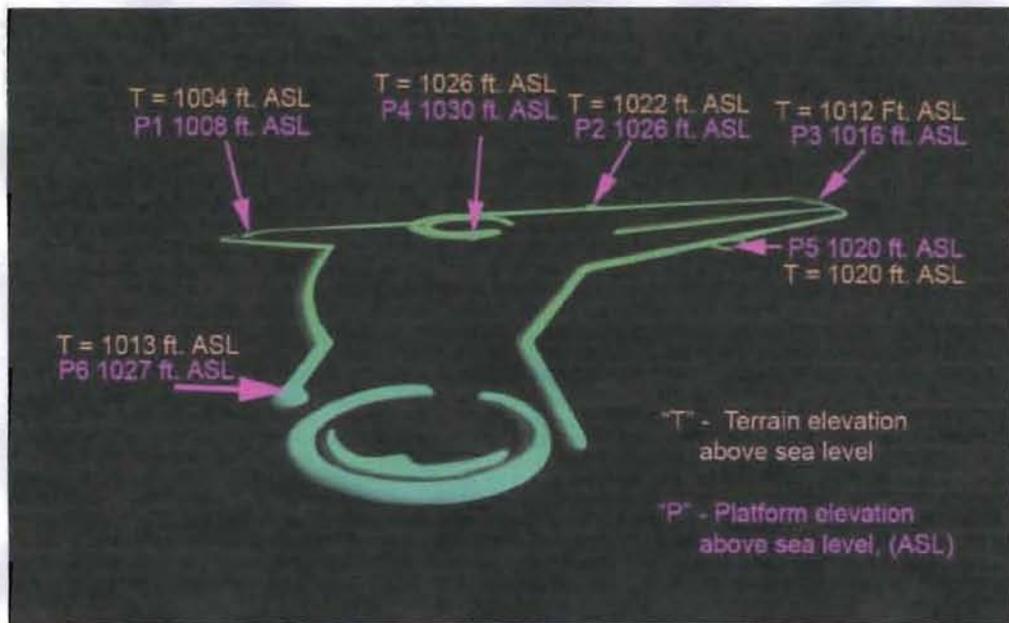


Figure 6 Three dimensional drawing of the earthwork showing terrain and platform elevations above sea level. *Image, R. Moats*

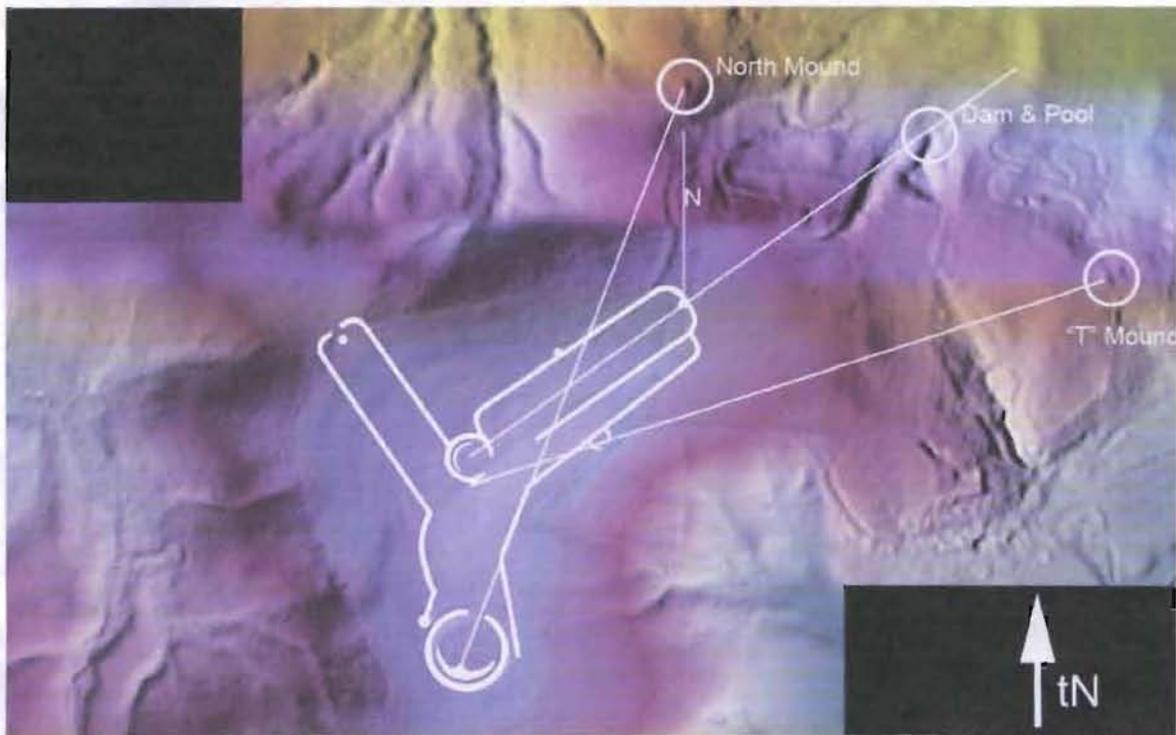


Figure 7 Mosaic LiDAR images showing the earthworks and outlying structures. *LiDAR images W.F.Romain, Interpretation and overlays, R. Moats*



Figure 8 Highlighted "North Mound". *Image, R. Moats*



Figure 9 Highlighted "Pool and Dam". *Image, R. Moats*



Figure 10 Highlighted "T Mound". *Image, R. Moats*

Terrestrial Alignments:

The three outlying structures, the North Mound, Pool, and T Mound, are clearly associated with the large earthwork by their proximity and location on significant azimuths. The North mound likely contains Hopewell burials but has never been excavated. There is no known record of the "T" mound being excavated. Agricultural destruction began before 1860. (*Salisbury 1862*). The Pool has never been investigated and its purpose is not known.

On azimuth 090° east \pm 5° at a distance of 12,672 feet sits a conical mound positioned on a ridge. The base is at a horizon elevation of less than +1° as viewed from the center of P6. (*Figure 11*). Known as the **Roberts Mound**, this feature was excavated in 1904 by W.K. Moorehead. (*Moorehead 1906*). Before excavation, the height of the mound was 27 feet. The current height above ground level is 18 feet as it was left in 1904. Moorehead found an abundance of ash and a partially cremated skeleton in association with an expanded center gorget inside the mound. This association is evidence for this mound being Adena and therefore older than middle to late Hopewell earthworks. The east/west alignment created between P6 and the Roberts mound is evidence for the intentional placement of observation mound P6 to align with the older Roberts Mound on an azimuth of 090°/270°. (*Figure 12*). The azimuth of 090° east is the midpoint between the solstice stand stills and represents the two equinox solar rise points at zero degrees horizon elevation; the vernal around March 21st and the autumnal around September 21st, both \pm 2 days. A study of terrain elevations minus obstructive trees indicates the Roberts Mound was completely visible from observation mound P6. At a height of 27 plus feet, the mound was prominently silhouetted against the eastern sky when viewed from P6.

Archaeoastronomy:

In order to search for archaeoastronomical alignments it was necessary to establish viewing points, sight lines, and horizon elevations. The viewpoints are the "platforms" P1, 2, 3, 4, & 6 and the "C" shaped structure P5. The horizon elevations were calculated for an observer with a ground to eye height of 5.5 feet. The formula is, $\tan A = \frac{VD}{HD}$ where A is the angle of the forward sight line to the horizon, VD means the difference in terrain elevation between the observation elevation plus 5.5 feet and the horizon terrain elevation, and HD means horizontal distance between the observation location and the horizon. The sight lines are all foresight lines from the viewpoints.

The horizon rise and set points were tested in two computer planetarium programs, Winstar™ and Stellarium™. Calibrations were made for each observation location elevation and horizon elevation and for the year 250 AD. These programs correct for Delta T, refraction, and precession.

With the earthwork being largely destroyed, possible errors in linear measurements, translation, methods, and registration of the overlays during the reconstruction process,



Figure 11 The Roberts Mound, winter 2010. *Image, R. Moats*

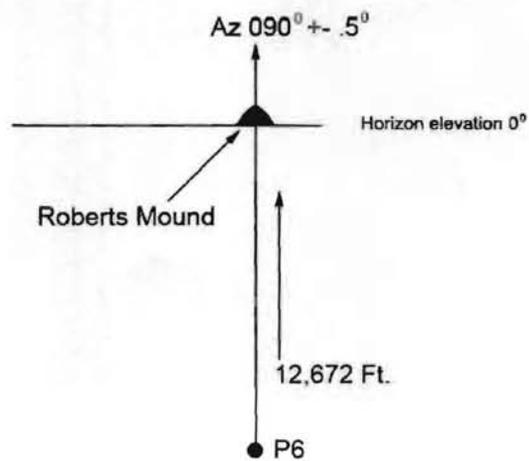


Figure 12 Plot showing alignment of P6 with the distant Roberts Mound. *Image, R. Moats*

the margin for error in the alignments is estimated at $\pm 1^\circ$ for azimuths and $\pm .5^\circ$ for elevations. Assuming the focus of the observer was on the visual illusions created by celestial body rises and sets in relationship to the earthwork and not precise astronomical measurements, the tolerances noted are well within acceptable limits. Solar, lunar, visible planets, and the constellation of Orion rise and set points were observed. Solar alignments are illustrated in *figure 13* and lunar alignments are illustrated in *figure 14*.

The **Central Circle** was an open enclosure with an internal crescent. Its position was the center of the geometric structure and at the highest terrain elevation of all other features. The angle of view elevation from P1 to the top of the central circle is $+3^\circ$. When viewed from P1, azimuths of 118° and 133° intersect with the perimeter of the circle and coincide with the minimum and maximum lunar south rise points at $+3^\circ$ horizon elevation. From platform P3, azimuths 229° and 244° , the minimum and maximum lunar south set points at $+1^\circ$ elevation, also intersect the perimeters of the central circle. This suggests the distances of P1 and P3 from the central circle were established based on the rise and set points of the moon. When viewed from above, the effigy inside the central circle appears to represent a crescent moon or a crescent formed by an eclipse of the moon or sun.

Maximum north risings of the sun and moon were viewed from P4 and possibly from the center of the central circle. When **sun** rise occurred on Az 057.5° , upper limb tangent to 058.2° lower limb tangent at zero degrees horizon elevation, it was the longest day of the year, the **Summer Solstice**. The parallel walls and midline of the north east causeway align with azimuth $058^\circ/238^\circ$. The illusion, as viewed from P4, was the sun rising in alignment with the south wall of the east causeway. (*Figure 15*). If the viewpoint was from the center of the central circle, the sun appeared to rise over the middle of the end of the causeway and platform P3. (*Figure 16*).

The moon would occasionally rise within the 10° view angle of the end of the causeway when viewed from the center of the central circle. The lunar orbit is constantly changing due to the Metonic cycle. Once every 18.6 years, the moon would rise at Az 053° when viewed from P4. When rising at this maximum north rise point, the moon would rise over P3 at the middle end of the east causeway. (*Figure 17*). This azimuth is the standstill of the lunar orbit to the north, the **North Lunistice**.

Maximum South Risings of the sun and moon were viewed from P1. The intersection of the ecliptic plane at maximum south at a zero degree horizon elevation is Az 121° . When the sun rises at this maximum south rise point it is the **Winter Solstice**. With a horizon elevation of $+3^\circ$ as viewed from P1, the maximum south rise point becomes Az 124° , the top center of the central circle. When viewed from P1 and sighting along Azimuth 124° at a $+3^\circ$ horizon elevation, the sun appeared to rise out of the central circle on Winter Solstice morning. (*Figure 18*).

With a viewing angle of 15° between the perimeters of the central circle when viewed from P1, the **moon** appeared to rise out of the circle between Az 118° and Az 133° on many occasions during the year. The southern most rise point, the **South Lunistice**,

Solar Alignments

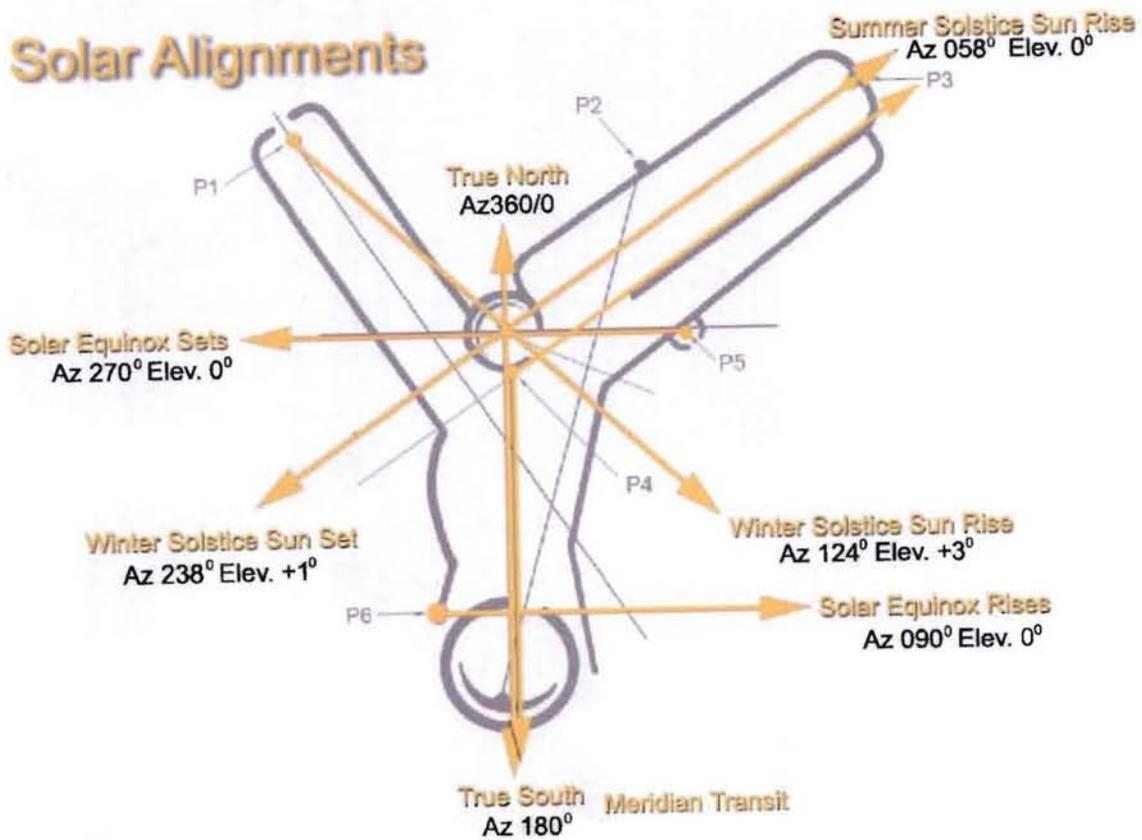


Figure 13 Plot showing solar alignments of the site. Image, R. Moats

Lunar Alignments

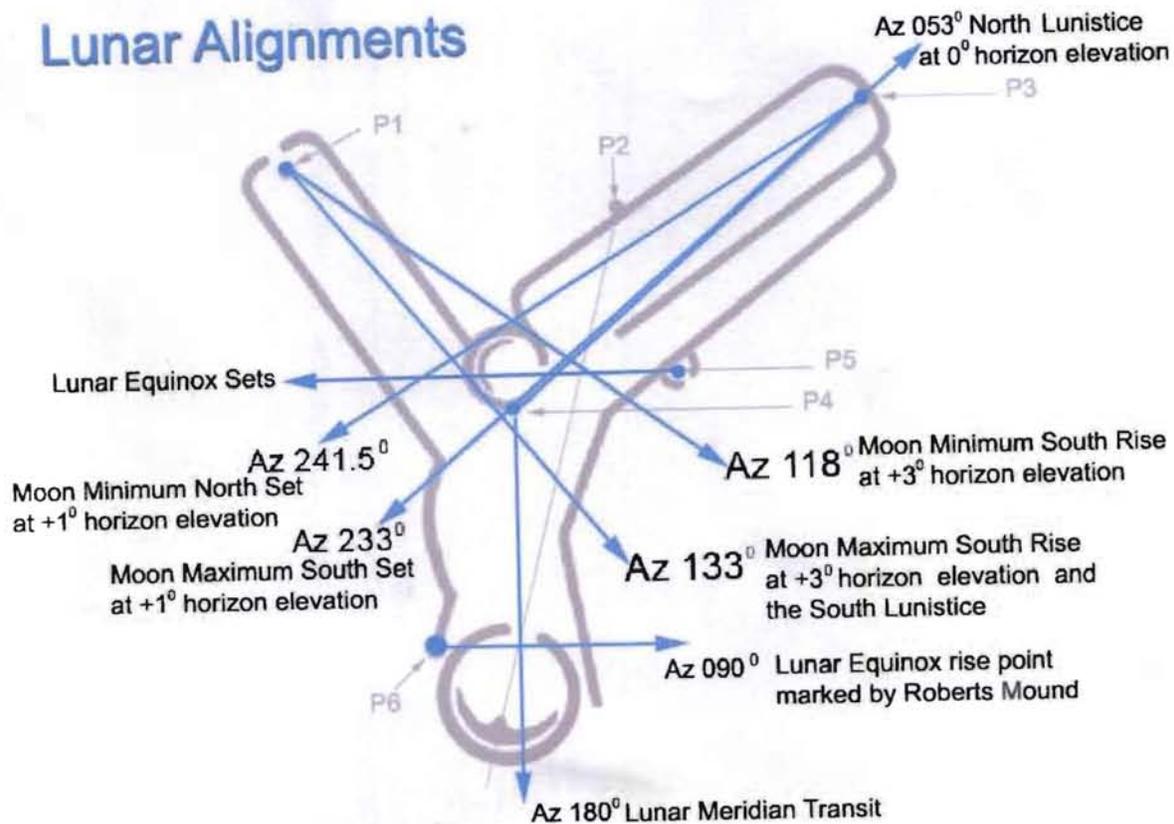


Figure 14 Plot showing lunar alignments of the site. Image, R. Moats

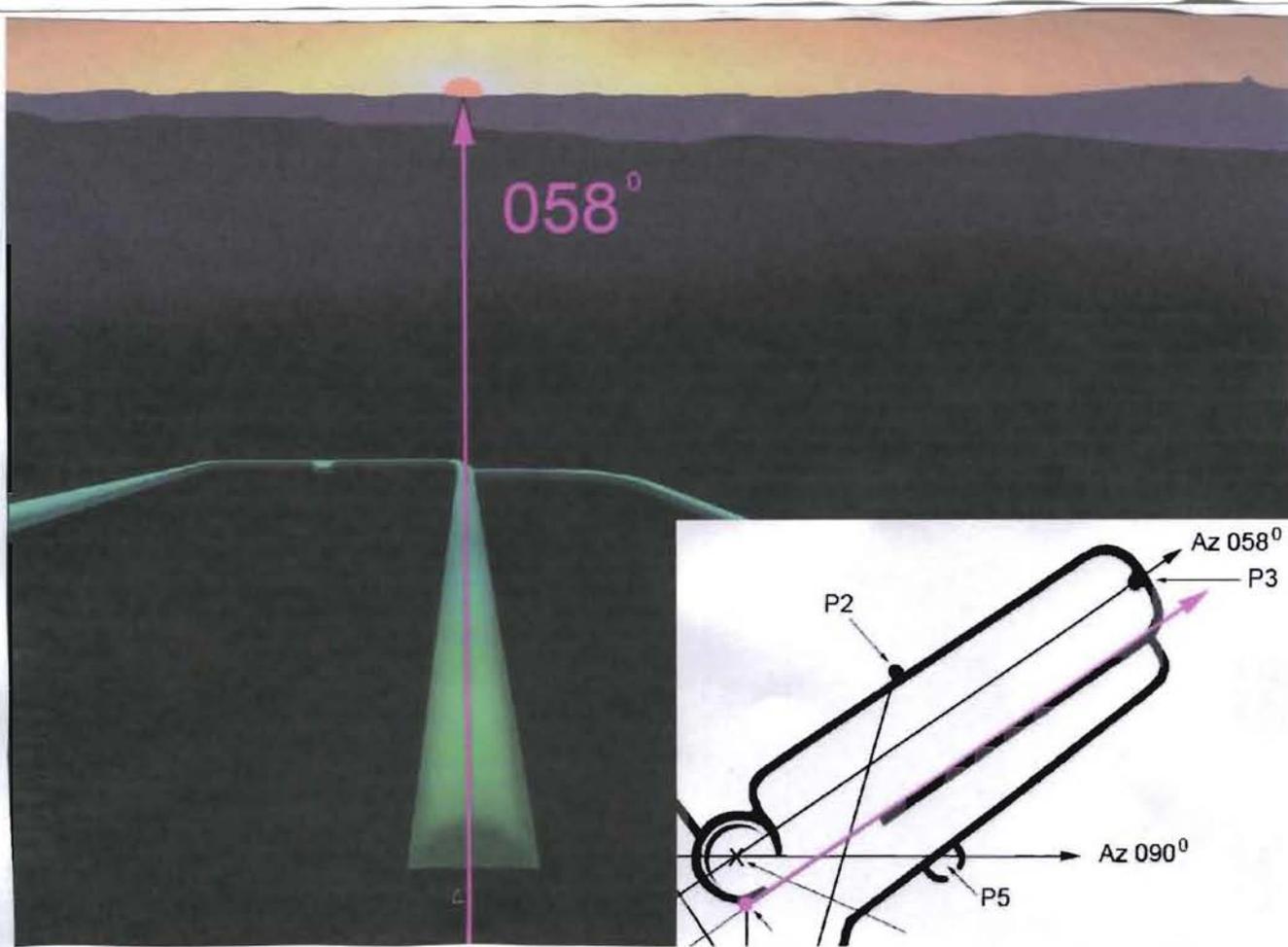


Figure 15 Summer Solstice Sunrise from P4 in alignment with the south wall of the east enclosure. *Image, R. Moats*

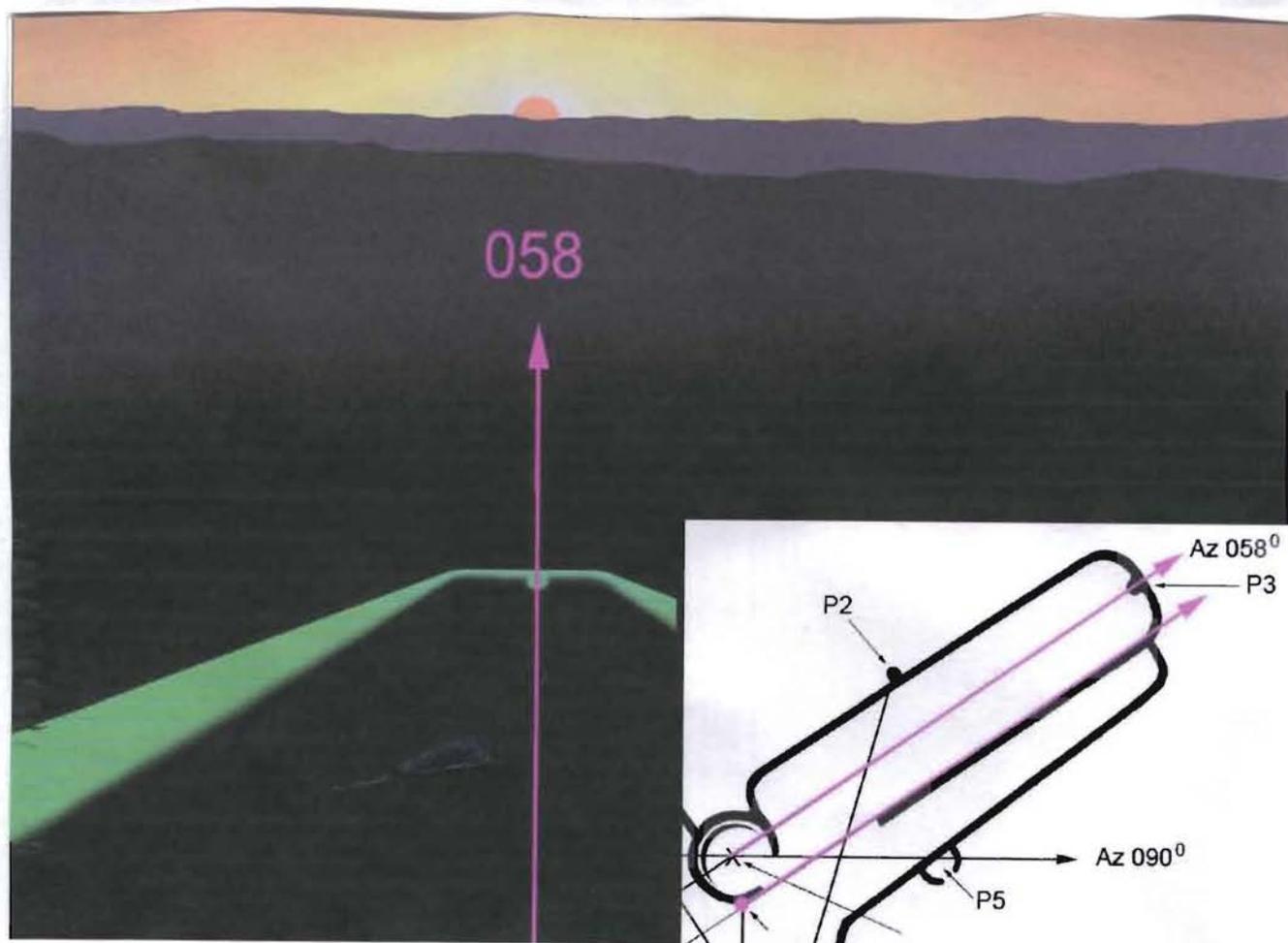


Figure 16 Summer Solstice Sunrise from the center of the central circle sighting down the midline of the east enclosure. *Image, R. Moats*

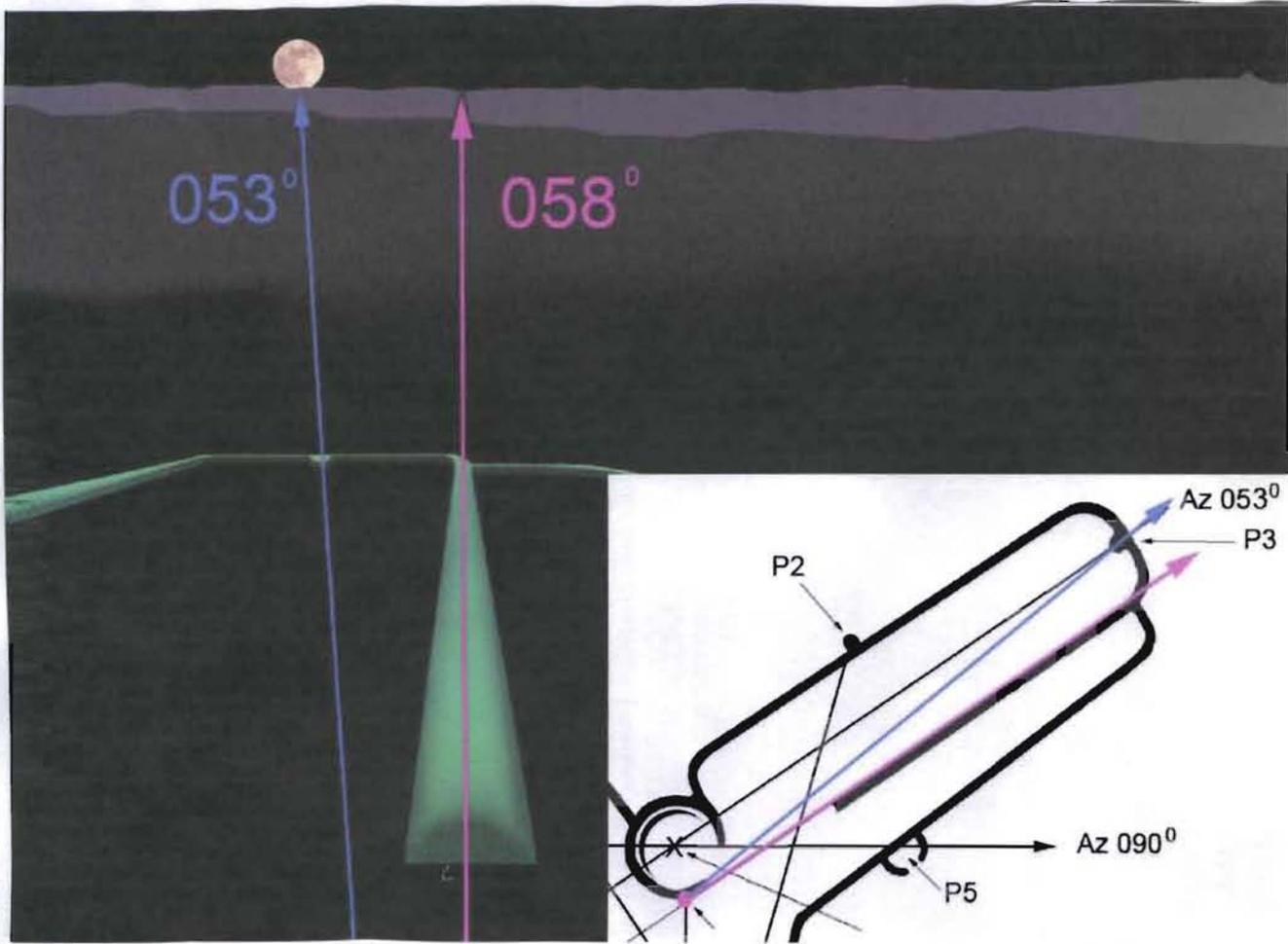


Figure 17 The Northern Lunistic at maximum north rise viewed from P4. *Image, R. Moats*

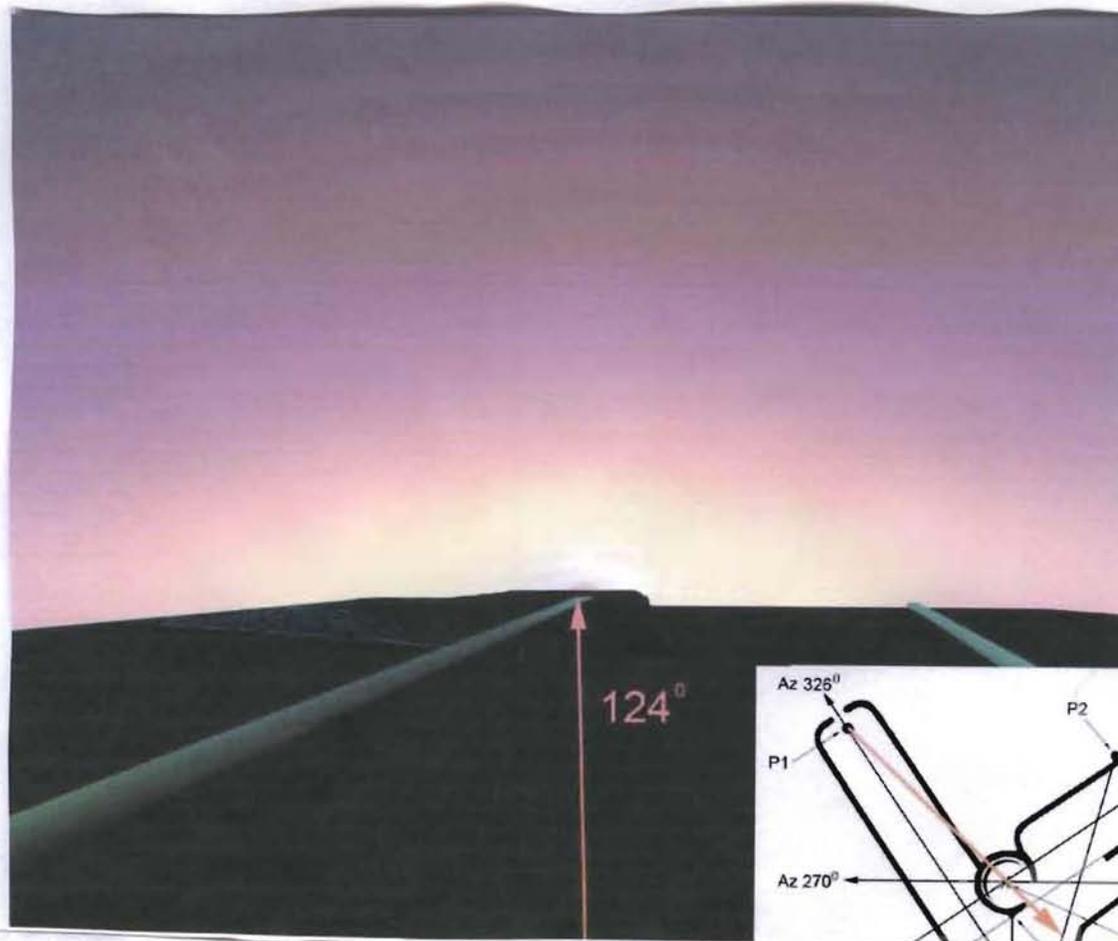


Figure 18 Winter Solstice sunrise out of the central circle as viewed from P1. *Image, R. Moats*

placed the moon rise at 133° at +3° horizon elevation. The South Lunistic moon therefore appeared to rise from the right rim of the central circle when viewed from P1. (*Figure 19*). At other times in the Metonic cycle the moon would appear over the **large circle** during transit at its lowest elevation in the south at +20° when viewed from P2. This was a dramatic difference from its highest orbital path of nearly directly overhead. When the moon was viewed at this low angle from P2, a fire on the central bulge of the internal crescent could cause smoke to rise and cross the lunar disk. Ash was reported at this location by Moorehead in 1896. (*Figure 20*).

On **Winter Solstice mid-day**, the ecliptic plane is at its lowest elevation on the southern horizon at +26.5°. On this shortest day of the year, when the sight line was along Az 180° at -1° horizon elevation from P4 and the **sun** was viewed to be directly above the large circle. This was the precise moment of the winter solstice, the **meridian transit** of the sun. (*Figure 21*). As with the moon transiting above the large circle when at its lowest elevation, a fire on the bulge in the internal crescent could send smoke over the solar disk.

It appears as if parts of the earthwork were truncated on the west end of the southeast walls so a viewer standing on P2 could see over the near terrain and into the large circle on a zero degree horizon elevation sight line. This sight line from P2 through the center of the opening passes through the center of the circle and is in alignment with the central bulge in the internal crescent on azimuth 197°. (*Figure 22*).

Maximum South Settings were viewed from P3 and sighting along Az 238°. This sight line passes through the center of the central circle at a horizon elevation of +1° at the top center of the central circle. The view angle for the perimeters of the circle is a narrow 7.5 degrees; ½ the angle when viewed from P1. From the perspective of P3, the sun appeared to set into the center of the central circle on winter solstice evening on Az 238° at +1° elevation, lower limb tangent contact. (*Figure 23*).

The maximum and minimum south set points of the lunar cycle are between Az 229° and Az 244° respectively. From P3 and sighting along the midline of the causeway on Az 238°, the **moon** would be frequently observed to set into the central circle. When setting on Az 229°, the southern perimeter of the central circle, it was the **South Lunistic** set.

Equinox Rises were viewed from P6 along Az 090°. There are two equinox sunrises in a year, the vernal around March 21st and the autumnal around September 21st, both ± 2 days. When viewed from P6, on or close to these dates, the sun rose behind the distant Roberts Mound 12,672 feet across the valley. This created a spectacular illusion. The Roberts Mound was silhouetted against the solar disk and the sun appeared to sit on top of the mound at the midpoint in the solar cycle. Because of the angle of ascension of the sun along the ecliptic plane, any alignment placing the sun at exactly the right point to create the illusion had to occur shortly after the actual vernal or shortly before the actual autumnal equinoxes. This strongly suggests the Roberts Mound was used as a marker for the midpoint between the solar standstills. The illusion of the sun behind the Roberts

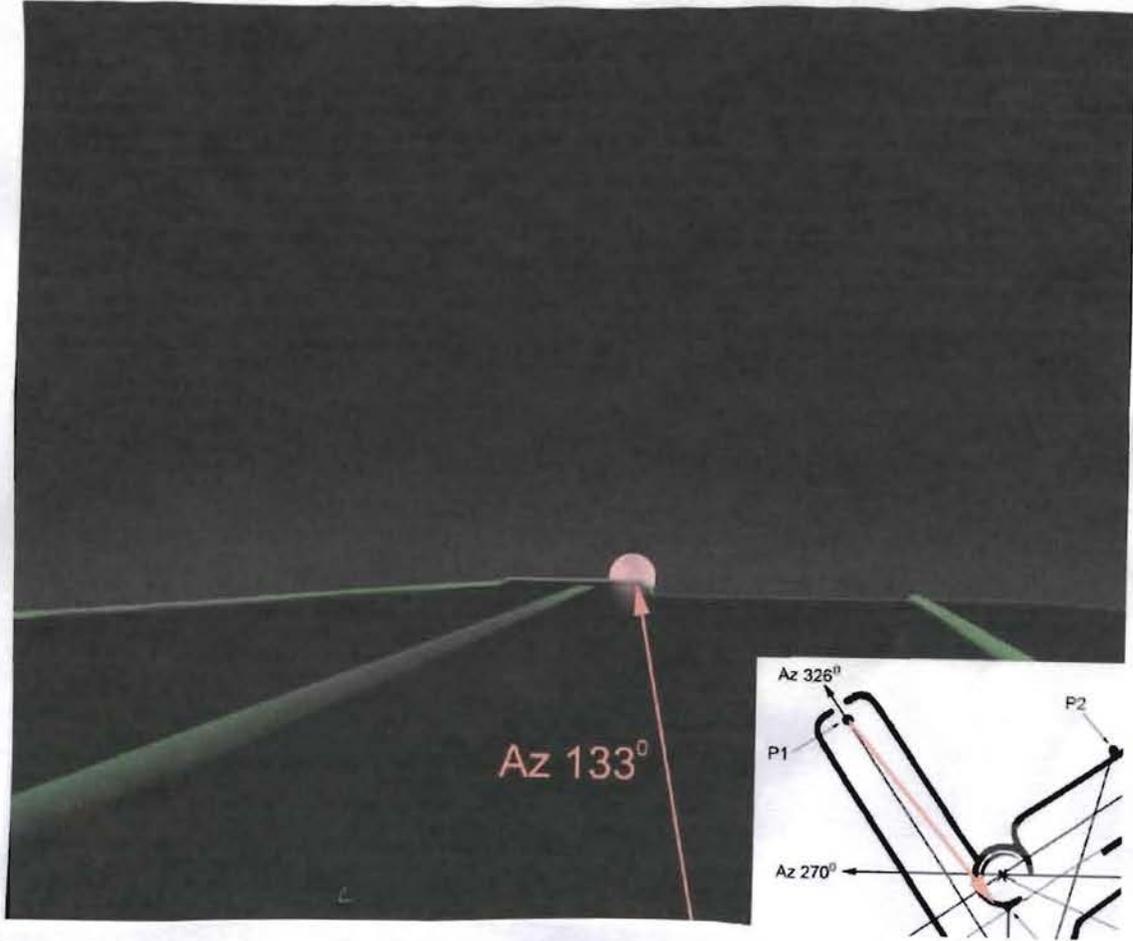


Figure 19 The moon rising from the central circle at Southern Lunistice as viewed from P1.

Image, R. Moats

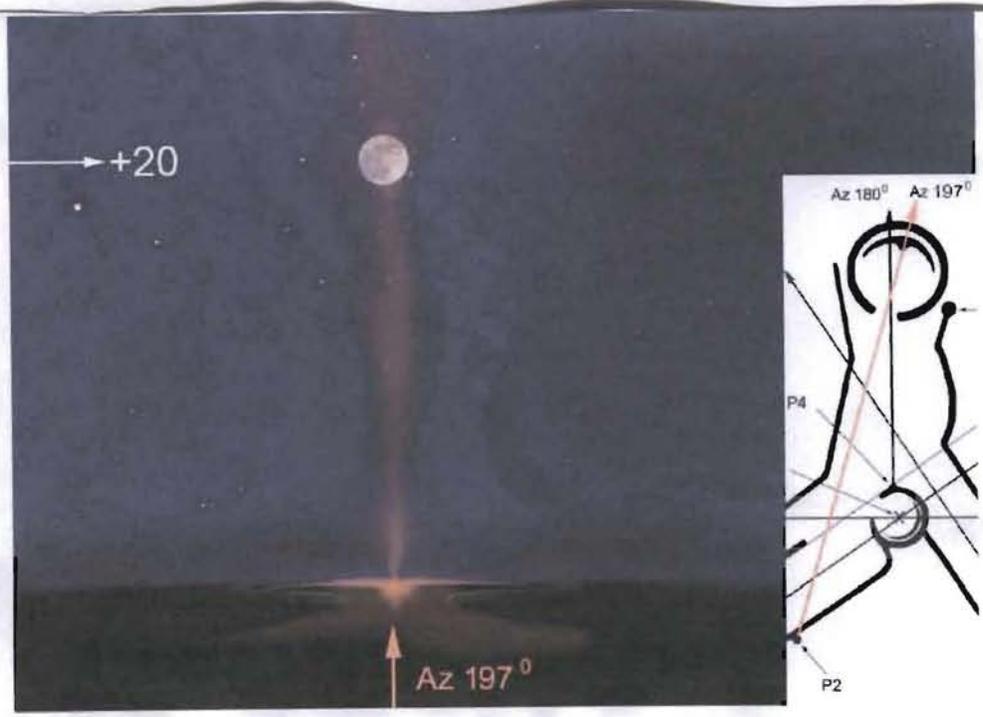


Figure 20 The moon over the large circle when at its lowest median transit altitude in the metonic cycle as viewed from P2. Smoke from a fire intersects with the lunar disk. *Image, R. Moats*



Figure 21 Sighting along azimuth 180° from P4, the sun is directly over the large circle at the moment of meridian transit, the Winter Solstice. *Image R. Moats*

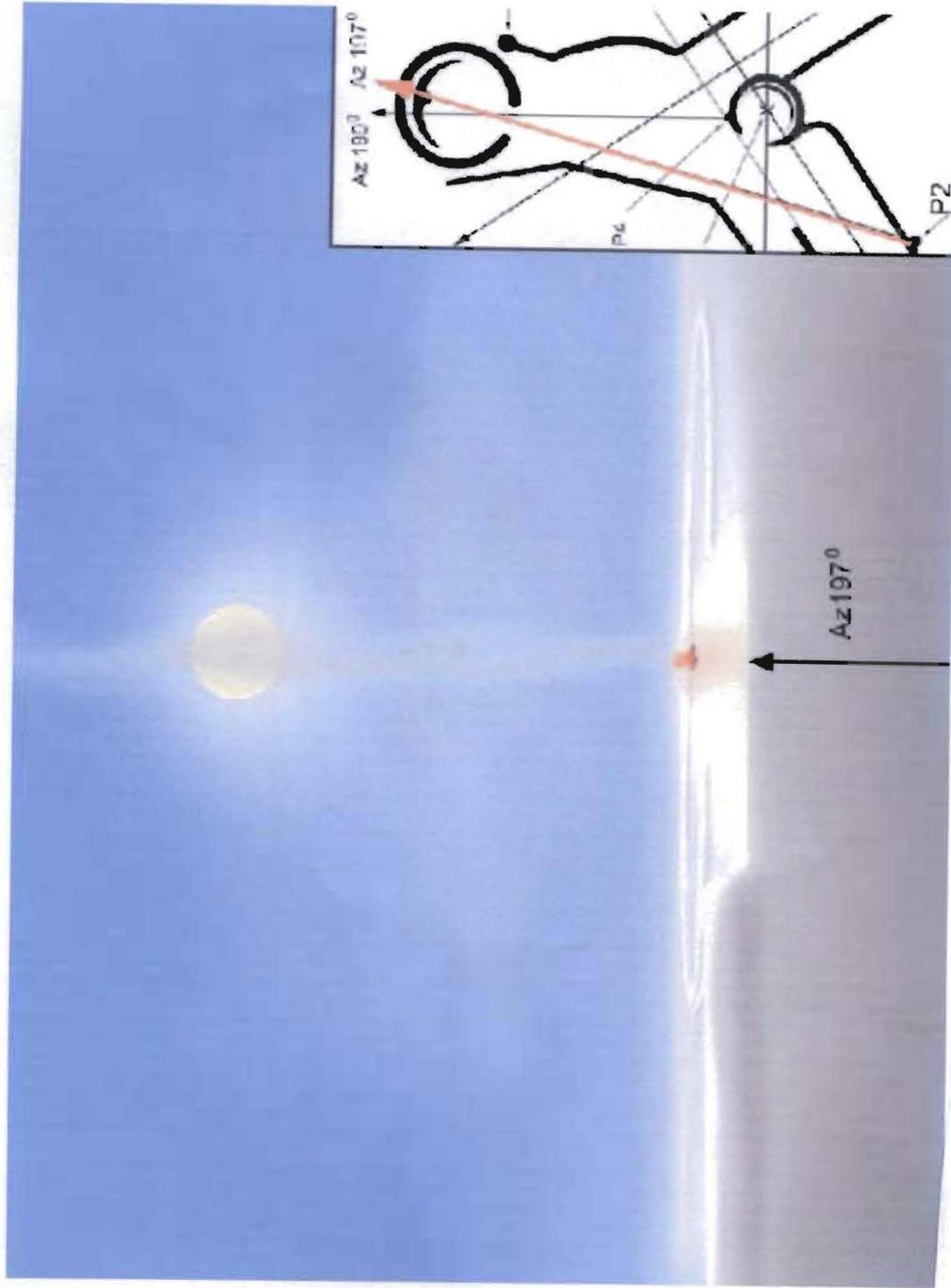


Figure 22 Sighting from P2 on azimuth 197°, the sun is suspended above the circle at midday of the Winter Solstice at 26° elevation. Smoke from a fire covers the sun.

Image, R. Moats

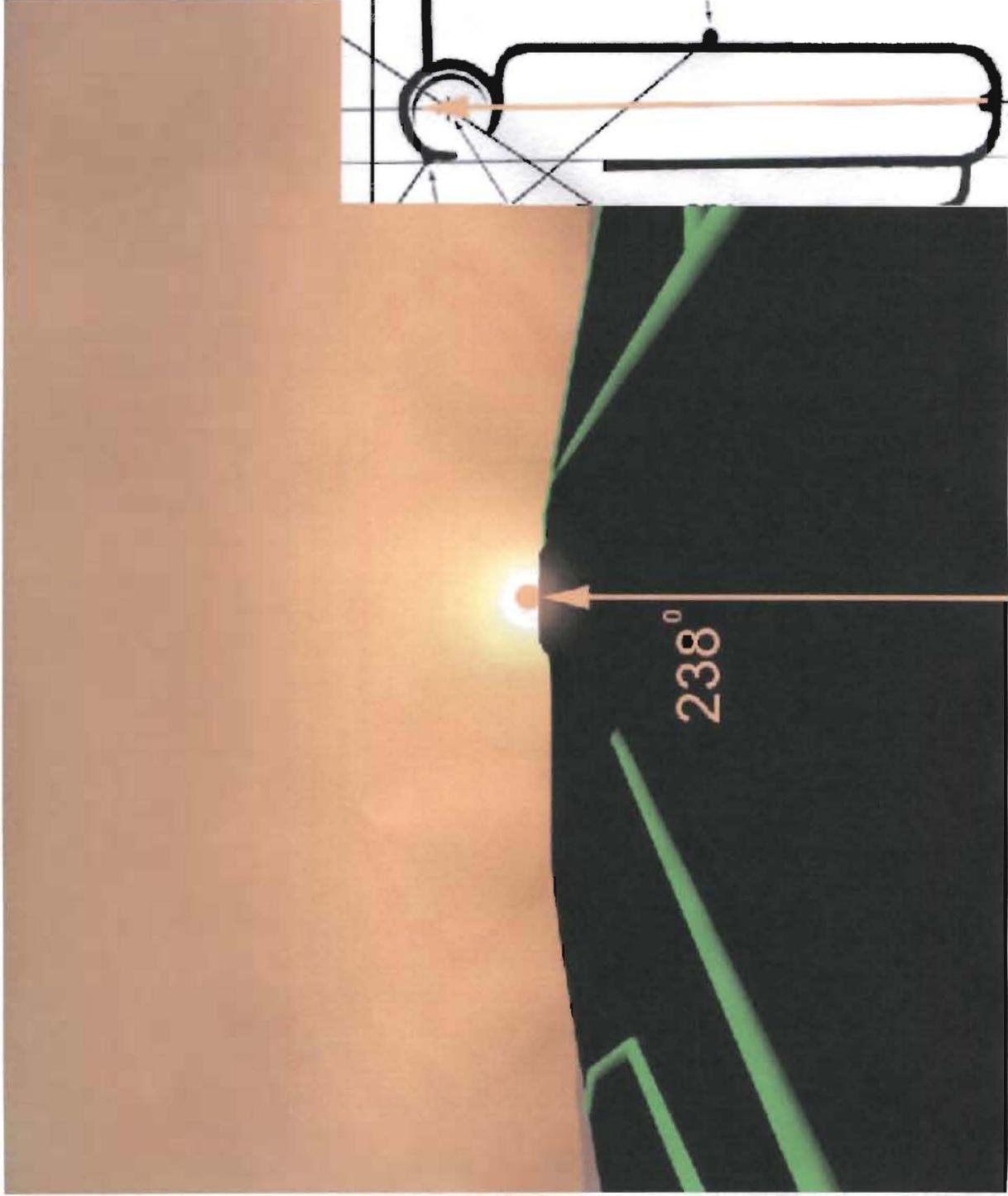


Figure 23 The sun setting into the central circle on Winter Solstice evening when viewed from P3. *Image, R. Moats*

mound with the apex of the mound overlapping the lower limb of the solar disk appears to be replicated in earth in the interior of the large circle. (*Figure 24*).

Lunar rises could also provide a similar illusion involving the distant mound. However, because of the required timing, and ever changing lunar orbit, a lunar alignment behind Roberts mound was very rare. A crescent moon aligning behind the mound could only occur when the sun was below the horizon and close to Az 090. If the crescent was tilted to the right of the observer then the sun had to be below the horizon and to the left of Az 090. The moon had to rise before sunrise on this same day between Az088 and Az089 for the apex of the mound to create the bulge in the central part of the crescent. The rarity of this precise alignment may have in itself been the motivation for the analog of the illusion inside the large circle. One such alignment occurred early in the morning of October 12th, in the year 255. This precise alignment may only occur one time every 18.6 years.

Given the constraints and possibilities, although it appears the effigy inside the large circle replicates a crescent sun or moon rising behind the Roberts Mound, it is more likely the analog is the illusion of the solar disk rising behind the mound two times per year. The comparative frequencies weigh in favor of the analog of a solar alignment. A partial eclipse causing a solar or lunar crescent causing the illusion is highly unlikely because of the extreme infrequency. The form of a crescent with a central bulge inside an earthen circular enclosure is very rare and this may be the only one of its kind. (*Figure 25*).

Equinox Sets occur on Az 270° at zero degrees horizon elevation. Feature P5, the “C” shaped enclosure on the south wall, is on Az 090°/270° in relation to the central circle. A viewer standing in this enclosure and sighting west along Az 270° would see the top of the central circle on the near horizon at an elevation of +1°. The angle of view between the perimeters of the central circle from P5 is 20°. On the evening of an equinox, the sun sets at Az 270°. The illusion from P5 was the sun setting into the central circle. The moon was often viewed to set into the central circle when the observer was inside P5. On some occasions, when the moons orbital path was close to the ecliptic plane around equinox times, the moon would appear to follow the sun into the circle. (*Figure 26*). At these times, the sun and moon were both observed setting into the central circle relatively close together when viewed from either P3 or P5. The interval between these coincidental settings could not be observed if the interval was short due to the light of the sun masking the moon.

The **ecliptic plane angle** is 17° right of vertical when viewed on azimuth 090° at autumnal equinox sunrise. (*Figure 27*). This angle of the ecliptic plane at 17° from vertical occurs again in the evening of the vernal equinox. (*Figure 28*). The angle of the centerline of the large circle opening from true north is also 17°. This centerline coincides with the foresight line from P2 into the central circle. (*Figure 29*). This strongly suggests the builders of the site understood the ecliptic plane and placed the position of P2 in relationship to the effigy to replicate the angle of the ecliptic plane at the two mentioned solar equinox times.

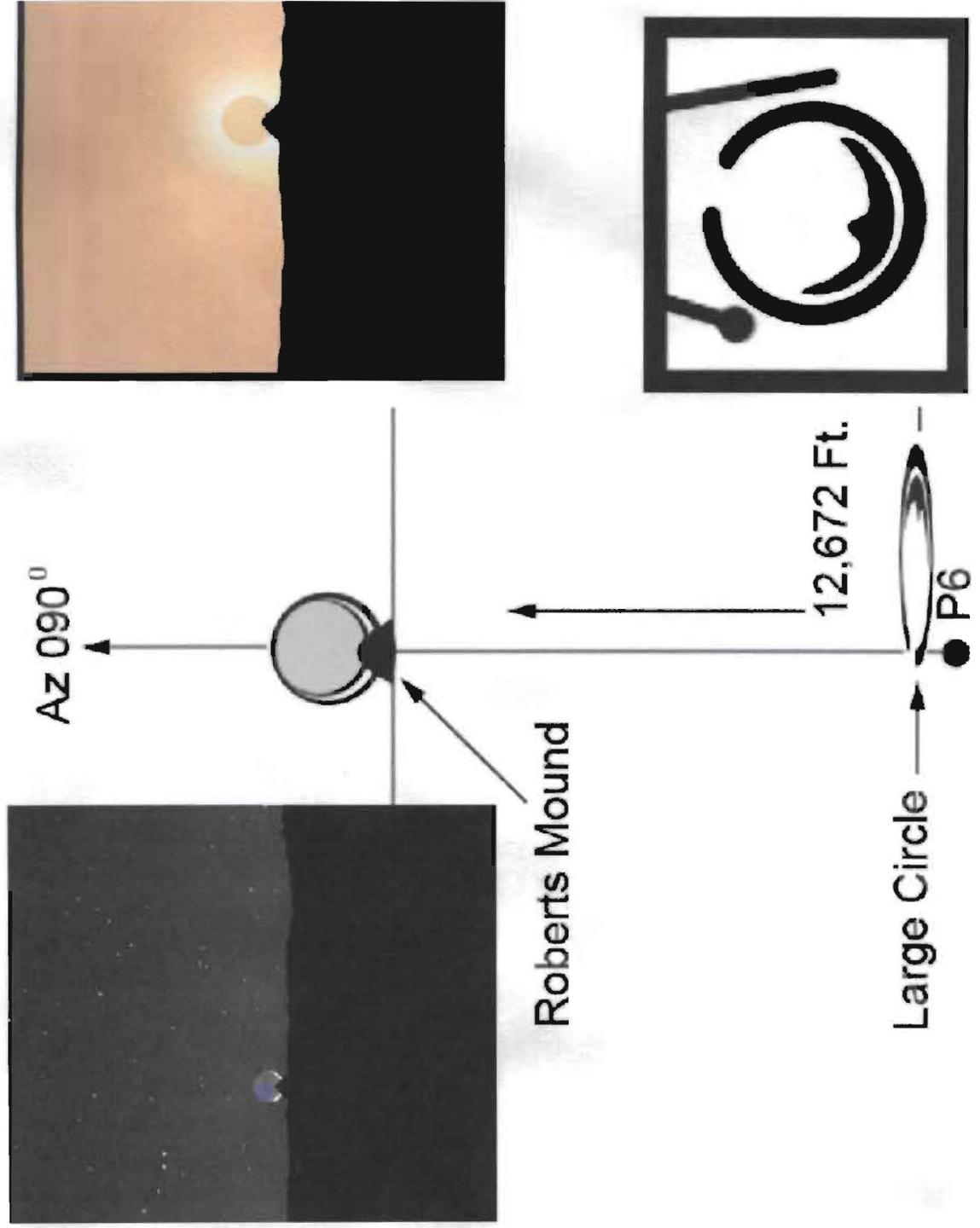


Figure 24 The illusions caused by the moon and sun rising behind the Roberts Mound.
Image, R. Moats

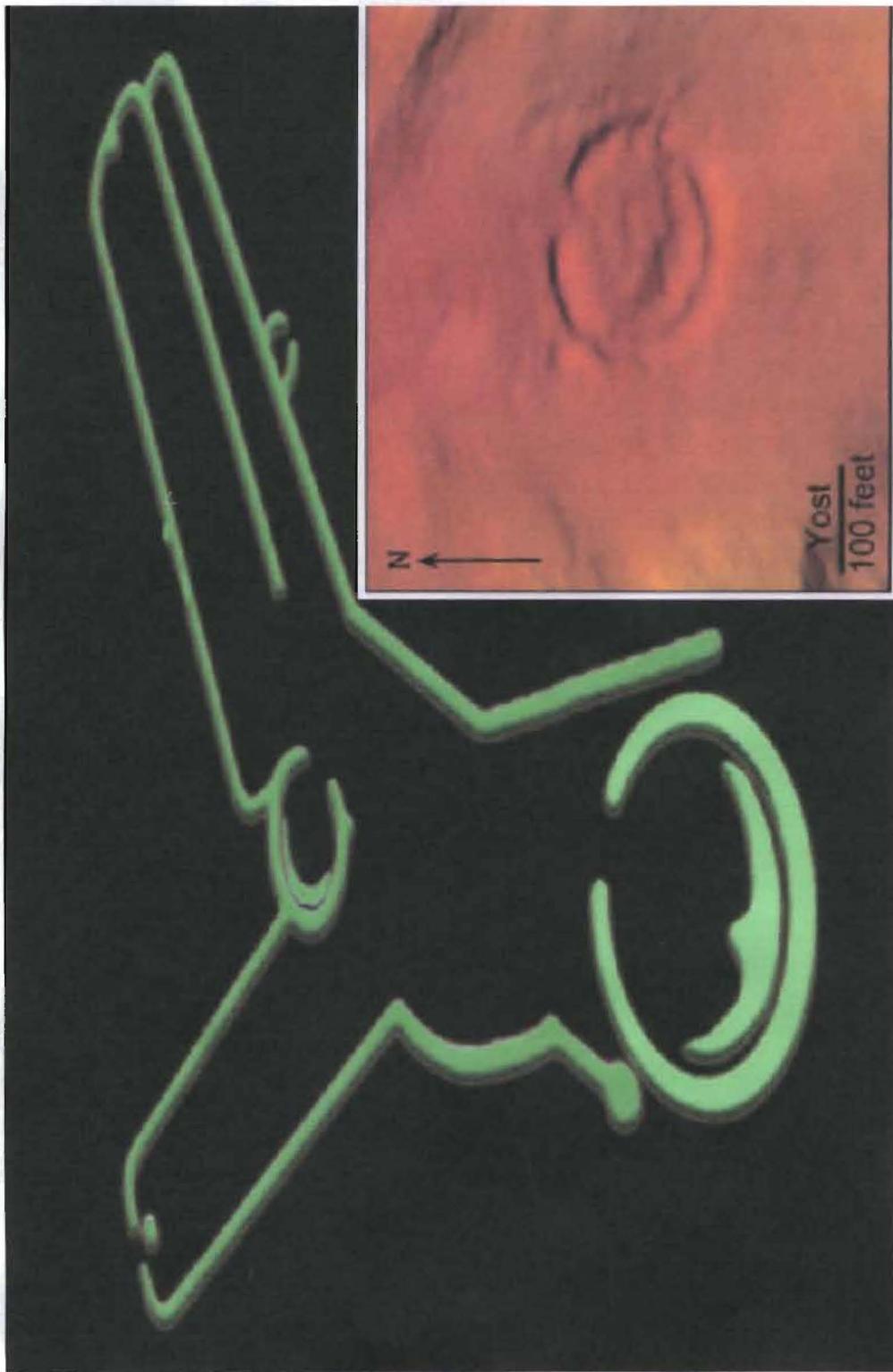


Figure 25 An oblique view of the earthwork and a LiDAR image of the large circle.
Image, R. Moats, LiDAR image, W.F. Romain

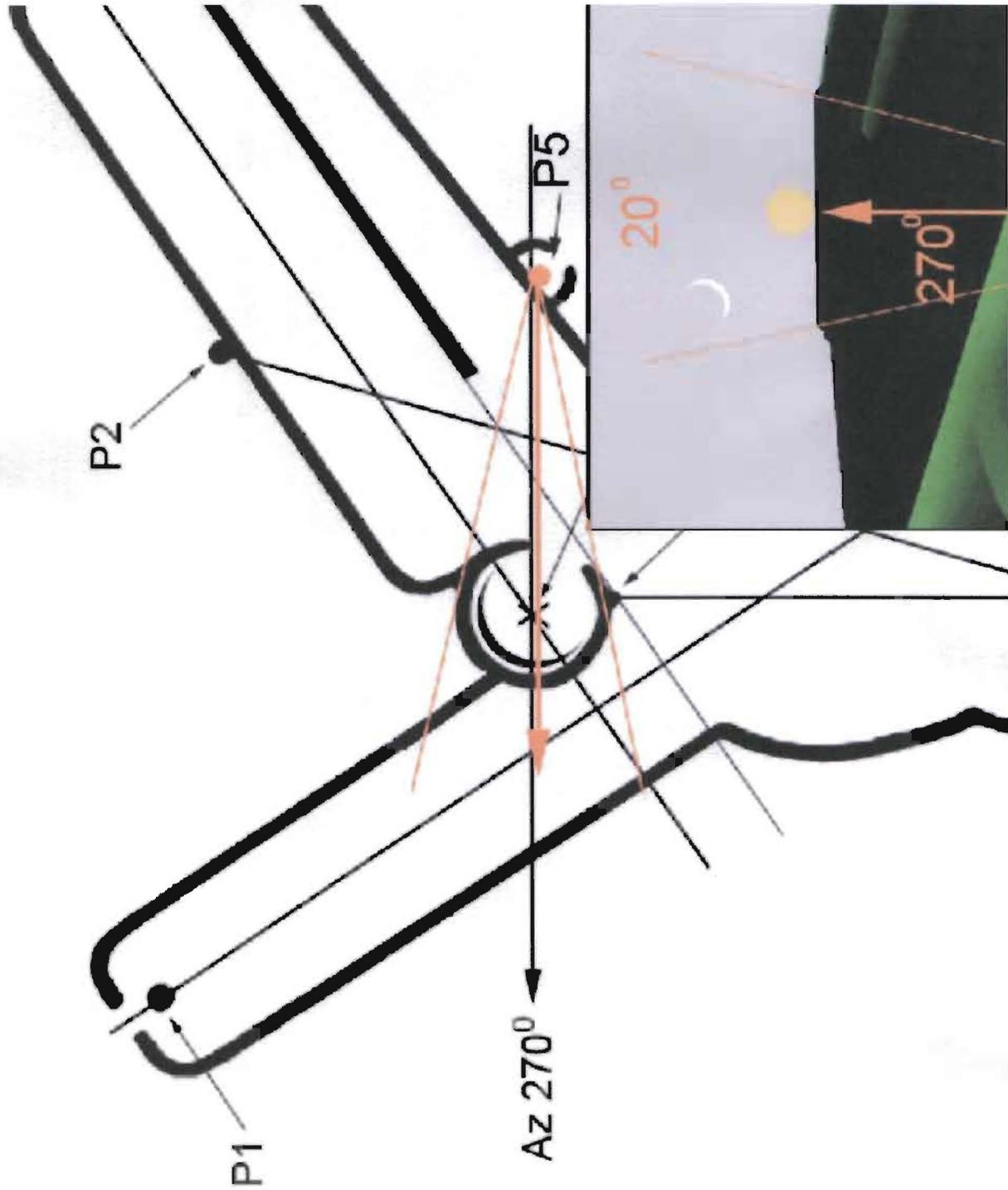


Figure 26 Illustration of the sun and/or moon setting into the central circle around the times of equinox when viewed from P5. Image, R. Moats

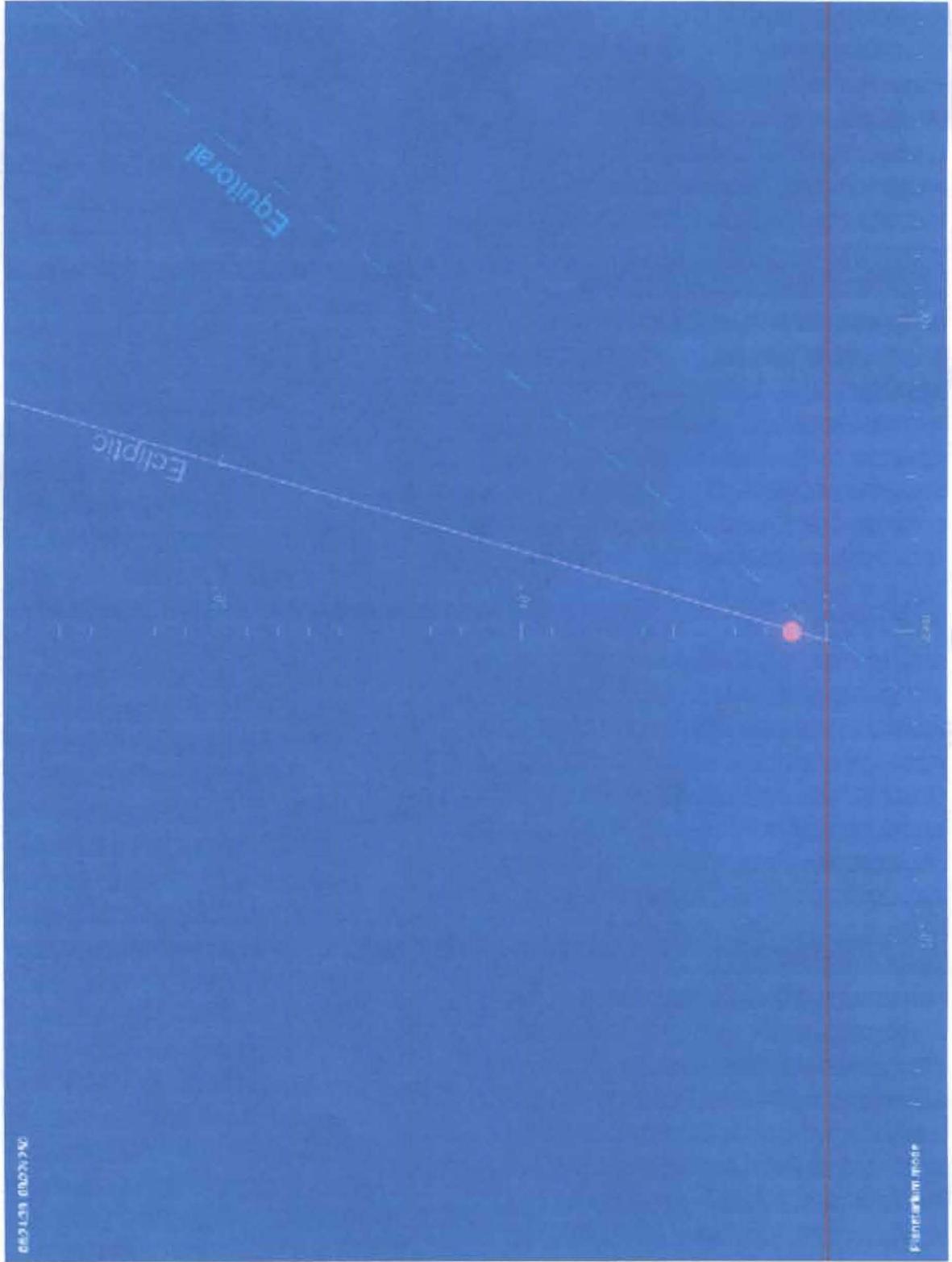


Figure 27 A screen shot showing the ecliptic and equatorial planes at the time of autumnal equinox sun rise in the year 250. *Image, Winstars™*

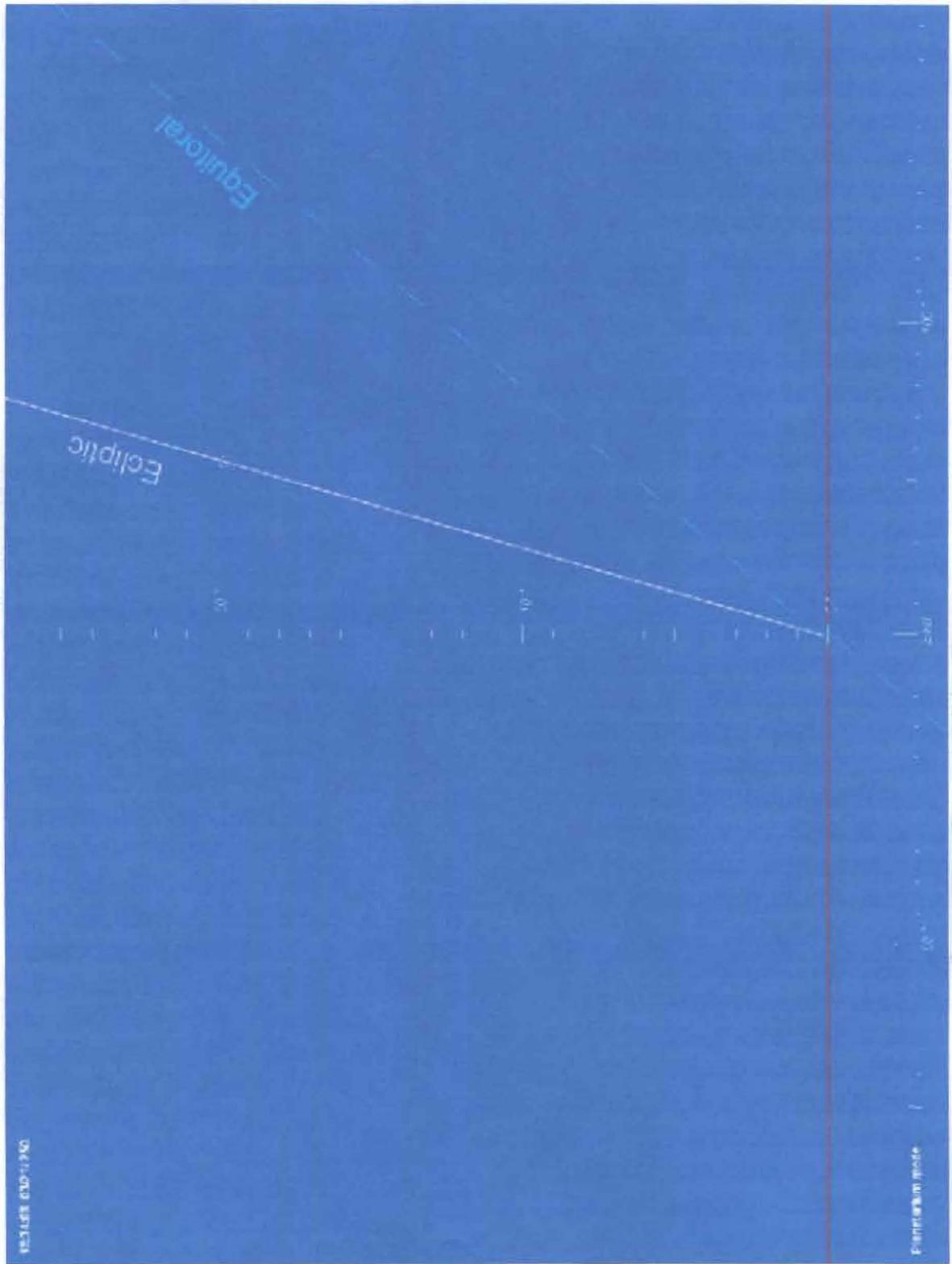


Figure 28 A screen shot of the ecliptic and equatorial planes at the time of vernal equinox
sun set in the evening of the year 250. *Image, Winstars™*

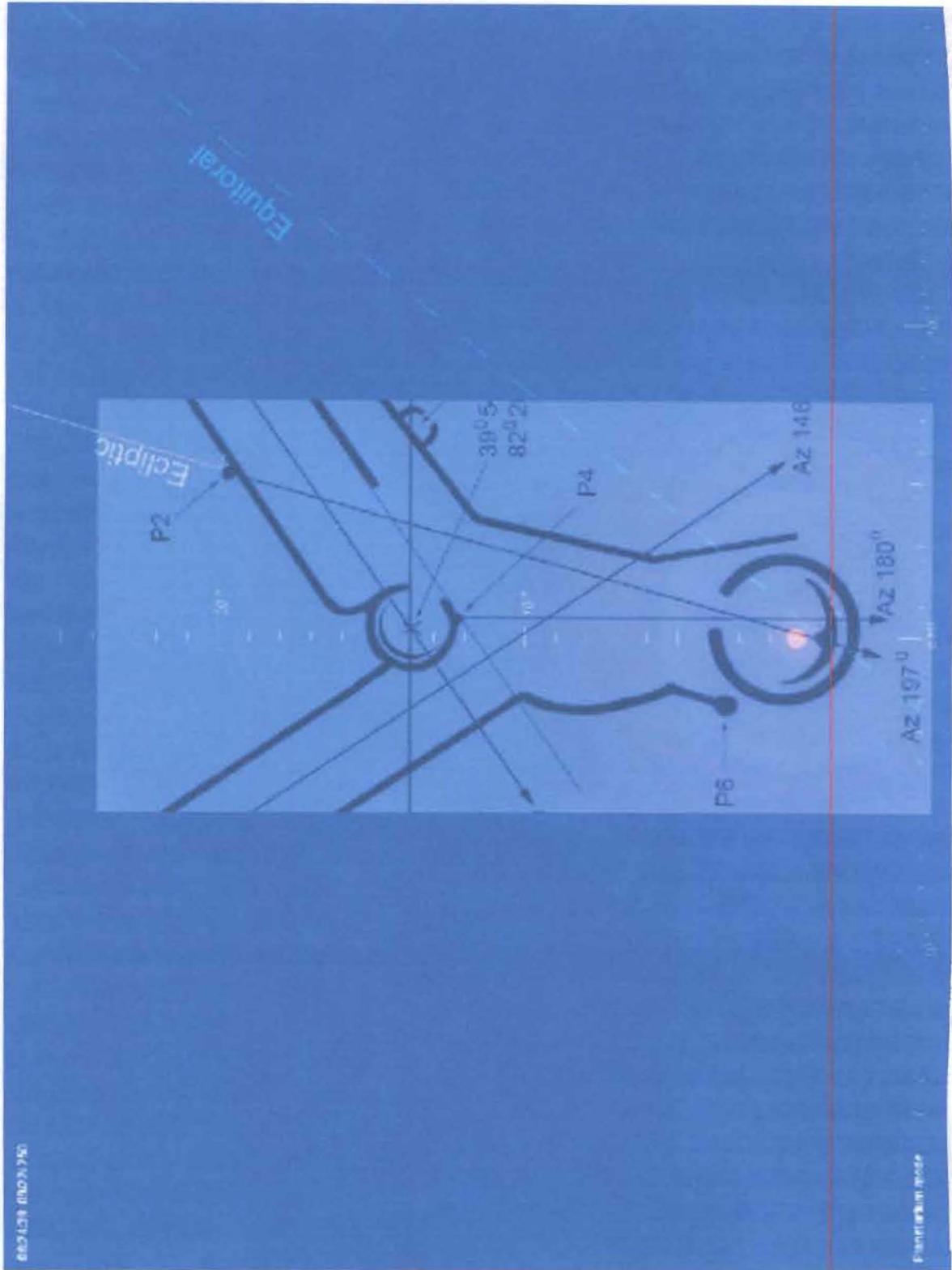


Figure 29 The site plot map is overlaid onto screen shots 26 and 27 showing the coincidence of the P2 sightline at Az017° with the angle of deviation of the ecliptic plane at equinox times. *Image, Winstars™ and R. Moats*

Planets, Stars, and Constellations could have been observed and monitored similar to the risings and settings of the sun and moon. The orbits of the visible planets are closely aligned with the ecliptic plane. The rise and set points for the planets could therefore be nearly the same as for the sun at any time of the year. The planets have longer periods than the sun or moon and would therefore be observed over a longer period of time, perhaps months or even years as in the case of Mars and Venus. Several bright stars such as Procyon, Betelgeuse, Sirius, Spika, and Rigel were viewed to rise from behind the mound at least one time per year. Any constellation aligning with the earthworks may be due to coincidence. However, a bright planet, star, or constellation rising or setting in apparent alignment with the burial mound or earthwork is likely to have carried great meaning. Any bright celestial body interpreted as rising out of the Roberts mound, when viewed from P6, would have had great significance. Since the mound was perceived as an ancestral burial site, the importance placed on a celestial body rising out of the mound, could have been consistent with a belief system involving burial practices, the movement of ancestral spirits, and life after death beliefs.

Around the time of winter solstice, the winter constellation of Orion appears to rise from the center of the west causeway when viewed from P1. Later in the night, when viewed from P4, Orion is directly above the large circle. In the early morning hours, Orion appears over the center of the east causeway when viewed from P3. And just before morning light, the three stars forming the belt of Orion appear to set into the central circle when viewed from P5.

Summary and Interpretation:

Considering the intricate construction, precise orientation, and the three dimensional properties which were necessary to achieve the alignments demonstrated, it is my conclusion that this site was a unique Hopewell Celestial Observatory. The site was used to observe the yearly and long period cycles of celestial objects. The visual illusions of the sun, moon, bright planets and constellation risings and settings in relationship to the earthwork and a distant burial mound was the function of the structure. The significance attached to these illusions and the associated practices are much more problematic to determine.

Construction of this earthwork required time, people, and knowledge. The time necessary for construction required multiple people following the directions of one or more individuals who had knowledge regarding the cycles of celestial bodies. The motivation required for so many to work toward a common goal had to be rooted in a common belief system. It is the belief system that motivated the work force to perform the construction at the direction of the knowledgeable elite.

The belief system is manifest in the structure. The significance of each observation and illusion related to the belief system. The predictability and reoccurrence of events from year to year and over long periods validated the belief system, reinforced the power of the

elite, and afforded assurance of a continuation of the cycles. Understanding of the belief system must then be based on interpretation of the visual illusions seen by the observers.

The key knowledge to build such a structure was based in mathematics, geometry, and determining the minimum and maximum north and south intersections of the ecliptic plane with the horizon in both the east and west. The incorporation of third dimension elevations complicated construction but was obviously done successfully and elegantly. Knowledge of the solar and lunar rise and set points and comprehension of the ecliptic plain could have been determined by long term observations. The knowledge required to build this three dimensional structure with all the inherent celestial alignments had to be in place prior to building the site. Experimentation with massive amounts of earth moving is not plausible. Because observations of the sun and moon needed to occur over at least 18.6 years, the knowledge base necessary for construction of this site was most likely came from outside the immediate chiefdom.

The placement of observation mound P6 to align within .5 degrees on azimuth 090/270 with the Roberts Mound required prior knowledge of the equinoxes. The construction of the large circle and internal crescent effigy was modeled after an equinox sunrise or the rare occasion of a crescent sun or moon aligning behind the mound. The orientation of the opening of the large circle and the position of P2 suggests a relationship between the burial mound and the ecliptic plane. Knowledge of celestial events formed the foundation of the belief system. The illusions caused by celestial body movements involving a burial mound, and risings and settings out of and into the earthwork all suggest a relationship to death, burial, rebirth, and after-life beliefs.

The Hopewell had a shamanistic three tier world view. In this view, the cosmos is comprised of three levels, the Upperworld, their circular Earthly World, and the Lowerworld. In this cosmology, the Upperworld contains the sun, moon, and stars as well as birds. The Earthly World was viewed as circular, divided into four quadrants by the cardinal directions and containing all the attributes of physical reality. The Lowerworld was viewed as under the earth and contained water, all the aquatic creatures including snakes, alligators, and mythical characters. These three levels are connected by a vertical axis called an "axis mundi" or "pathway". (*Eliade, 1964; Furst, 1976; Romain 2009*).

The vertical axis mundi can be a column of smoke. (*Romain, 2009*). On this pathway connecting to the Upperworld, communications in the form of prayers and supplications offered for continuation of the life cycle could have been carried. The visual illusion of smoke carrying their requests to elements in the Upperworld may have been an integral function of the belief system. Evidence of fires reported by Moorehead in the large circle suggests this hypothesis may apply.

The Hopewell may have viewed the Upperworld as an accessible and influencible realm. When celestial events recurred as requested, hoped, and/or predicted, their perception of success may have been based in their own efforts. With the primary focus of activities centered on the winter solstice, the most threatening time in the solar cycle in regards to survival, they may have believed they could influence the sun to raise high in

the sky again and continue the celestial cycle. If prayers and supplications to a higher being or ancestral spirits were offered for continuation of the life cycle, renewal and continuation proved their efforts were successful; their requests had been heard and honored. Renewal of the Upperworld cycle validated their belief system.

The illusions of celestial bodies rising out of and into the central circle was part of the belief system. Their goal may have been to bring the Upperworld down to earth. The axiom of "as above, so below" may be at work here. The "capturing" or "conjoining" of the sun and moon may also be involved. If they believed the crescents or disks carried their ancestor's spirits, the practices may have been directed toward resurrection of the dead. This kind of cognitive archaeology is certainly arguable and plausible. The true beliefs and motives of these Native Americans are difficult if not impossible to comprehend.

Between the year 100AD and 300AD there were 59 partial and 60 total lunar eclipses visible from beginning to end visible at this site. In the same period, there were 79 partial solar eclipses. Of these, only eight were 90% to 97%. One occurred on the 1st of March 192 AD with 99.2% occlusion and created the solar corona. This was the only visually total eclipse visible from this venue in this time period prior to likely construction of the site. (2012 NASA). Because solar crescents were so infrequent it is not likely this was the precursor for the central circle effigy or the large circle effigy. The central circle diameter marks the minimum and maximum south rise and set points. Therefore the central circle is most likely an effigy representing the moon. A single eclipse crescent rising on azimuth 090 at this or any other location is so rare that it is not plausible this was the event that precipitated the building of the large circle effigy. The effigy was probably modeled after a solar equinox alignment. Eclipse prediction is not likely to be the function of the site but it cannot be eliminated.

The apparent application of the Golden Ratio and Phi strongly suggests an insertion of knowledge from outside of the isolated chieftom that built the site. Since the Golden Ratio was seemingly not known until use by the classical Greeks, knowledge of this ratio by the Hopewell is controversial even though it appears at other Hopewell sites. (Hamilton, 2012). Controversial too is the apparent application of advanced geometry such as Pythagorean geometry. What is amazing is the builders of this site not only used terrain elevation to achieve the desired alignments but compensated for it with advanced geometry as applied to astronomy.

The diameter of the central circle was apparently based on the minimum and maximum south lunar rise and set points. The diameter of the large circle relates to the sun. The ratio between the diameters may be the result of the visual differences of the two disks although they are in fact the same diameters as viewed from earth. The Golden Ratio and the application of trigonometry may not be at work here but it also cannot be ignored.

The Winter Solstice seems to outweigh other celestial cycle events. Not only is the winter solstice sunrise and sunset observed, but also the median transit of the winter solstice sun over the large circle and later it's setting into the central circle. These

multiple illusions centered around the winter solstice strongly suggests life cycle renewal played a major role in the belief system.

The Native Americans we call the Hopewell built this three dimensional earthwork high on a hill top, closer to the sky; closer to the world above. They were motivated by a belief system involving monitoring and perhaps influencing the continuation of the celestial cycle and therefore their own life cycle. This belief system involved the Upperworld, life after death, and perhaps spirits of their ancestors. They may have performed observations and practices to stop the sun from "going away" in the winter; to cause it to return it to its life giving place high overhead. When observers saw a bright object "rise out of" a burial mound, they may have perceived it to be a visible ancestral spirit. Over successive nights they watched it traverse the sky and eventually enter into the band of stars of the Milky Way. With the return of the life giving sun and the arrival of ancestors into the Milky Way, the practices they performed at the site were complete. They had once again witnessed the continuation and completion of the human life cycle from birth, through death, to rebirth, and arrival into the "Great River" of ancestral spirits in the "Upperworld".

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