Chapter 1

Inka Astronomy South of the Tawantinsuyu

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Abstract: In this work we present the results of the last years of archaeoastronomical research at the Inka site "El Shincal de Quimivil" located south of the *Tawantinsuyu* (Catamarca, Argentina). We analyze the relationship between the *ushnu* and the surrounding hills and its orientation associated with the sun and the local *huacas*. The *ushnu*, which represents the center of the site as an axis mundi, is framed by four cardinally distributed hills. On the other hand, we expose the relationship we've found between two rock alignments that are found on one of the surrounding hills to the *ushnu* (Western hill), with respect to the sunrise. These alignments give us important dates within the inka calendar and a proof of the use of the metropolitan calendar in a region far away from Cusco. Finally, we analyze a structure that we call Segmented Wall, which is located in the Southeast sector within the great square of *El Shincal*, as a solar marker to establish important dates in the inka calendar. We consider that this wall was used by the inkas, in a similar way to that reflected in the account of the chronicle of *Huarochiri* by Francisco de Ávila, where the observation of the shadow of a wall established the date for the worship of *Pariacaca*. But in this case, the observation of the shadows on the wall could be associated with the anti-zenith steps of the sun and the dates related to sowing and harvesting.

Keywords: *Ushnu*, *Shincal*, *Huacas*, Inka.

Contents

1. Introduction

This work gathers the last seven years of research at the "El Shincal de Quimivil" site. Several works have shown that it was one of the most important inka centers in the south of *Tahuantinsuyo* (Corrado, Giménez Benítez, Pino Matos, and Balbi, 2018; Farrington, 1999; Raffino, 2004). The "Shincal de Quimivil" stands out above other Inka settlements in northwestern Argentina (NOA) and Chile, in addition to other characteristics, among which its public structures stand out, the constitution of spaces prepared for festive and ceremonial practices (Farrington, 1999) and the construction of a wide landscape that articulates architecture with physical aspects of the surrounding geography (Corrado and Giménez Benítez, 2019).

In each province of northwestern Argentina, there are dozens of Inka occupations, but very few present the set of architectural features and planning of "El Shincal de Quimivil". This has a square (delimited by walls of quadrangular morphology) with a *ushnu* (also with a quadrangular plan) located almost in its center, several residential buildings, *kallancas*, public spaces, more than seventy warehouses of the qolqa type and a hundred other buildings of different shapes and locations. In addition, it is impossible not to ignore the use of the surrounding natural space to achieve a fusion of the architecture of the site with the hills and bodies of water, such as streams and springs. We must mention the importance of four hills arranged cardinally with respect to the central square, marking four points of reference. These four hills become markers for each cardinal end, while

the plaza and the *ushnu* were centrally located in relation to them. The hills, to a greater or lesser extent, were subject to modifications: flattened peaks, access stairs, stone enclosures, rocks cut out or with visible marks, and constructions on the slopes and base (Corrado and Giménez Benítez, 2019). In this way, the accumulation of research capitalized interpretations tending to highlight the ceremonial importance of this site, in direct connection with the construction of a sacred landscape (Corrado, Giménez Benítez, Pino Matos, and Balbi, 2018; Farrington, 1999; Raffino, 2004).

2. "El Shincal de Quimivil"

The site has several attributes that make it similar to the New Cusco (Farrington, 1999; Raffino, 2004). This site has been one of the most important ceremonial centers in the southern *Qollasuyu* region (Raffino, 2004) (Figure (1)). With an urban layout around the central square (*aukaipata*) or the *ushnu*. This type of disposition is reflected in the large regional administrative centers (Pino Matos, 2004). We can say that some of its most important features represent a schematization of the typically Inka space. The center of the site, as an axis mundi, is represented by the *ushnu*, a ceremonial platform, which we will detail later. The architecture of this space was made, like the rest of the site, with cut rocks forming double walls with their flat faces facing outwards (Raffino, 2004). The main square that contains the *ushnu* is also of square morphology limited by double-row walls. Its dimensions, 175m on a side, are distinctive in comparison to other southern Inka sites. There are public structures, housing complexes and some places for food production and storage.

3. The *Ushnu* of "El Shincal"

The *ushnu* of "El Shincal" (27°41' 11.53" S, 67° 10' 42.80" W) is the largest south of Cochabamba (Raffino et al., 1997), with dimensions of 16m on each side and 2m Tall. On the west face it has an access staircase, it is made up of nine steps that rise a total of 1 m, ending in a simple span of trapezoidal morphology that would correspond to the access door to the interior of the platform (Lynch, Giovannetti, and Páez, 2013; Raffino, 2004; Raffino et al., 1997). The walls are of the double type (between 0.80m and 1m thick) filled with mud to settle (Figure (2)). All of the rocks with which the *ushnu* was built were edged, — the same characteristics of the other constructions on the site to achieve flat and straight faces (Corrado, Giménez Benítez, Pino

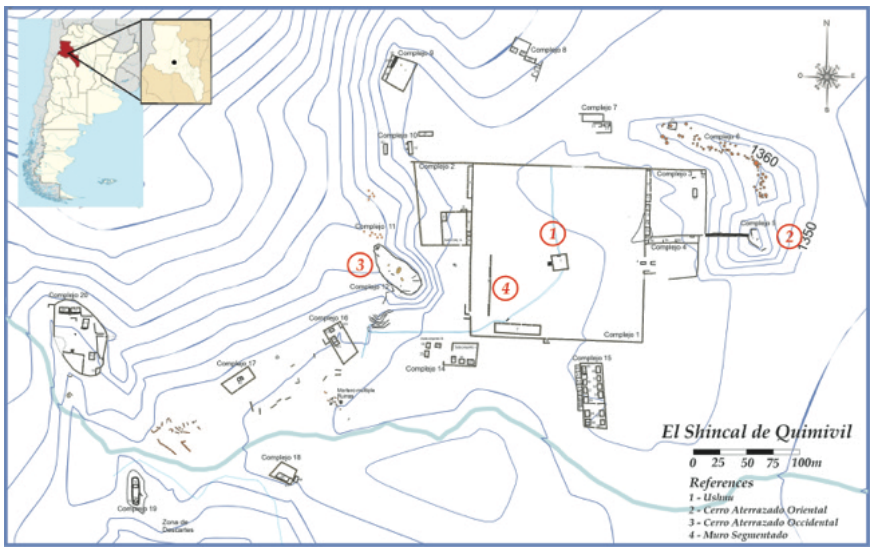

Fig. 1. Site map.

Matos, and Balbi, 2018; Farrington, 1999; Raffino, 2004).

Like the *ushnu* of "Huanuco Pampa", it presents a *tiana* (*tiyana*) or interior bench (Raffino, 2004). It is an elongated structure 3m long, 0.80m thick and 0.80m high. It is placed very close to the north wall of the structure and it is arranged in such a way that its axis is in the east, — west direction (it is not oriented in the same way as the *ushnu*, the reconstruction probably did not respect the original orientation).

In addition to the *tiana*, another material manifestation was found in the interior space of the *ushnu*, a cluster of small-sized rocks, arranged in an orderly manner in the manner of mounds. Raffino et al. (1997) argued that it was the remains of a paved floor in front of the *tiana* of more or less quadrangular morphology, something like a specially prepared space for dignitaries to step on (Raffino, 2004; Raffino et al., 1997). But other works propose (Giovannetti et al., 2012) that a libation structure would be treated, as reported in some early chronicles of the Spaniards when they described the *ushnu* platforms of Peru (Pino Matos, 2010). Photos from Raffino's excavation campaign (Raffino et al., 1997) lend credence to this latter interpretation.

Inside the great square, the *ushnu* is not only shown as the representation of a stage of rites and ceremonies during important events, but also,

Fig. 2. *Ushnu* of the "Shincal of Quimivil".

the spatial axis that marks alignments towards points that surely played a fundamental role in the sacred landscape (Farrington, Moyano, and Díaz, 2015, p. 58). The *ushnu* and the square are framed between four hills that possess anthropic evidence. The east and west hills are flattened, so far there is no evidence that this has been done artificially (Figure (3)). They also have some *Huacas* rocks on their tops.

In the southern hill (*Cerro Loma Larga*) material remains have been found prior to the inkas (associated with the *Aguada* Culture) (González, 1998). To the north, another hill suggests a similar importance to the east and west hills due to the amount of vestiges on the surface and its surroundings (access stairway, circular constructions and carved rocks).

The *ushnu*, apparently, was located in a central position with respect to the aforementioned hills (Figure (3)), concordant in this aspect with most of these platforms along the *Tawantinsuyu* (Hyslop, 1990; Monteverde Sotil, 2011; Pino Matos, 2004b).

We know that in many sites of the Inka empire, some of its structures have a relationship with certain celestial objects, evidenced in places such as *Huánuco Pampa* (Pino Matos, 2004), *Pumpu* (Pino Matos and More-

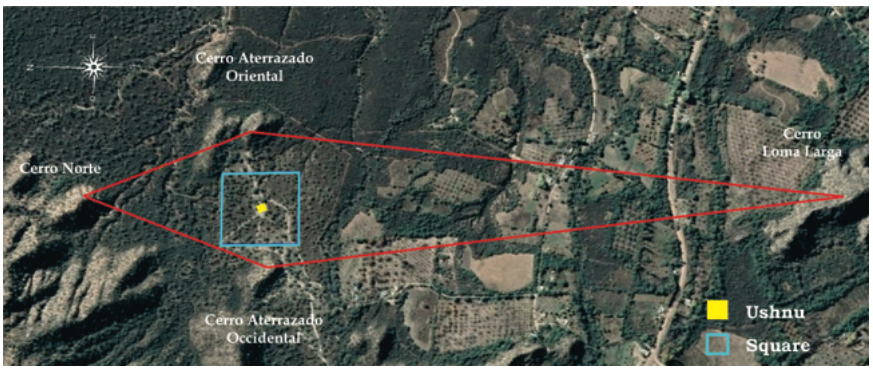

Fig. 3. Location of the four hills that frame *ushnu* and the square.

ano Montalván, 2014), among others. In the same way, in "El Shincal de Quimivil" we have found evidence of structures related to solar events.

4. Our Measurements

For the measurements, a *Suunto tandem* was used that has a compass and clinometer, the first has an error of 1/4° in the azimuth and the second, an error of 1/2° in the height. The magnetic correction for the date of observation was obtained from the NOAA (2022). For example, the magnetic declination at "El Shincal" on June 21, 2018 was 4.73° ± 0.5° W. Site plans were made with a Pentax R-315NX Total Station (± 5" angular accuracy). Georeferencing was performed using a Thales Mobile Mapper Differential GPS (Giovannetti et al., 2013).

5. Orientations of Shincal's Architectural Structures

The archaeoastronomical measurements focused on the orientation of three structures, the *ushnu*, the rock alignments on the top of *Cerro Aterrazado Occidental* and the segmented wall. For being until now the relevant structures of the site due to their calendrical relationship with local and metropolitan Inka festivities.

6. The *Ushnu* Alignment with the Equinox

As we have already mentioned, the *ushnu* is inside a rectangular square, but it does not share the same orientation, the *ushnu* is rotated with respect to

the square by about 5°. And the square is cardinally oriented.

We consider that the orientation of the *ushnu* responds to two causes:

a The line that passes through the circle of stones on the Cerro Este (A = 84°50'; h = 4°30') and the *Huaca* rock of Cerro Occidental (A = 265°10'; h = 4°50'), both orientations measured from the *ushnu* (Figure (4)). Both data (A) are corrected for magnetic deviation. (Table (1)).
b The sunrise on the equinoxes of March and September, but the equinoctial orientation would not correspond to the astronomical equinox (δ of the Sun = 0°) as some authors affirm (Farrington, Moyano, and Díaz, 2015; Moyano, 2013, 2016; Moyano et al., 2015), but rather in a compromise between the direction given by the line that passes through the *huacas* of Cerro Oeste and Cerro Este, and the mean temporal equinox (González García and Belmonte, 2006; Ruggles, 1997) (Figure (5)).

Fig. 4. *Ushnu* orientation with respect to the east and west hills.

In the case of "El Shincal", the *ushnu* alignment with the eastern and western hills would respond to this idea. In which we see that the orientation towards the hills (which we find in other Inka sites) is superimposed by the orientation at sunrise on an important solar date (Figure (5)). This

Table 1. CAPTION?

	Year	Measured Azimuth	Magnetic Correction	Corrected Azimuth	Corrected Height	Declination of the Sun	Date
Alignment of Rocks at the Passage of the Sun to the Zenith at Cusco (ARCC)	2015	109°	4°5'	104°55'	0°30'	-13°11'	February 12-13 October 28-29
Ushnu	2016	89°	4°22'	84°38'	4°30'	2°36'	March 26 September 16-17
Rock Alignment to the June Solstice (ARSJ)	2018	65°20'	4°44'	60°40'	5°00'	23°12'	June 21

Fig. 5. Left: Sunrise on the astronomical equinox of March 2015. Right: Sunrise on September 18, 2016.

would be similar to what happens in *Pumpu*, where the axis of the *ushnu*, in addition to corresponding to the orientation towards important hills of the local landscape (which are *huacas*), overlaps with the sunrise on the day of the zenith passage in the place (Pino Matos and Moreano Montalván, 2014).

7. Rock Markers and Solar Dates

On the extreme SE of the *Cerro Aterrazado Occidental* there are two lines of rocks. Which present important solar alignments for the Inka calendar. The two rows are formed by edged rocks of irregular morphology, with an approximate size ranging from 20cm to 30cm. The first alignment we are going to talk about is formed by 9 rocks (Figure (6)), whose declination is $23.3° \pm 0.5°$. These rocks are oriented to the sunrise on the June solstice, the winter solstice in the southern hemisphere and the *Inti Raymi* festival for the inkas.

This festival was not considered by the inkas as a punctual astro-

nomical phenomenon, but had an extended duration, between 2 or 3 days (Ziołkowski, 2015, p. 357). There are divergences among some chroniclers on the importance of this festival, on the one hand, this was "the moderate festival of the sun" (Guaman Poma de Ayala, 1615; Polo de Ondegardo, 1559), while another chronicler, inka de la Vega (1609) affirmed that *Inti Raymi* was the main festival. These divergences could result according to the social context of the informant: he could detail only that part of the festival to which he could have direct access, which was determined by his social and religious hierarchical position.

The second alignment is made up of 10 rocks, which are oriented marking another important solar phenomenon within the Inka festive calendar. It marks the sunrise on the horizon on February 12-13 and October 28-29 (Gregorian calendar), with a declination of -13.33° ± 0.5° (Figure (6)). These last dates do not have any particularity for the movement of the sun at the latitude of "El Shincal".

Fig. 6. Rock lines of *Cerro Occidental*.

This last calculated declination corresponds to the dates of the passage

of the Sun by the zenith of Cusco. The latitude value of Cusco is 13°30'45" S. This shows that the rock lines (ARCC) of *Cerro Aterrazado Occidental* mark the two dates of the passage of the sun by the zenith of Cusco (Figure (6)) (Table (1)). Table (1) gives the dates obtained for the calculated

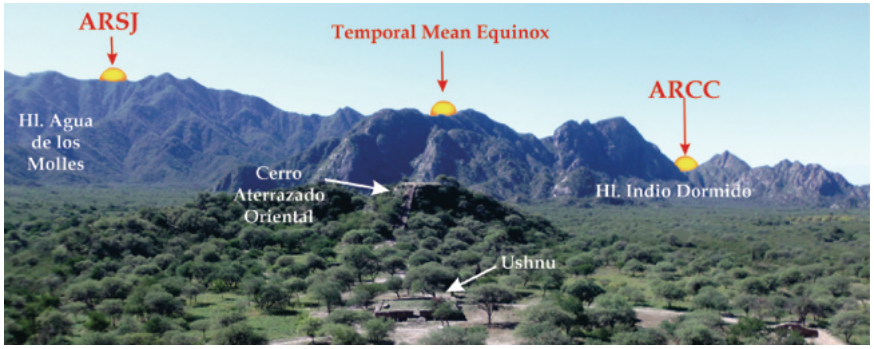

Fig. 7. Sunrises for three important dates in the Inka metropolitan calendar.

declines

8. The *Ushnu* and the Structures of *Cerro Occidental*

Currently, the residents of the area see on the eastern horizon, a series of hills that together have the appearance of a "sleeping Indian". We do not know if in the time of the Inkas they saw a similar figure. But it is important to note that the stone line (ARCC) points to a well visible region of the horizon where a "v" shaped depression is observed (which corresponds to what local people call the neck of the "sleeping Indian") (Figure (8)). The stone line marks the sunrise for the date of the passage of the sun through the zenith of Cusco and that also corresponds to the sunrise in this characteristic feature of the horizon (Figure (9)).

As Zuidema (1981) and Avení (1981) have shown, the Inkas were not only interested in the solstice moments of the annual route of the Sun, but also in the moments of its passage through the zenith and anti-zenith of Cusco; these phenomena occurred, at that time, on February 2, October 20, August 8 and April 16 (in the 16th century before the Gregorian reform). Apparently closely related to the first of the listed phenomena, that is, with the passage of the Sun through the Zenith of Cusco on February 2 (Julian), an important festival of "Rayme" was celebrated in Cuzco.

Fig. 8. The arrow shows us the characteristic feature of the horizon where the line of rocks is oriented (ARCC).

Ziołkowski (2015) argues that the imperial calendar coexisted with local calendars, therefore, that there is an orientation that marks a Cusco date is an element of utmost importance, since it would be putting the local use of the metropolitan calendar into relevance.

Fig. 9. a) Sunrise on the June Solstice and) Sunrise on February 13 (passage of the sun through the zenith of Cusco).

9. Segmented Wall

Inside the large square, the segmented wall (Corrado, 2016) is 62m long and is divided into five segments by four spans (Figure (10)). This wall is

located in a North-South direction with a deviation of $1° \pm 0.25°$ towards the East. The wall is divided into 5 segments of about 12m each. Three of the five segments were partially reconstructed by Raffino (2004) in the 1990's, using the *anastylosis technique*, performing the recomposition of collapse contexts. In segments 1 and 4 (Figure (10)), the wall has two well-defined stone benches attached (Figure (5)). It is possible that each of the five segments of the wall had an attached bench. It can be assumed that the objective of the observers sitting on the sidewalks was the actions that took place on or behind *Cerro Occidental*. Probably the rituals performed by specialists on the top, at sunset or other celestial bodies on certain dates required others to observe from below in a privileged position.

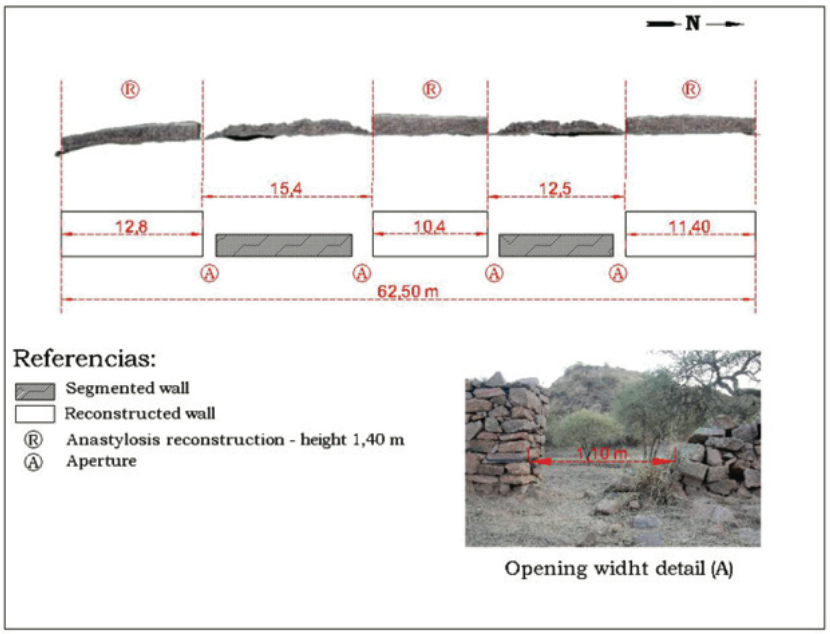

Fig. 10. Detail of the segmented wall.

Regarding the use of a wall to determine some important dates, there are some suggestive ethnohistoric accounts such as Francisco de Ávila's treatise on *Huarochirí* where reference is made to specialists called *Yañca*, who could determine on which date they should leave to worship the God *Pariacaca*. These *Yañca* used the projections of the shadow of a wall to observe the Sun,

through the use of light and shadow effects in their calendrical observations, they could indicate the day they had to carry out the pilgrimage and the ritual festivity to this deity (Taylor, 1999, p. 55).

10. Wall Measurements and Results

Azimuth measurements of the wall were taken and an almost North-South orientation was obtained ($1° \pm 0.25°$, corrected for magnetic deviation). The heights of the sun have been calculated for the dates when the shadow of each section of the wall, at noon, is the length of the openings. For this the possible real heights of the aforementioned wall have been considered. It was found that the minimum height was 1.2m, since the wall marks before *anastylosis* present this height. On the other hand, a maximum height of 1.4m has been taken, which is the average current height of the wall with the reconstruction (Figure (11)).

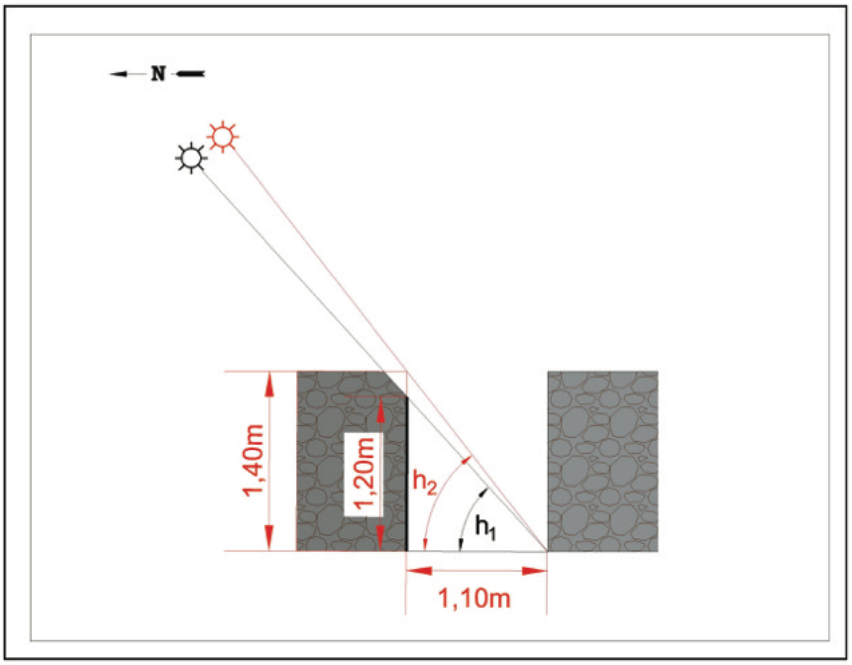

Fig. 11. Heights that the wall could have had and the projection of its shadow on one of the openings, taking into account the possible associated heights of the sun.

The values of the height of the sun were calculated by plane trigonometry in a right triangle (Figure (10)) for the extreme values of the height of the wall, they are: h1 = 47.5° ± 0.2°; for the minimum height of the wall; and h2 = 51.8° ± 0.2° considering the wall's maximum height.

Once the values of the heights had been obtained, the calculation of the declination of the sun was performed, with the expression: $\delta + h = 90° + \varphi$. This expression is used when it passes through the meridian of the place (superior culmination, noon of the place), where δ is the declination of the sun, h is the height of the sun at noon and φ is the latitude of the place of observation. It has been assumed that the wall is oriented according to the meridian of the place. This idea is consistent with the small deviation of the same with respect to the north-south direction.

The values calculated for the declination of the sun corresponding to each height of the wall are the following: $\delta_1 = 14.8° \pm 0.2°$ for 1.2m and $\delta_2 = 10.8° \pm 0.2°$ for 1.4m.

Each declination of the sun gives us two dates on the calendar, except for the solstices. Given the declinations obtained, there are two ranges of possible dates for the wall, due to the uncertainty of the actual height of the wall. The intervals are from April 7 to 19 in the Julian calendar (17 to 29 of the Gregorian calendar) and from August 3 to 15, also Julian, (August 13 to 25 in the Gregorian calendar), since these correspond to the possible extremes in wall height. These dates give some clues to the wall's possible uses as a solar marker.

It is known that the inkas were interested in observing the critical moments of the apparent annual shift of the sun. Also, some authors such as Zuidema (1981, 1982, 2011) which postulates that the so-called anti-zenithal passages or steps through the nadir of the sun in Cusco, which occur on April 26 and August 18 in the Gregorian calendar, were important phenomena for the inkas. Anti-zenithal steps are phenomena that cannot be directly observed. But, Zuidema (1981) relates that the inkas observed the positions of the solar horizon on these dates, as well as those of the passage of the sun on the zenith day.

The anti-zenith dates proposed by Zuidema (1989) are those in which the sunset occurs at 180° from the sunrise position related to the zenith passage. The mentioned author proposes a zenith / anti-zenith alignment between *sucancas* in *Cerro Picchu* and in *Tipón*, 24km southeast of Cusco. Affirming that the zenith sunrise could be observed from *Mount Picchu* to *Tipón* and the anti-zenith sunset from *Mount Tipón* to *Picchu* (Zuidema, 1977, 1981, 1982).

The anti-zenithal passage occurs in Cusco every August 18 and April 26 (Gregorian) and coincides with the sowing and harvest of corn, times of inka ceremony and celebration (Zuidema, 1981, 1982). Agricultural festivals related to corn are likely to be associated with anti-zenith celebrations. Zuidema (1981) adds that the inkas had August and April as the respective beginning and end of their agricultural season and argues that they could only have determined the corresponding dates of August 18 and April 26 by observing the anti-zenith passage of the sun.

Ziołkowski (2015) maintains that the Cuzco calendar was divided into two solstice cycles that constituted the mainly ceremonial and religious part of this system of time reckoning. And two cycles associated with the administrative-religious tasks and the ceremonies of delivery of the tribute and its partial redistribution. One of the latter began at the beginning of February, it was probably related to the passage of the sun through the zenith in Cusco (February 2 or 3 in the Julian calendar) and the second sometime in August, although it is not clear in association with what type of solar phenomenon.

Some authors relate the passage of the sun through the anti-zenith of August, presenting proposals on the places of observation, location of the horizon markers and directions of the alignments, associating them with various astronomical phenomena such as solstices, passages of the sun, the zenith and anti-zenith (Avení, 2001; Zuidema, 1981, 1982). Among these proposals, the hypothesis of the passage of the sun through the zenith and anti-zenith stands out, dates that were very important in inka society (Zuidema, 1981), an idea that was much debated as there was no physical evidence of observatories and horizon markers related to said phenomena (Bauer and Dearbom, 1995). The ritual importance of the months of April and August postulated by Zuidema (1981, 1989, 2011), coinciding with the passage of the Sun through the anti-zenith in the latitude of Cuzco, are based on the supposed location of the pillars to the west, which also they served as markers of harvest and ritual planting times, and the end and start of the agricultural year (Bauer and Dearbom, 1995; Zuidema, 1981, 1989, 2011).

> [...] Within the period from August to April the sun passes through the zenith, a path high in the sky. In April the earth "closes", from then until August the sun has a low path in the sky [...] (Zuidema, 1989, p. 452).

The month that began the Cusco agricultural year, although it was

mobile, always included the date of the passage of the sun through the anti-zenith of Cusco. The names of this month meant "the month to break the earth" or "the month to sow". The ceremonies that were carried out in this period were mainly related to the planting of corn (Ziołkowski, 1987). That's how Guaman Poma de Ayala (1615) describes it:

> [...] Y comiensan a senbrar (en agosto) el mays hasta el mes de enero, conforme el rrelojo y rruedo del sol y del templo de la tierra; ci es yunga tarde, ci es cierra, tenprano, como conbiene en este mes [...]

On the other hand, the other passage through the anti-zenith in Cusco occurs on April 26 of the Gregorian calendar and Ziołkowski (1987) says that the penultimate month of the inka calendar, generally called *Arihuaquis*, was related to the vegetative cycle of corn and the beginning of the harvest.

In places such as *Huánuco Pampa* (Perú), there is evidence that these zenith and anti-zenith orientations have been used, such as those studied by Pino Matos (2004); Pino Matos and Moreano Montalván (2014) where he describes a complex system of orientations similar to those of Cusco. In addition, this author finds a similar relationship at the *Pumpu* site in the highlands of *Chinchaycocha* (Perú). But in both places their zenith and anti-zenith dates are related to the latitude of the sites and not related to the latitude of Cusco.

As Pino Matos (2005) tells us, these astronomical orientations would have a double purpose: first the organization of space in the inka settlements and simultaneously that of establishing time, constituting calendars especially associated with different solar events (solstices, equinoxes and passages of the sun through the zenith and anti-zenith).

As is known, the "El Shincal" is outside the tropics, therefore, there is no zenith or anti-zenith passage, but as Ziołkowski (2015) says it would not be rare to find structures or markers associated with these dates that are very important within the Cusco metropolitan calendar.

11. Conclusion

The organization of the calendar and festivals by the Inka was closely related to the agricultural and festive calendar, as well as using it as a tool of power by the Inkas over their subjects. In addition, the local evidence so far in "El Shincal", refers us to the observation of the movements of the Sun, determining local and Cusco dates such as the equinoxes, the June solstice

and the days of the sun's steps through the zenith, in the Cuzco.

As has been observed above, we have found that certain anthropic structures, such as the ushnu and the lines of stones on *Cerro Aterrazado Occidental*, are oriented to positions of the Sun on the horizon, in this case predominantly to the eastern horizon. Where we find important evidence of the materialization of the metropolitan calendar at this site (Ziołkowski, 2015), with markers of some important dates of the sun's position on the horizon (Šprajc, 2001).

These horizon markers, — natural or anthropic —, were reference points where these phenomena were observed and based on these permanent observations, the Inkas could have a control of the critical events of the sun. These markers are closely related to dates within the Inka festive calendar.

Some chroniclers (Cieza de Léon, 1554; de Acosta, 1590; de Betanzos, 1551; de la Vega, 1609; Polo de Ondegardo, 1559) mention the use of pillars by the inkas to maintain the regularization of the calendar. These chroniclers highlight 2 important events instituted by *Pachakuti Inca Yupanki*, the first is that he is credited with erecting these pillars around Cuzco between the years 1440 and 1470 and they continued in use until the arrival of the Spanish (Ortiz García, 2012), and the other event was the reform instituted on the state calendar. For Earls (1976) this reform was the final stage in the evolution of the Andean calendars, where the astronomical calendar and the agro-ecological labor cycles were articulated, and, consequently, manifesting a series of innovations in the organization of the administrative bureaucracy. This passage from one stage to another did not mean the forgetting of the ancient local calendrical techniques, since the management used by a community, for certain ecological micro-environments, could not be substituted by the state calendar, since it served other purposes (Ziołkowski, 1987; Ziołkowski and Sadowski, 1982).

As is evident, the Inkas had reached a certain knowledge and understanding of the periodic movements of the sun. The use of this knowledge was very useful for the social sphere, through the establishment of the dates for sowing and harvesting and consequently the festivals that accompanied them, where the elite demonstrated their power and control in the most distant regions of the Empire (Ortiz García, 2012).

As we have observed, evidence of large-scale festive production has been found in "El Shincal" and solar markers have been found, evidenced by the orientations of some structures at sunrise, marking specific dates of the metropolitan calendar of the inka state (Ziołkowski, 2015). On the other hand, we have proposed the possible use of the structure called Segmented

Wall as a marker associated with the sowing and harvesting dates in Cusco and its possible relationship with the anti-zenith passages.

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