COSMOLOGY OF THE INCAS: EFFECTS OF LIGHT AND SHADOW

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Inca Solar Orientations

Astronomy was an integral part of Andean mythology and creation, and was at the very heart of the Incas' religion and agriculture.

The Incas proclaimed themselves to be the children of the Sun. They worshipped it and viewed their emperor as being the Sun's direct descendant.

Inca Solar Orientations

The civilization of the Incas was built upon cultures that had preceded them such as the Huari, Nasca, and Chavin.

Their period of dominance, lasting only a century, was far too short to independently develop such advanced forms of religion, social structure, construction, and astronomy.

The Incas were adept assimilators of knowledge, both what was available at the time of their empire's inception, as well as that of the many tribes conquered during their reign.

Inca Solar Orientations

The Emperor, Pachacuti, his son, and grandson successively built the largest empire ever known in the Americas, 4800 km from Chile to Columbia.

They established armies in fortresses at distant stations with the infrastructure of roads and storehouses that was necessary to support them.

Temples and shrines were constructed as a part of exerting state control over its subjects, as well as pilgrimage centers designed to reinforce the legitimacy of royal rule over the populace.

Inca Solar Orientations

The Incas made solar worship the official religion of their empire.

Pachacuti imposed it across the realm, maintaining that he was the son of the Sun and his wife the daughter of the Moon. The Incas venerated the Sun, the Inca, and his predecessors.

The ruling Inca was the central figure in solar worship, supporting the assertion that he was the descendant of the Sun.

Inca Solar Orientations

Inca claims for legitimacy were based upon this assertion that the Inca royalty were direct descendants of the Sun.

Demonstrations of that genealogical link with the Sun could occur during public festivals when the Sun would rise on the horizon at a location predicted by the Emperor and priests, the most likely times being identifiable elements of the solar cycle.

Inca Solar Orientations

Pachacuti instituted a ritual calendar that was measured by the position of the Sun on the horizon.

Religious and agricultural ceremonies and festivals were celebrated and served to reinforce the legitimacy of the emperor and the ruling elite.

Rituals marked times for planting and harvesting, as well as major religious celebrations of the Sun.

Examples of prominent festivals were those of Inti Raymi at the June solstice, Capac Raymi at the December solstice, Inti Raymi at the March Equinox, and Coya Raymi at the September equinox.

Inca Solar Orientations

Inti Raymi was the Inca's solar festival at the time of the June solstice and it is still celebrated in Cusco today.

Garcilaso wrote that the feast of Inti Raymi was the most important one of the year.

It was a festival for the masses that brought many pilgrims to Cusco. It was an elaborate ritual that took place over many days where thanks were given to the Sun and prayers said for the crops.

Inca Solar Orientations

Capac Raymi was another festival of the Sun, in this case at the time of the December solstice.

This was a celebration of crop germination and the start of a new season.

It also was important as the annual time for young Inca adolescents to undergo their rituals of coming-of-age. Capac Raymi was principally celebrated by the nobility rather than the masses.

Inca Solar Orientations

Since the Sun was the primary deity of the Incas, it is reasonable that many huacas (shrines) were associated with solar worship.

In the early 16th Century there were over 400 huacas in the Cusco Valley.

Most were destroyed by the Spaniards, but those that remain primarily were the huacas that had been designed in rock.

Inca Solar Orientations

Many huacas were orientated to the June solstice sunrise, while others pointed to the Sun at December solstice.

Light tubes or cave openings allowed altars to be illuminated at specific times while other orientations guide the eye to the horizon on significant solar dates.

Pillars were set on hills to mark the passage of the Sun on the horizon as a calendar.

Inca Solar Orientations

The Incas learned the cycles of solstices and equinoxes and used this knowledge as a key component of their annual crop management activities.

Inca Solar Orientations

In a practical sense this knowledge was put to work via horizon astronomy as the Incas marked the passage of sunrises and sunsets on their horizons in order to keep time for agriculture and religion.

Ultimately these celestial orientations were integrated into their temples and huacas, as well as other constructs such as solar pillars built more specifically for astronomical purposes.

Inca Solar Orientations

The Incas used solar pillars to mark time passage for purposes of crop management and religious festivals. All were destroyed in an extirpation effort led by Catholic priests following the Spanish conquest.

Beyond Cusco, however, two solar pillars overlooking the modern village of Urubamba escaped the Spanish purge. Field research has verified, when viewed from a large granite boulder in the center of the Huayna Capac's palace, Qwespiwanka, that they mark the position of the rising Sun at June solstice.

Additionally, from the same boulder and in the direction of the December solstice sunrise, are located stone structures on the summit of Cerro Unoraqui.

Inca Solar Orientations

Andean tradition links the equinoxes with fertility, September, in the Spring, when the soil is first prepared for planting, and in March, the Fall, when maize was harvested.

Inca Solar Orientations

While zenith passage took place overhead and not on the horizon, in their system of horizon astronomy the Incas included observations of the position of sunrise on the two days of zenith passage, in our calendar on February 13th and October 30th.

This horizon position could then be used to determine the date of nadir, or the anti-zenith Sun.

Vertical towers, such as the Sunturhuasi in Cusco, were used to facilitate the observation of the Sun or Moon at zenith.

Inca Solar Orientations

Anti-zenith passage occurs in Cusco each August 18th and April 26th and coincides with the planting and harvest of maize, times of Inca ceremony and celebration.

Maize-related agricultural festivals would likely be associated with anti-zenith observances.

THE INCAN MILKY WAY

THE INCAN MILKY WAY

Spaniards attempted to define Andean astronomy in European terms familiar to them, failing to fully realize that the Incas viewed the cosmos from a different perspective.

While European astronomy followed a zodiac that centered around the ecliptic, the Incas oriented their sky with the Milky Way.

ORIENTATION AND QUADRAPARTITION

The Milky Way at times will be viewed as rising in the southeast, passing through the zenith, and setting in the northwest.

Twelve hours later the horizon positions have shifted and the band of stars rises instead from the northeast, traveling again through the zenith, but now setting in the southwest.

This 24-hour rotation cycle creates two zenith-intersecting intercardinal axes that divide the celestial sphere into four observable quarters.

ORIENTATION AND QUADRAPARTITION

At the time of the December solstice, when the Sun rises at 114° on the Cusco horizon, the evening positioning of the band of the Milky Way lies similarly to the southeast. During the June solstice sunrise at 064° the Milky Way is situated in like fashion in the northeast.

Times of the solstices are the only ones when the Sun rises and travels with the Milky Way. Inca cosmology recognizes that both the celestial river and the sun rise together at the dry season's beginning in June and the rainy season's start in December and sometimes uses this in correlation to explain the seasonal intensity of the sun, which feeds upon the powerful waters.

ORIENTATION AND QUADRAPARTITION

The Inca ordered their sky by this celestial quadripartition, in contrast with the use of the ecliptic for reference by ancients such as the Babylonians.

This gave the Incas a nearly 90° difference in their perspective of the heavens and the cosmological constructs that were developed accordingly.

CELESTIAL RIVER

Inca cosmology viewed the Milky Way as a river flowing across the night sky in a very literal sense. They saw earthy waters as being drawn into the heavens and then later returned to earth after a celestial rejuvenation.

The earth was thought to float in a cosmic ocean and when the "celestial river's" orientation was such that it dipped into that ocean the waters were drawn into the sky. The Milky Way is therefore an integral part of the continuing recycling of water throughout the Quechua universe.

CELESTIAL RIVER

The Incas believed the waters of the celestial river to have originated with the Sun.

The Vilcanota River flows southeast to northwest through the Sacred Valley, past Machu Picchu and beyond. Its waters are thought to rise into the Milky Way, and once having traveled its celestial course, fall again to the Earth as rain. The Milky Way is said to be a heavenly reflection of the Vilcanota.

DARK CONSTELLATIONS

The Milky Way provided visual inspiration for several themes of Inca cosmology. The Incas recognized *dark constellations*, or the shapes of beings formed by dark *clouds* in the visible band of the galaxy.

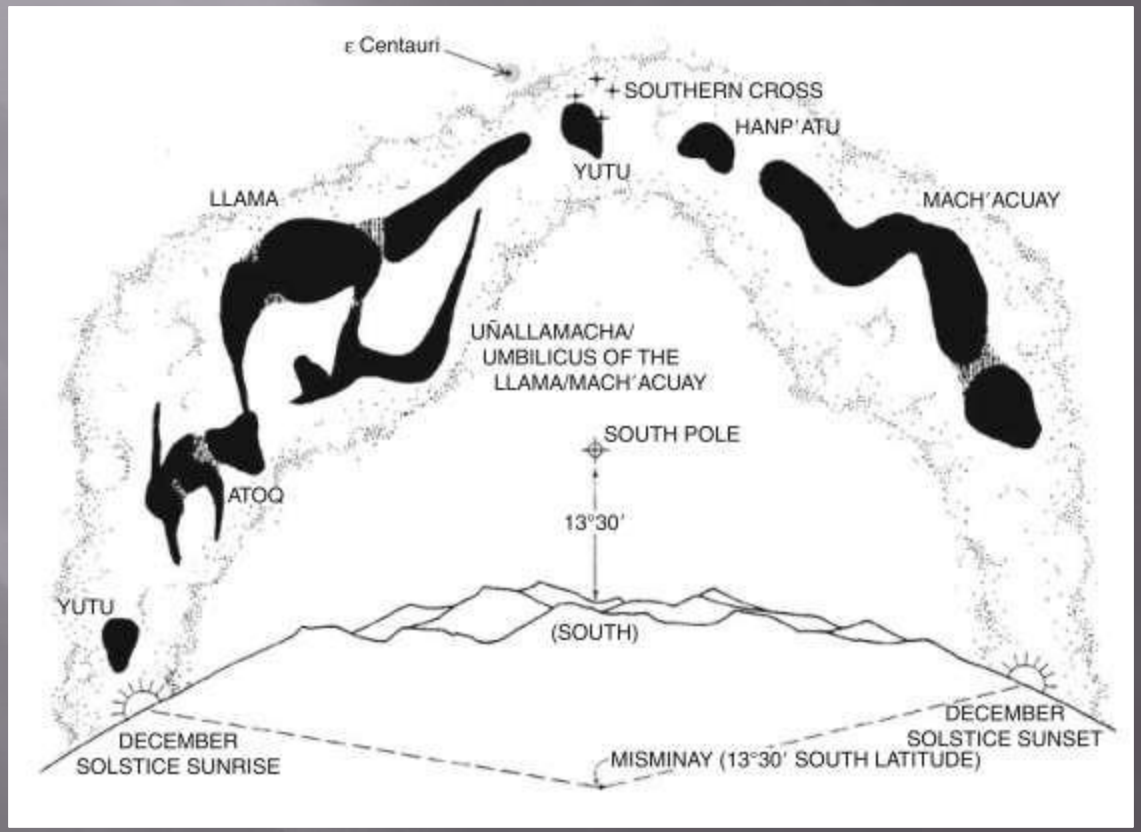
The Incas saw great cosmological characters meant to guide them in their daily lives.

DARK CONSTELLATIONS

The dark constellations of the Incas stretch across nearly 150° of the Milky Way's expanse. Most are animals that figure prominently in Andean cosmology and myth.

The Spanish chronicler Polo de Ondegardo found the Incas to believe that the animal constellations were responsible for the procreation and augmentation of their animal counterparts on the Earth.

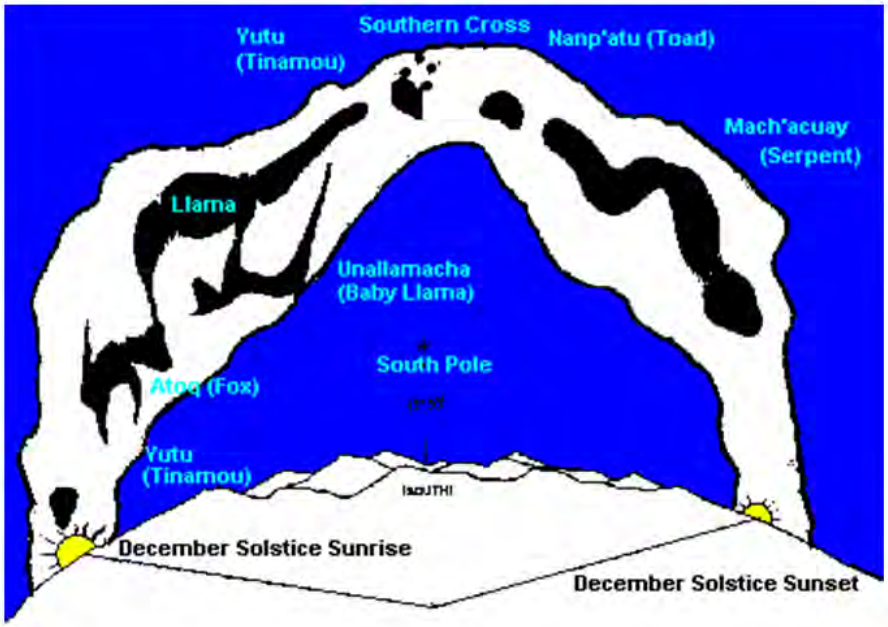
INCAN MILKY WAY



MILKY WAY

INCAN MILKY WAY

The Inca “Dark Constellations”



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INCAN MILKY WAY

INCAN MILKY WAY

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INCAN MILKY WAY

Inca Solar Orientations

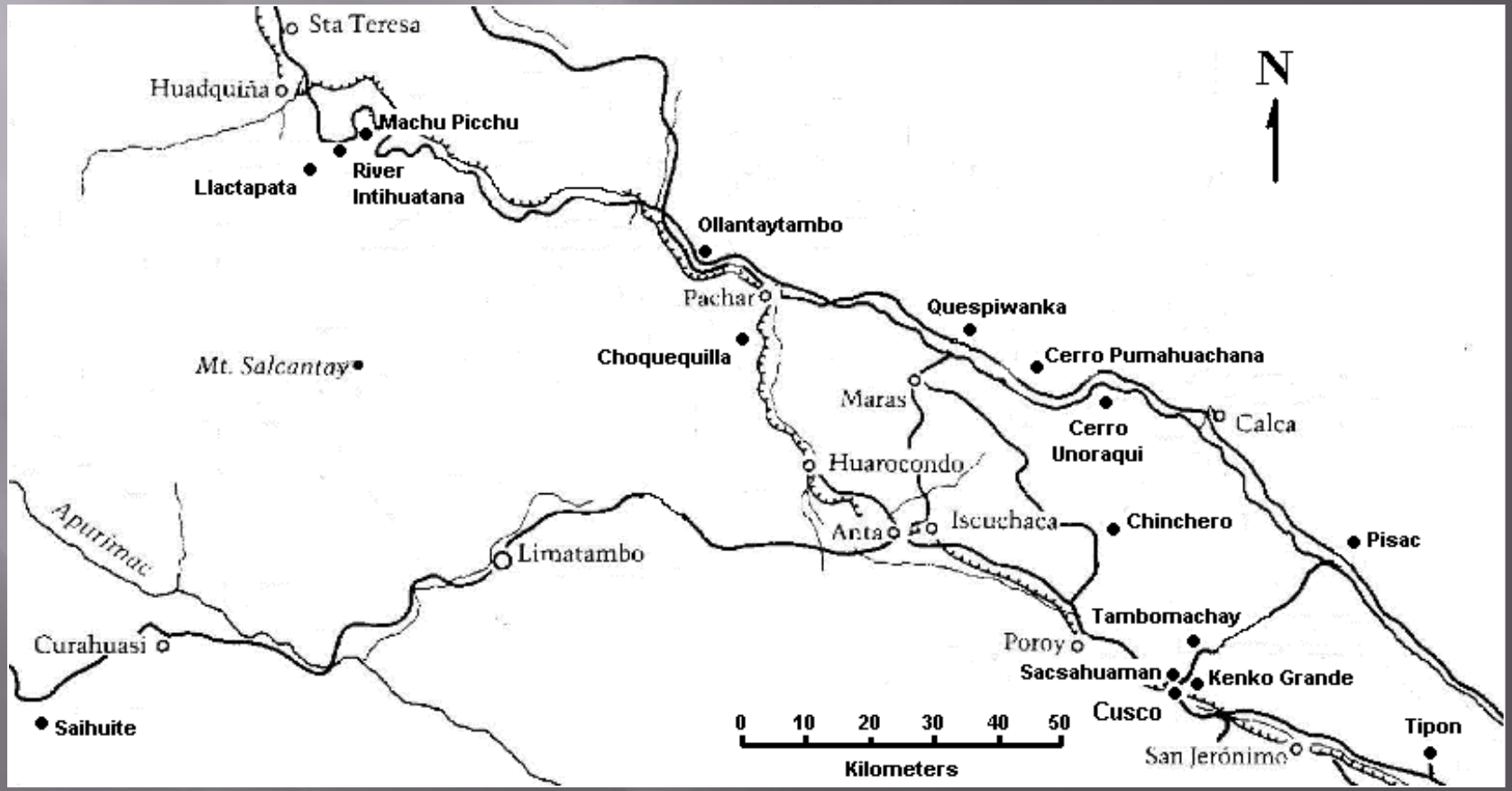
Numerous examples of Inca astronomy are explored in this paper.

Astronomy was thoroughly interwoven throughout many facets of Inca society.

FIELD RESEARCH

- 5 Research Trips
- 29 research sites

- 19 sites Cusco Region
- 7 sites Sacred Valley Region
- 3 sites Machu Picchu Region



Cusco Region

Kenko Grande
Kenko Chico
Mesa Redonda
Tetecaca
Patallacta
Kusilluchayoc
Lacco
Huaca Solar Horizon
Lanlakuyok
Puca Pucara
Tambomachay
Sacsahuaman
Mollaguanca
Sapantiana
Rumiwasi Bajo
Rumiwasi Alto
Kusicallanca
Tipon
Saihuite

Tambomachay

Tambomachay

Tambomachay

The cave of Tambomachay is associated with an Inca platform and staircase. The cave opening looks out on a bearing of 135° while the platform more directly faces the December solstice sunrise at 114°.

Sacsahuaman

The city of Cusco was laid out in the shape of a puma with Sacsahuaman serving as its head and its zigzagged andesite ramparts as teeth.

The site also features a constructed circular depression.

Sacsahuaman has been called a temple of the Sun and certain carved seats are aligned to the southeast for the December solstice sunrise.

The orientation of Cusco with Sacsahuaman southwest and above it ensured the June solstice sun would first strike the head of the city's puma before illuminating its body.

Sacsahuaman

Puka Pukara

Puca Pucara is located at the top of a small hill along the road to Pisac and consists of several structures and a fountain.

Entry to the main part of the compound is through a pair of double-jambed doorways connected by a corridor.

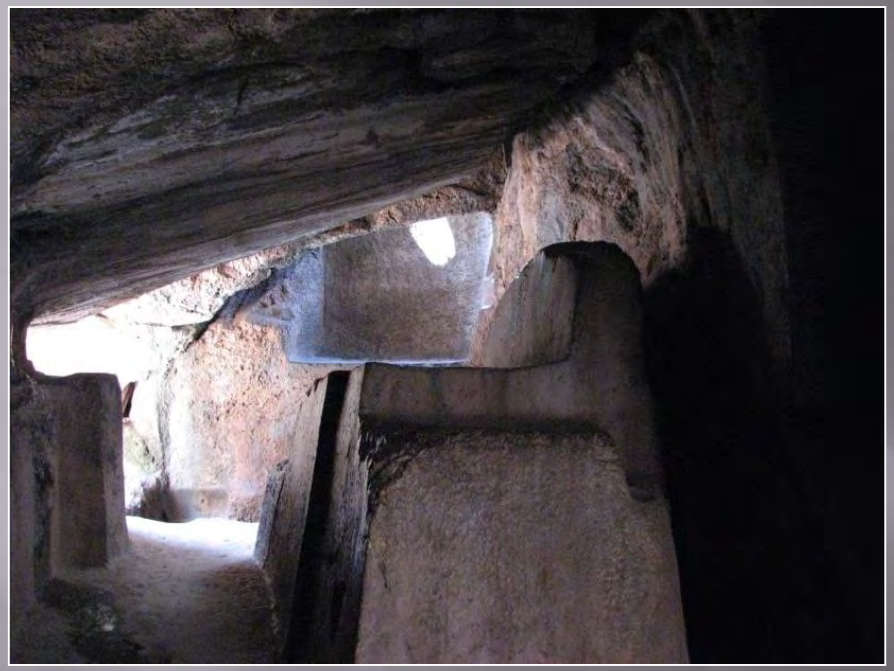
The doors and corridor are oriented 090°/270° on an axis that also aligns with the fountain.

Puca Pucara is situated such that when viewed from the upper platform the June solstice sun will rise over a distinct notch in the horizon ridgeline on a bearing of 065°.

Puka Pukara

Kenko Grande

- Limestone outcropping
- Carved in situ
- Two sucancas (gnomons)
- Effects of light and shadow
- June solstice sunrise
- “The Awakening of the Puma”



Kenko Grande

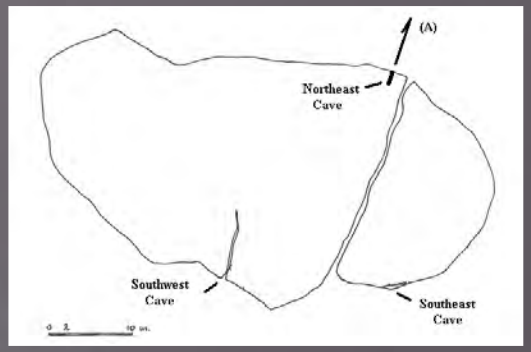
- Cave within Kenko Grande
- Altar and three stairs
- June solstice
- Sunlight climbs the stairs

Kenko Grande

Lacco

Southwest Cave

- Limestone outcropping
- Light-tube
- Directed at altar
- Crescent moon

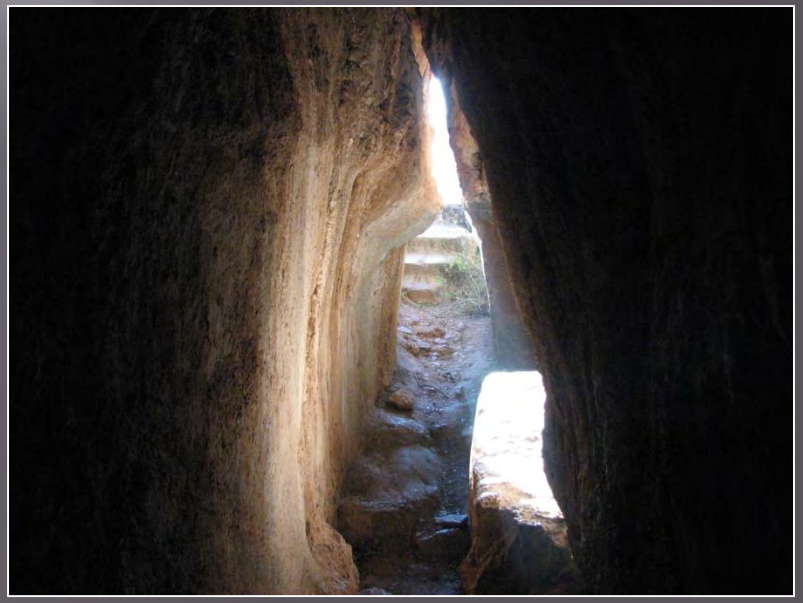


Lacco with Nevado Ausengate

Lacco

Northeast Cave

- Northeast Cave opening oriented June solstice sunrise- adjacent cave not developed
- Illuminates altar and cave interior



Lacco

Southeast Cave Entrance

Lacco

Southeast Cave
Inner Chamber

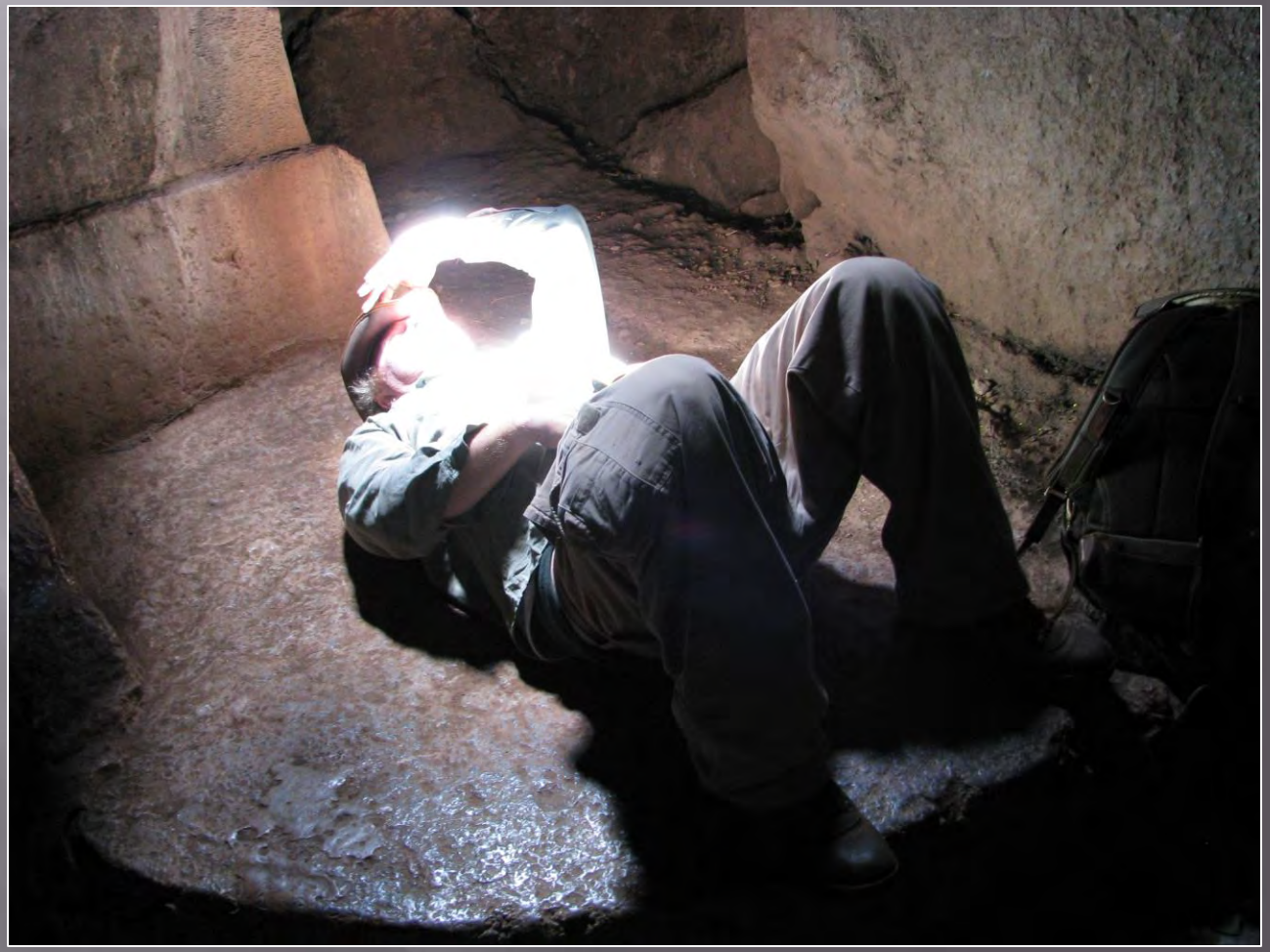
- Temple of the Sun
- Light-tube/Altar
- Zenith sun

Lacco

Southeast Cave

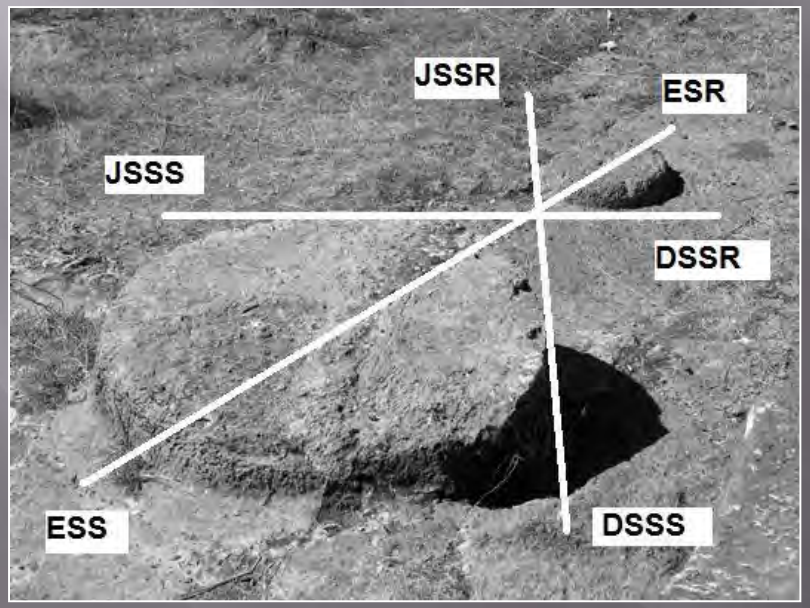
Lacco

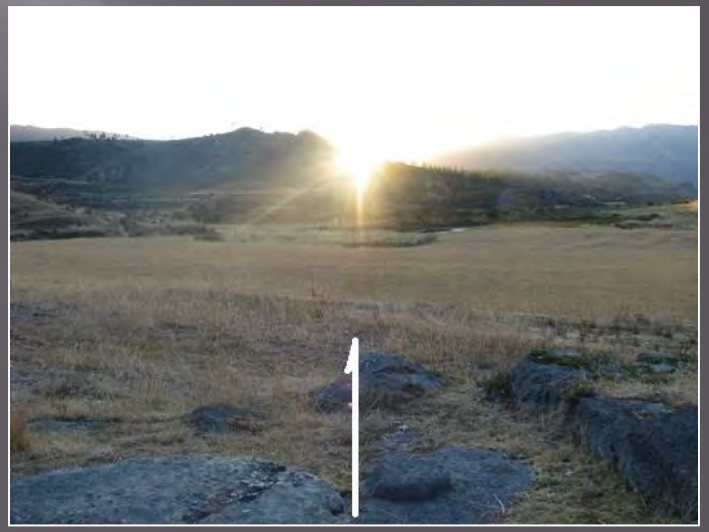
Southeast Cave



Huaca of Solar Events

- Limestone outcropping
- Two carved circles
- Carved seats
- Alignments for solstice and equinox horizon events

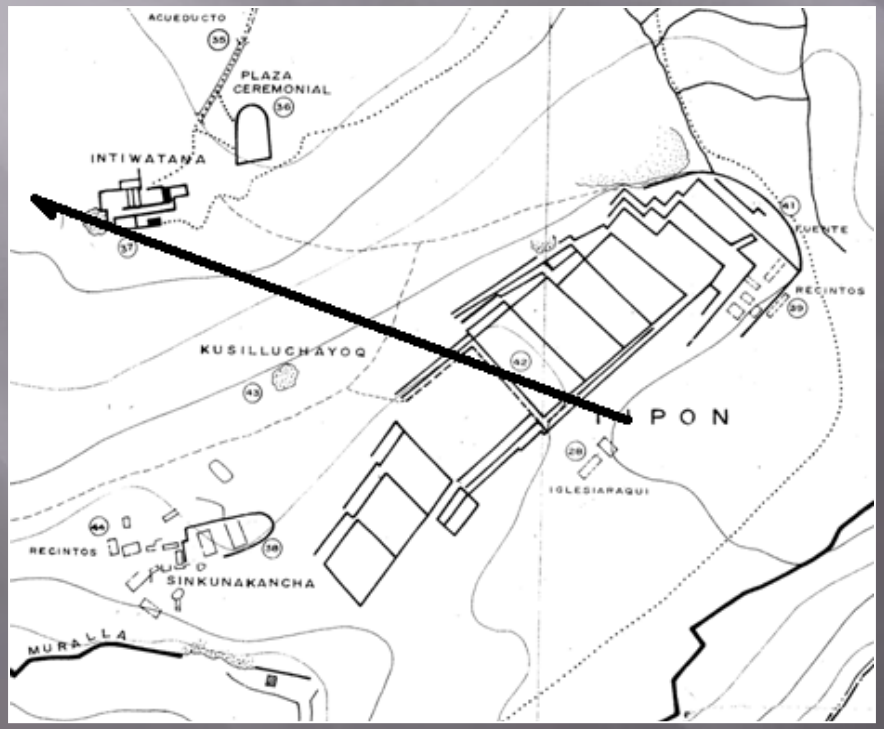




June Solstice Sunrise

Tipon

- Terraces and fountains
- Intihuatana
- Elite/non-elite viewing of the June solstice sunset



Saihuite

In Saihuite the axis between the horizon points of the June solstice sunrise and December solstice sunset dominates the upper sector of the complex.

The Principal Stone lies with the adjacent structure on the axis of the June solstice sunrise and December solstice sunset.

Saihuite

Niche and corridor aligned for the June solstice sunrise.

Saihuite

Niche and corridor aligned for the June solstice sunrise.

Sacred Valley Region

Chinchero
Pisac
Quespiwanka
Cerro Pumahuachana
Cerro Unoraqui
Choquequilla
Ollantaytambo

PISAC

Intihuatanas, or “hitching places of the sun,” are found at Machu Picchu, the Urubamba River, and Tipon and likely were places of solar worship.

In Pisac the intihuatana is a large, partially carved rock in the temple group that is enclosed by a semi-circular masonry wall adjoining a straight masonry wall in the form of the letter “D”.

It displays a stone gnomon on its flat upper surface within the walled enclosure. The gnomon aligns with a nearby peak in the 065° direction of the June solstice sunrise.

PISAC

The Intihuatana of Pisac

PISAC

Immediately to the east of the Intihuatana is another enclosed rock which appears to be an observing platform, or usnu. It opens on the southeastern horizon toward the 114° direction of the December solstice sunrise.

PISAC

While the Intihuatana could be considered as a temple of the Sun, to its west is a structure called the Temple of the Moon. The temple could be illuminated by moonlight, but there are no obvious orientations.

Quespiwanka Pillars

- Sixteen towers once on Cusco horizon
- Beyond Cusco 2 survive near Urubamba on Cerro Saywa
- Mark rising Sun at June solstice when viewed from palace of Huayna Capac
- Validate chronicles of Cusco pillars

Quespiwanka Pillars

The white granite boulder of Quespiwanka in front of a modern chapel

Quespiwanka Pillars

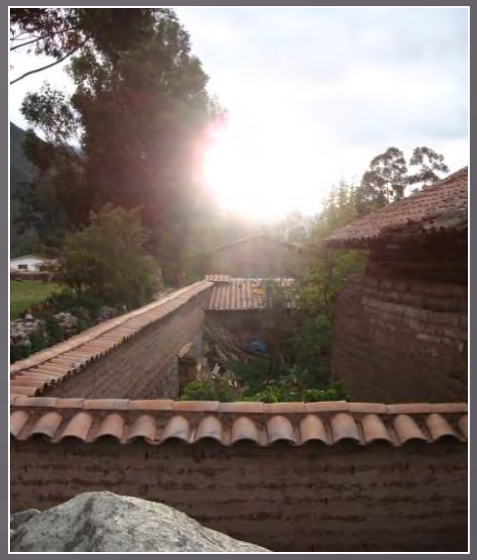
The orientation of Cerro Unoraqui as viewed across Cerro Pumahuachana from Quespiwanka in the direction (C) of the December solstice sunrise. (B) is the direction of the June solstice sunrise and (A) the June solstice sunset

Quespiwanka Pillars

Quespiwanka Pillars

Cerro Unoraqui

- DSSR view from white granite boulder at Quespiwanka
- View across Cerro Pumahuachana
- Pillars on 4377m summit
- North/South alignment



Cerro Unoraqui
4377m/14,360 ft Above Sea Level

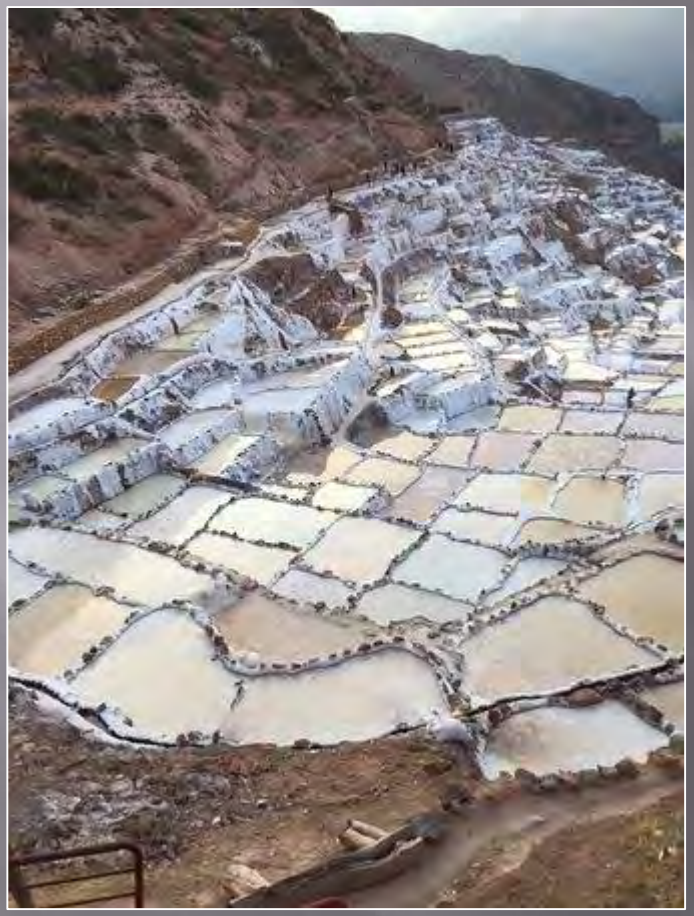
Chinchero

- Walls & terraces oriented N/S & E/W
- South determined by gnomon
- North, East & West established geometrically
- Titikaka & Chinkana on 065/245 degree axis of JSSR/DSSS

Chinchero

Titikaka and the direction of December solstice sunset as viewed from the top of Chinkana.

Maras



Salt ponds

No supportable astronomy

Moray

Muyu A

Moray

As part of his estate of Chinchero, Topa Inca, fashioned three natural sinkholes into a remarkable set of terraced basins.

A major break-through in the understanding of Moray came from the hydrological analysis of the Wright Paleohydrological Institute. Their work established that the basins could not have functioned as irrigated agricultural lands.

Water channels were designed to feed water to drop structures near the southern end of the basins, but water would have had to flow uphill to reach the northern portions of the terraces.

Moray

Wright and colleagues have concluded that the basins were primarily designed for ceremony and ritual.

The shaped basins could have been "inverted" huacas, animated by the water flowing into them.

Ceremonies intended to encourage rainfall may have taken place when water was released from the reservoirs above the basins.

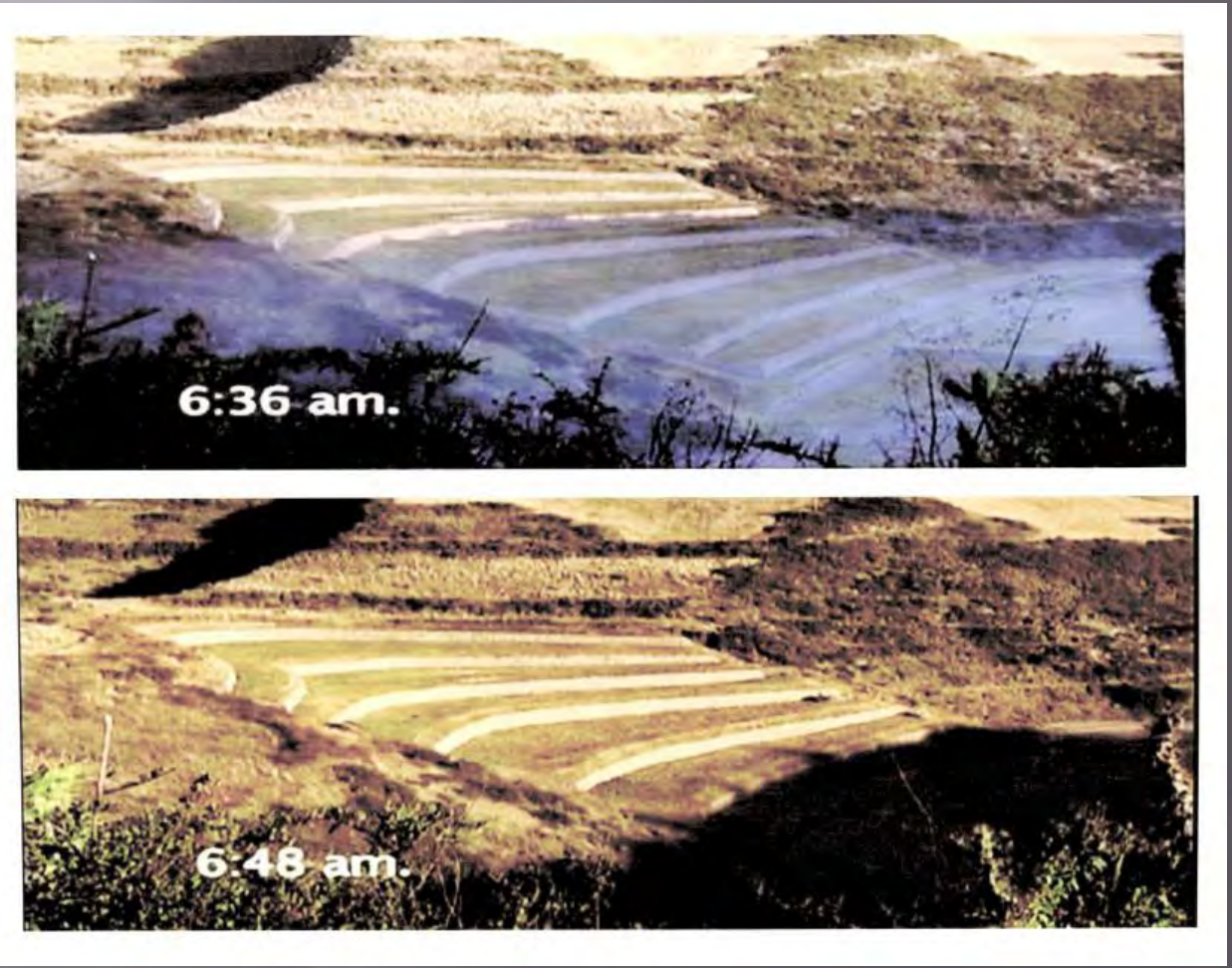
A dramatic public ceremony may also have occurred on the days of the zenith sun, when terraces would cast no shadows and the light of the Sun would pass directly into the Earth and Pachamama.

Moray

Celebrations at June solstice are indicated by the nine linear terraces, which are aligned with the moving shadow of the rising sun, a remarkable engineering feat.

The smallest of the muyus, D, above the terraces, appears to have been ceremonially important as a site for observing June solstice sunrise. The line to June solstice sunrise crosses the Ceremonial Platform. Sunrise occurs slightly to the south of Cerro Chicón.

Moray



June Solstice Sunrise shadows on the linear terraces of Moray

Ollantaytambo

Pachacuti conquered and razed the original settlement at Ollantaytambo and built his own personal estate, which included a ceremonial center containing massive stonework, elaborate stone carvings, and a water shrine with water channels and fountains.

Ollantaytambo

The most striking feature when first approaching Ollantaytambo is a magnificent set of 17 stone terraces that ascend the hillside.

The extensive terraces of Pumatillis face out to the rise of the December solstice sun and, in the opposite direction, face in toward and frame nicely the June solstice sunset.

Ollantaytambo

What is sometimes known as Ollantaytambo's Temple of the Sun was extensively damaged by the Spanish in their purge of indigenous religion, however a foundation and a wall of six monoliths survives. The wall faces the Pinkuylluna mountain, which from this location is close to the orientation of the rise of the June solstice sun.

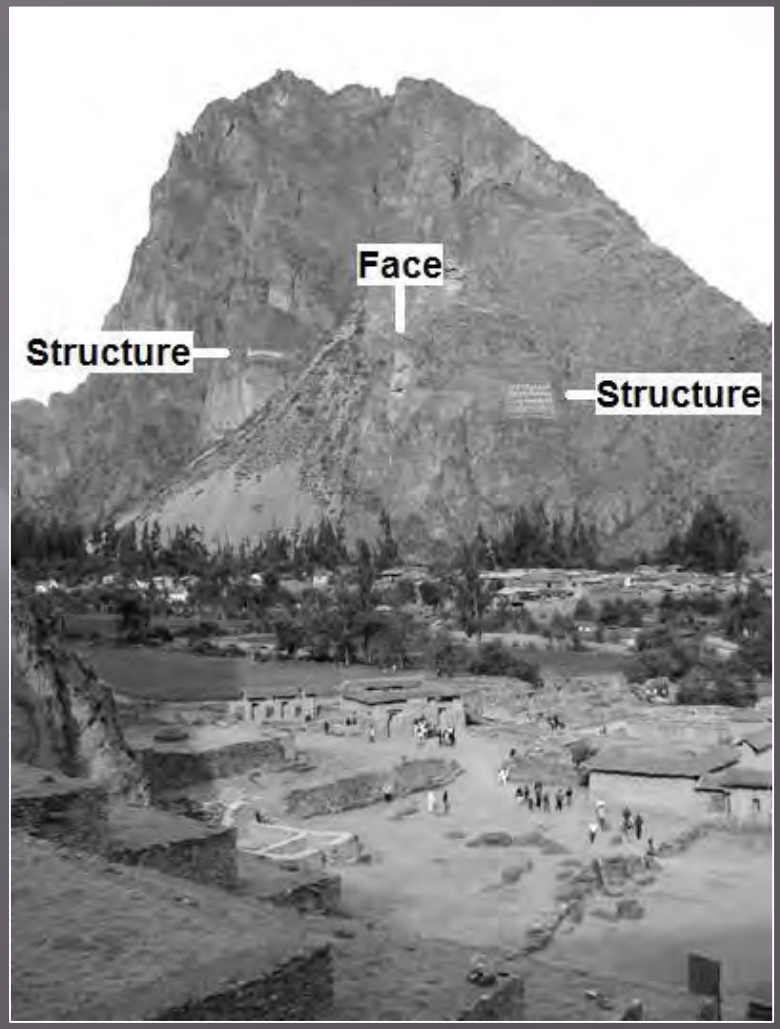
Ollantaytambo

The Pinkuylluna mountain lies opposite Ollantaytambo to the northeast and aligns with the June solstice sunrise as viewed from the Temple of the Sun.

The mountain exhibits two structures and a face on its side.

Ollantaytambo

Pinkuylluna mountain



Ollantaytambo

While the Temple of the Sun was the primary site for ceremony in Ollantaytambo's hanan, or upper, sector, the Incamisana was its ceremonial counterpart in the lower hurin sector.

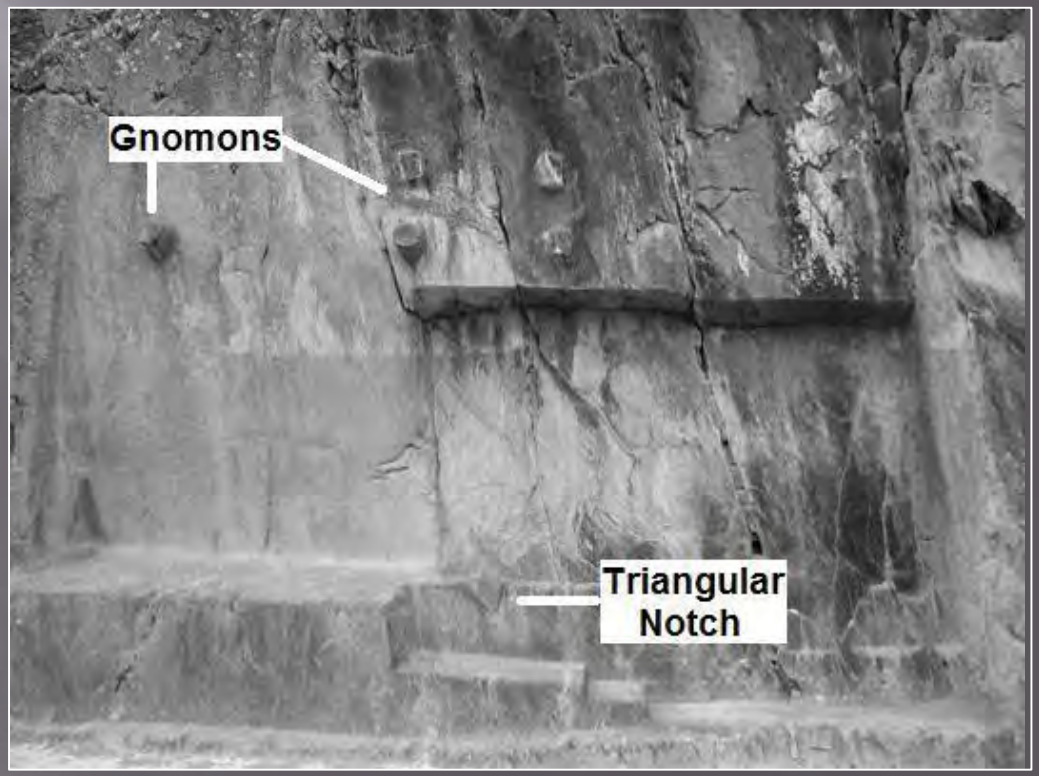
Horizontal gnomons project a distinct shadow effect.

Ollantaytambo

The Incamisana

Ollantaytambo

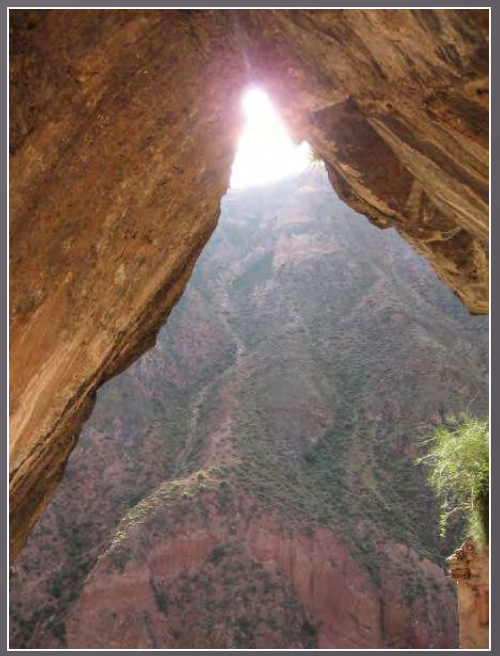
The horizontal gnomons of the Incamisana



Ollantaytambo

On the December solstice at local noon the shadow of one of the gnomons is said to reach down and "insert" itself to fill a carved triangular notch in the base below.

Choquequilla



- Associated with Ollantaytambo
- Cave opens to December solstice sunrise
- Black granite huaca faces inward with carving similar to the Fountain of the Nuestros

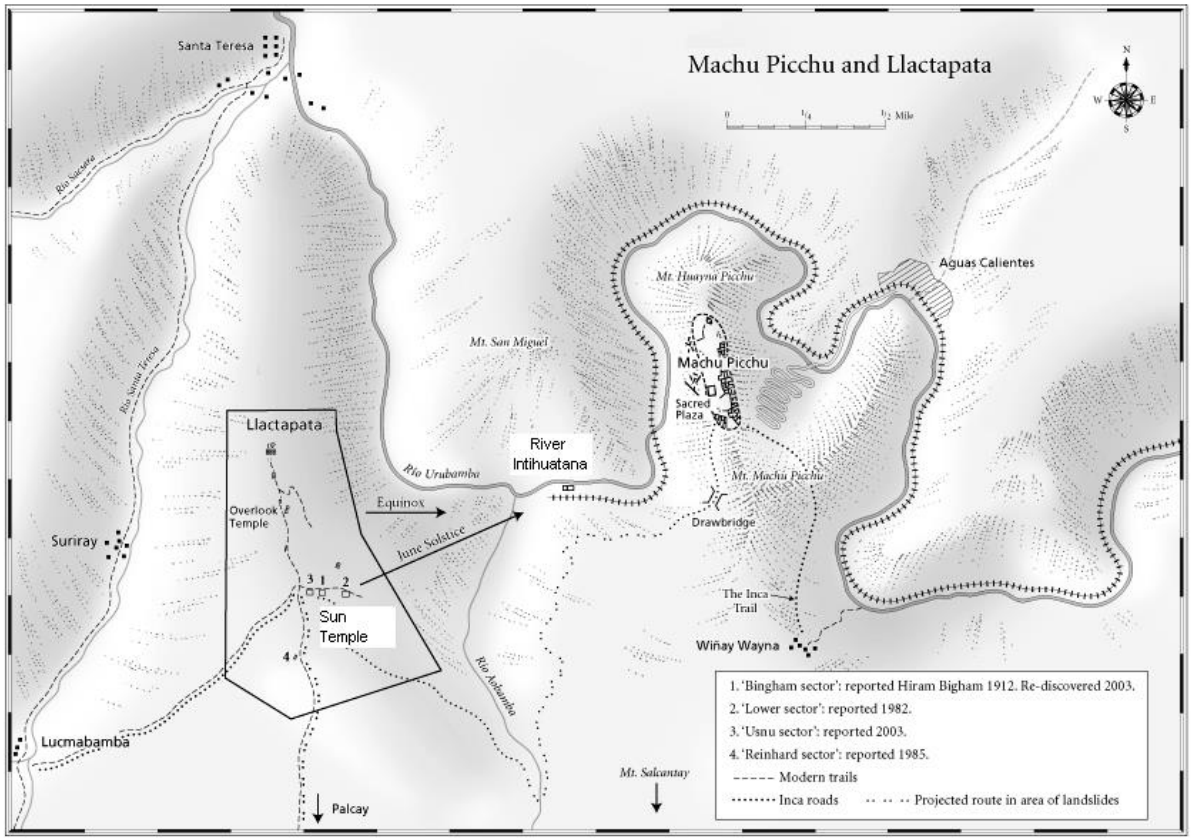
Machu Picchu Region

Machu Picchu

River Intihuatana

Llactapata

Machu Picchu Region



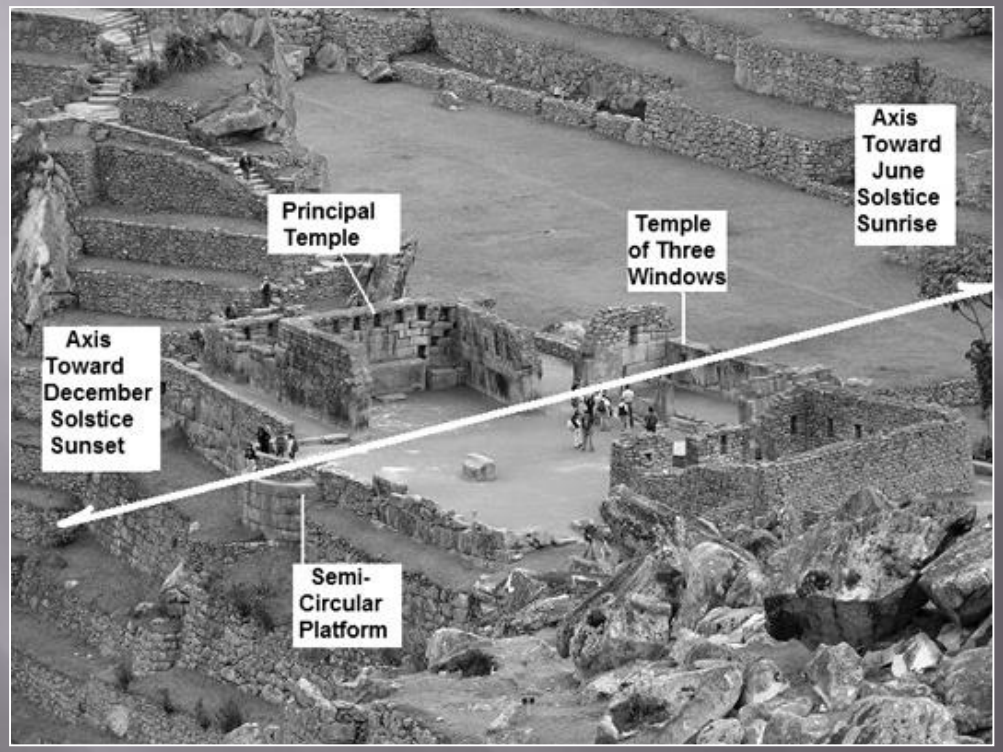
- Llactapata
- River Intihuatana
- Machu Picchu
- JSSR-DSSS Axis
- Equinox Axis

Machu Picchu, Llactapata, and the River Intihuatana

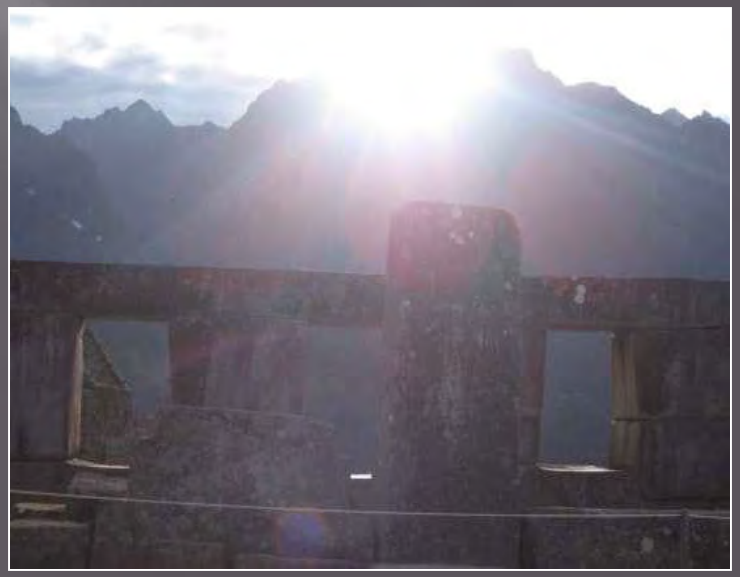
Switchbacks between Machu Picchu and Aguas Calientes

Machu Picchu

Machu Picchu - Sacred Plaza



- Principal Temple
- Temple of Three Windows
- Semi-circular platform
- JSSR-DSSS Axis



The Mortars

The Mortars

Carvings called The Mortars, located within a building in the Eastern Urban Sector, are two carved shallow basins situated on a floor surrounded by walls and are oriented such that on the day of an equinox mid-morning sunlight will pass thru an adjacent window (to the right of the mortars) and cast a reflection off the water within the northern mortar basin.

The two mortars are aligned approximately north and south with respect to one another.

Intimachay

In the Eastern Urban Sector lies a cave called the Intimachay. It has been said that this cave was constructed to observe sunrise at the time of the December solstice and the festival of Capac Raymi.

A tunnel-like horizontal light-tube was oriented to admit sunlight to the cave for about 10 days before and after the solstice. It was aligned so as to cast a shaft of light to the back of the cave during this period. The window did not function to illuminate the cave, but instead was aligned precisely with the December solstice sunrise

According to Cobo, Capac Raymi was a festival celebrated by the nobility that included ceremonies of passage to manhood for young Inca noblemen. A site such as this could have played a role.

Intimachay

Temple of the Condor

South of the Intimachay is the Temple of the Condor where designers carved a head in stone while incorporating in situ rock as wings in the site's overall visual image of a condor, the creature that represented Hanan Pacha, their world above.

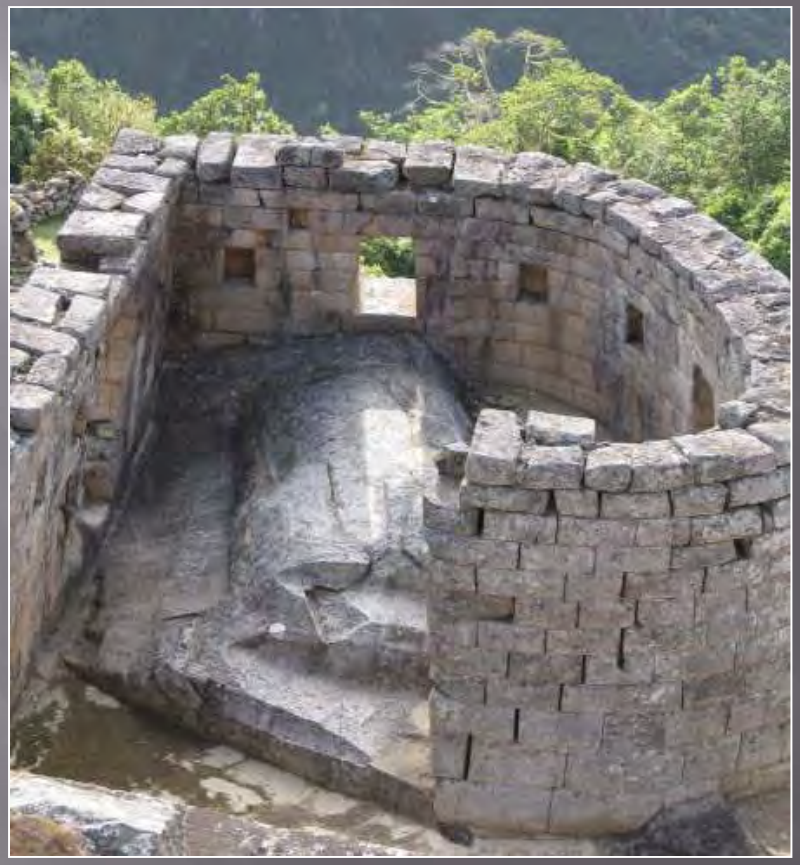
Zuidema argued that the Inca were interested in the timing of the region's anti-zenith passages of the sun, occurring on April 26th and August 18th, the two days that the sun is at nadir for the latitude of Cusco.

The Temple of the Condor's cave is oriented to the anti-zenith sunrise with a true azimuth of 074°, and therefore could have played a role in associated ceremonies if such festivities took place.

As the Sun rises on or near days of the anti-zenith, or nadir, its rays pass between two external structures, illuminate the condor stone, and extend beneath the boulder to the stairs at the cave's entrance.

Temple of the Condor

The Torreon



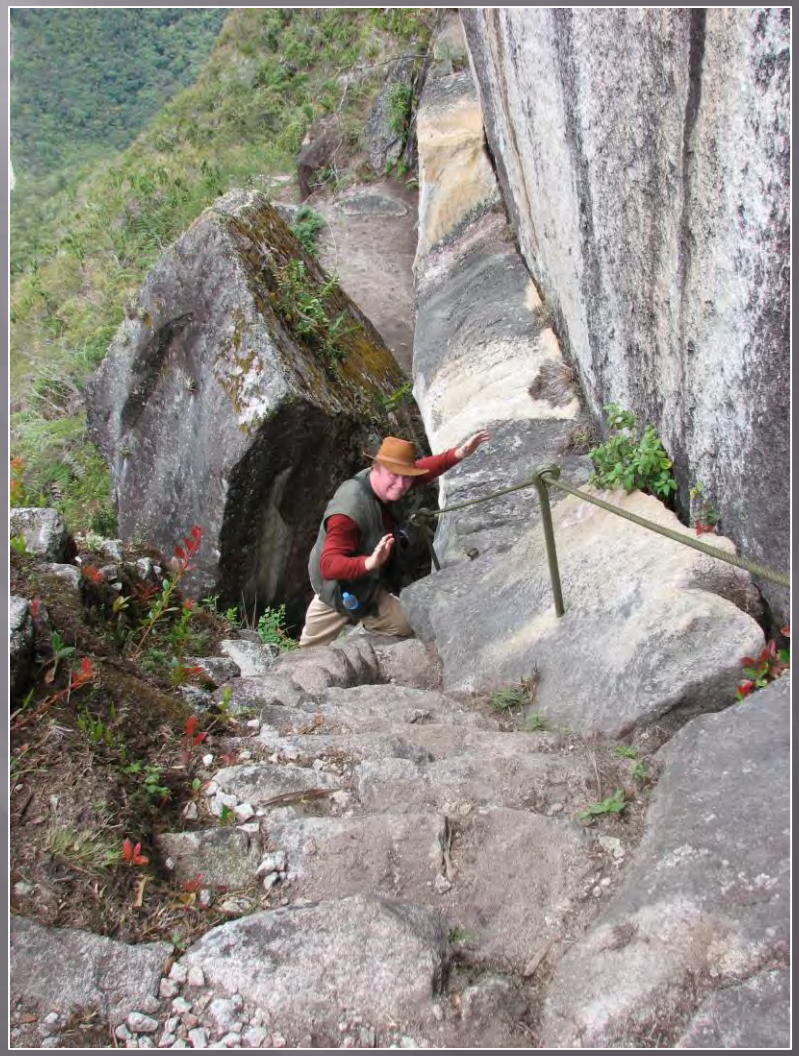
Contains a carefully fitted rock wall that includes a window open to the horizon positions of the June solstice sunrise and the heliacal rise of the Pleiades.

The Gran Caverna

The Gran Caverna includes the Temple of the Moon and is located far below the peak of Huayna Picchu on its northwest face.

The Gran Caverna

The Gran Caverna



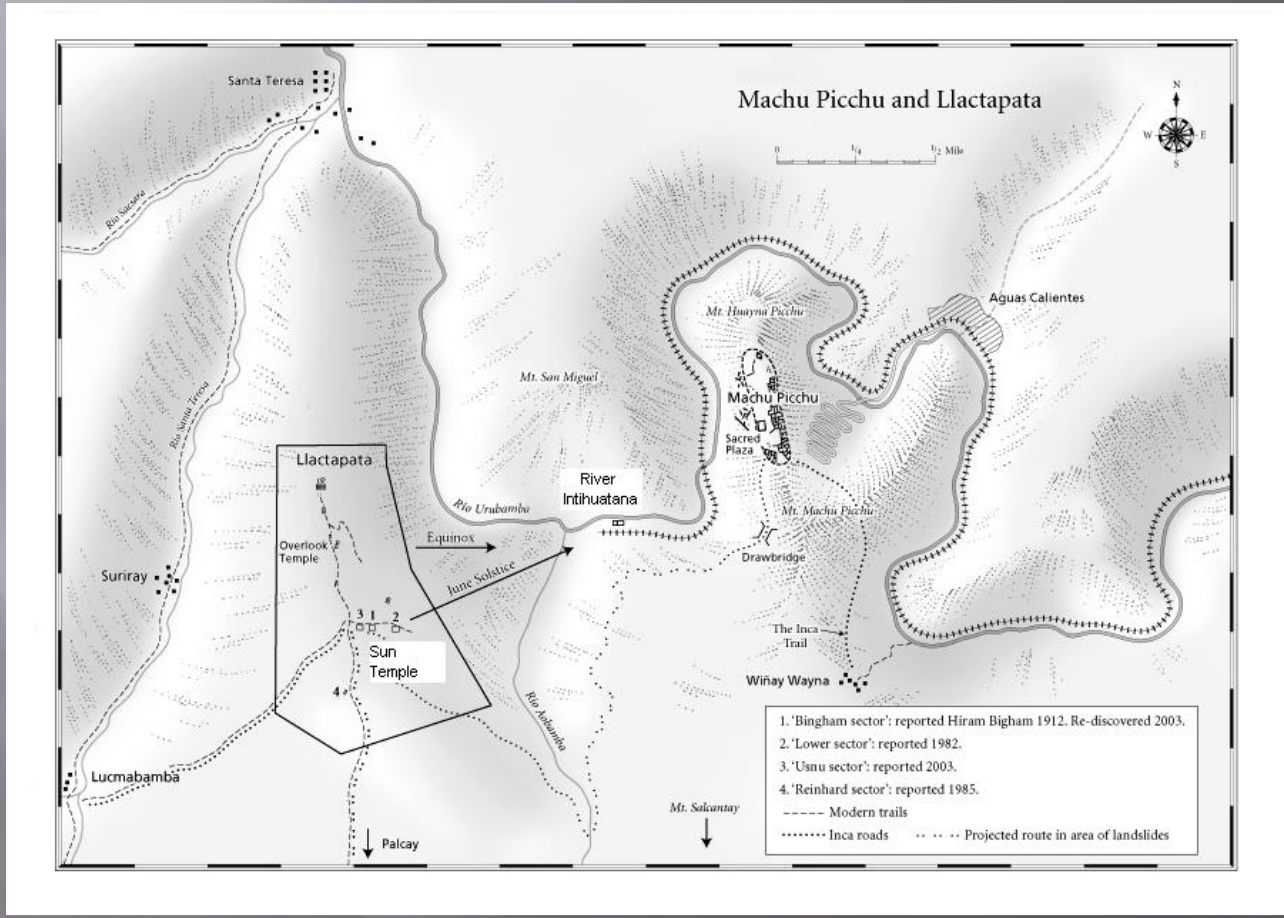
The Gran Caverna

The Gran Caverna

- Northwest face Huayna Picchu
- Upper cave 5 double-jamb niches

- Lower cave door and windows open to June solstice sunset

Machu Picchu Region



Machu Picchu, Llactapata, and the River Intihuatana

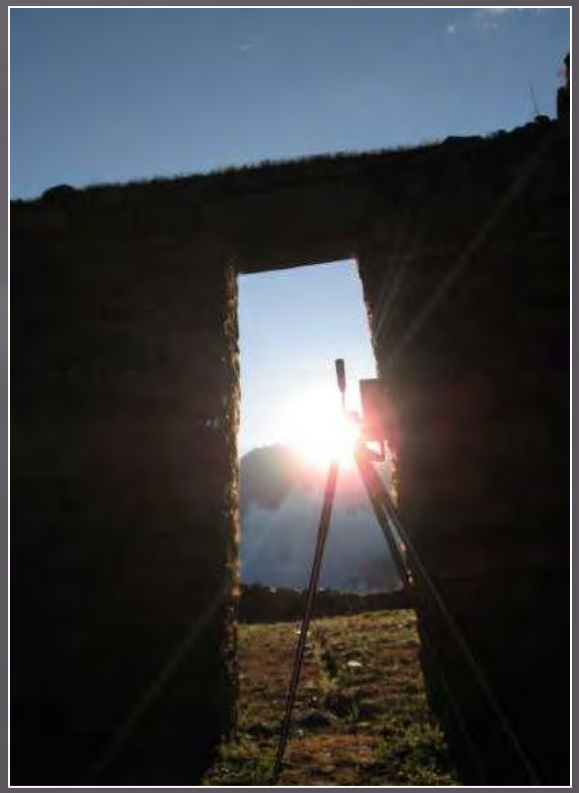
Machu Picchu Intihuatana and Llactapata

Llactapata

- Overlooks Machu Picchu 5 km
- Rediscovered 2003
- Aligned for June solstice sunrise & Pleiades rise

Llactapata

- Overlooks Machu Picchu 5 km
- Rediscovered 2003
- Align June solstice sunrise & Pleiades rise – El Niño



Sun Temple Llactapata

Sun Temple Llactapata

June solstice sunrise

The River Intihuatana

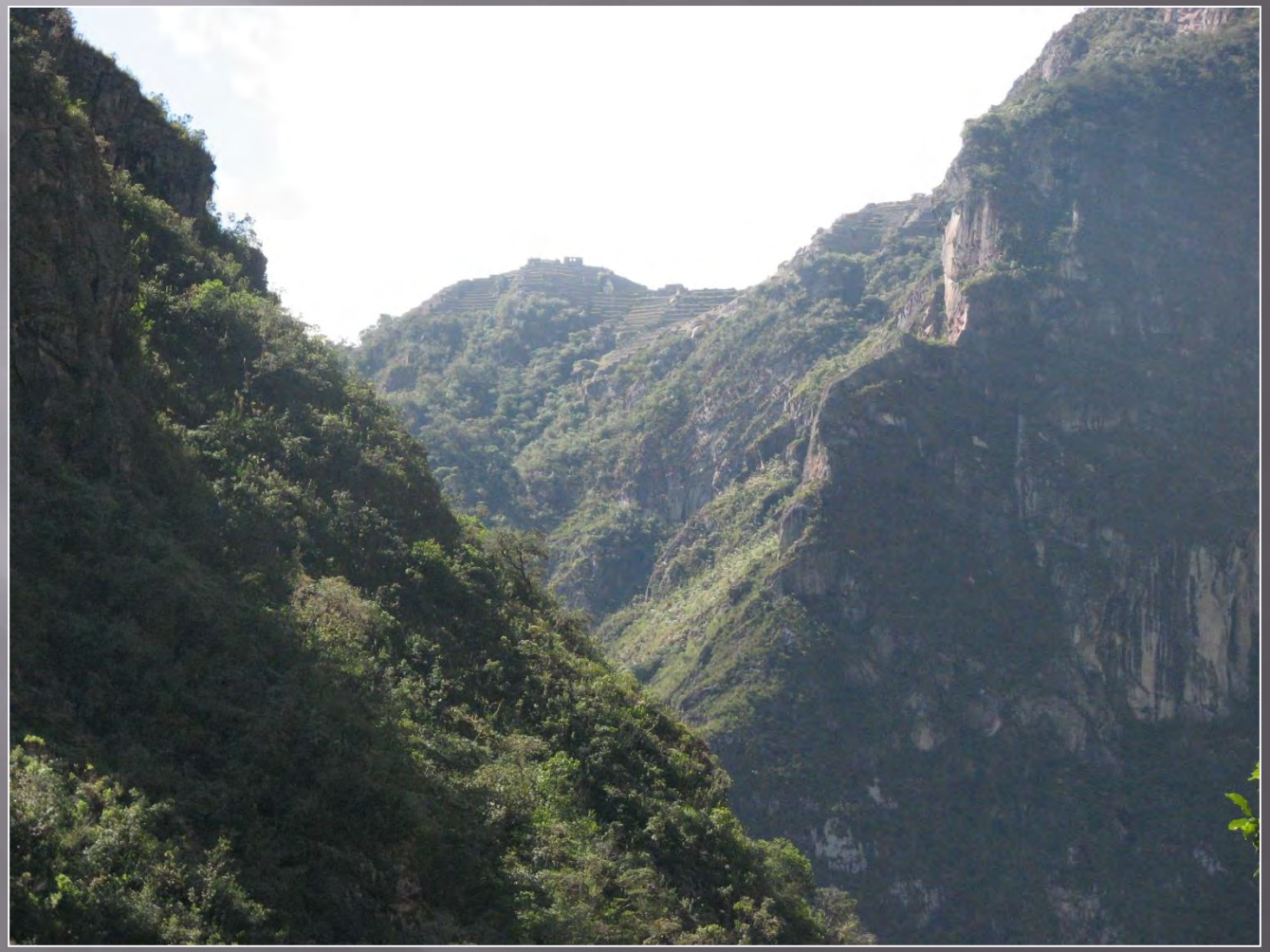
- Urubamba River canyon
- Carved granite
- Between Machu Picchu & Llactapata
- Platform, steps, fountain, basins, cave
- Hiram Bingham 1911

River Intihuatana

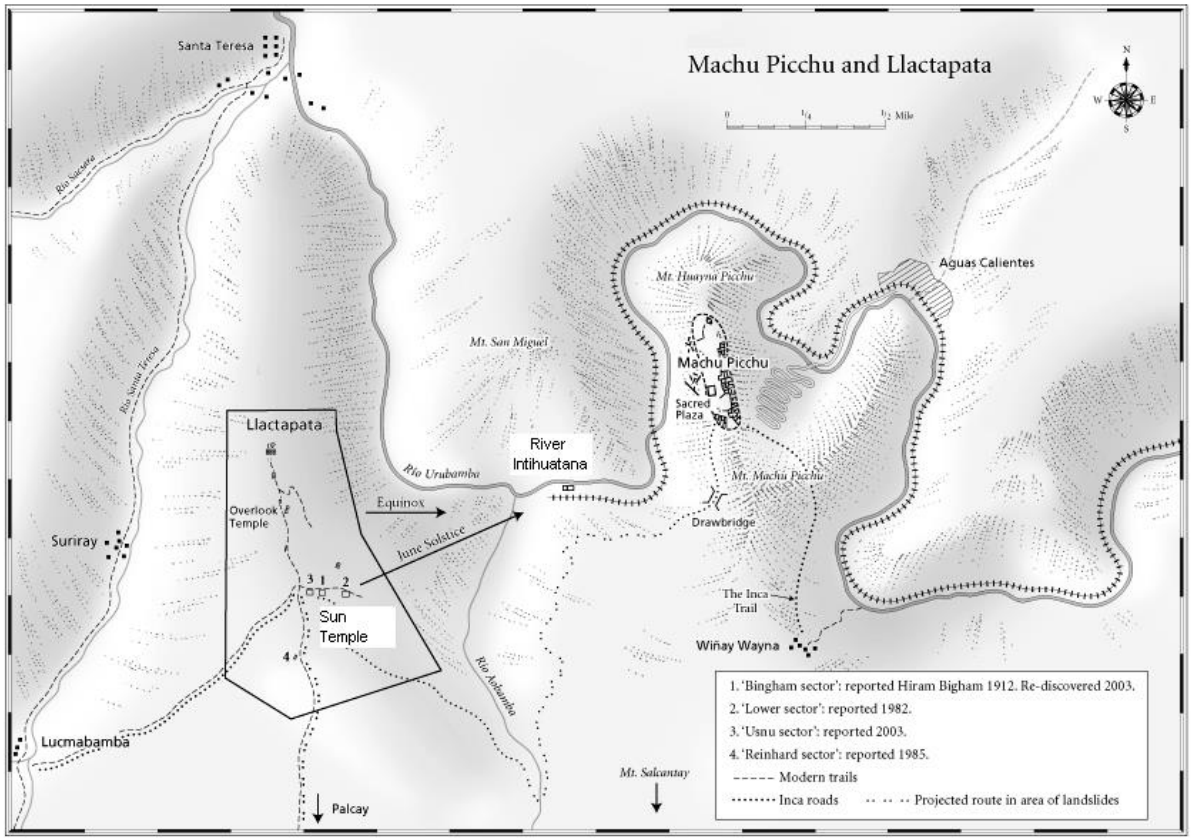
- Urubamba River canyon
- Carved granite
- Between Machu Picchu & Llactapata
- Platform, steps, fountain, basins, cave

Sightline to Machu Picchu Intihuatana and Sacred Plaza

Machu Picchu Intihuatana and Sacred Plaza



Machu Picchu Region



- Llactapata
- River Intihuatana
- Machu Picchu
- JSSR-DSSS Axis
- Equinox Axis
- Ceremonial Complex

Machu Picchu, Llactapata, and the River Intihuatana

Example of Findings

Section	Huaca	JSSR	JSSS	DSSR	DSSS	ESR	ESS	Zenith	Anti-Zenith
9.2	Kenko Grande	X		X		X	X		
9.3	Kenko Chico			X					
9.4	Mesa Redonda								
9.5	Tetecaca								
9.6	Patallacta								
9.7	Kusilluchayoc		X						
9.8	Lacco	X						X	
9.9	Solar Horizons	X	X	X	X	X	X	X	
9.10	Lanlakuyok					X			
9.11	Puca Pucara					X	X		
9.12	Tambomachay			X					
9.13	Sacsahuaman							X	X
9.14	Mollaguanca	X			X				
9.15	Sapantiana								
9.16	Rumiwasi Bajo			X					
9.17	Rumiwasi Alto			X					
9.18	Kusicallanca			X					
9.19	Tipon		X						
9.20	Saihuite	X							

Huaca Astronomical Orientations in the Cusco Region

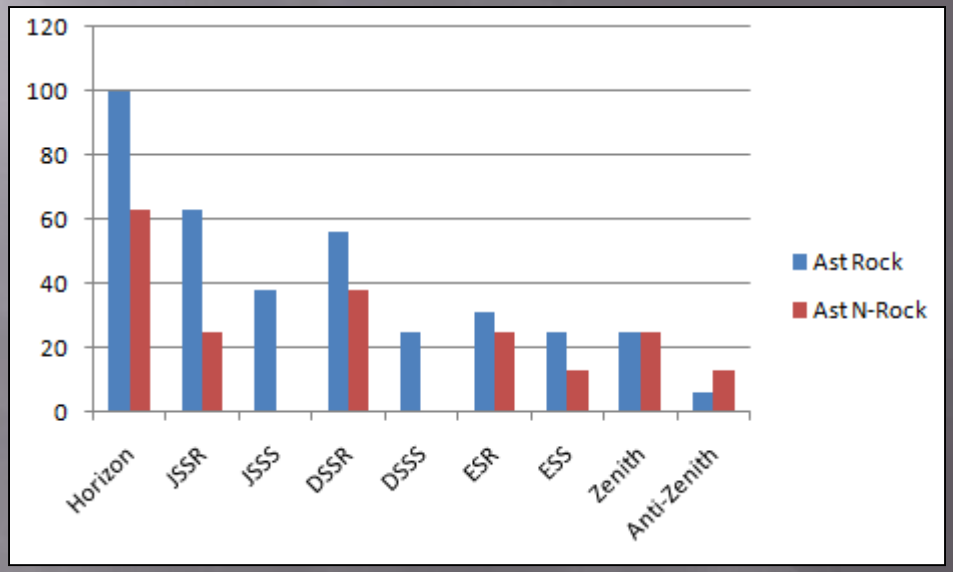
Example of Findings

Section	Huaca	JSSR	JSSS	DSSR	DSSS	East/ESR	West/ESS	Zenith	Anti-Zenith
10.2	Chinchero	X			X	X	X		
10.3	Pisac	X		X					
10.4	Quespiwanka	X	X	X					
10.5	Cerro Pumahuachana								
10.6	Cerro Unoraqui								
10.7	Choquequilla			X					
10.8	Ollantaytambo	X	X	X				X	

Section	Huaca	JSSR	JSSS	DSSR	DSSS	East/ESR	West/ESS	Zenith	Anti-Zenith
11.2	Machu Picchu	X	X	X	X	X		X	X
11.3	River Intihuatana					X		X	
11.4	Llactapata	X							

Huaca Astronomical Orientations in the Sacred Valley and Machu Picchu Regions

Example of Findings



Percentages of Astronomical Alignments per Huaca Category

Category	Horizon Events	JSSR	JSSS	DSSR	DSSS	ESR	ESS	Zenith	Anti-Zenith
Astronomical Rock	100%	63%	38%	56%	25%	31%	25%	25%	6%
Astronomical Non-Rock	88%	25%	0%	38%	0%	25%	13%	25%	13%

Percentages of Astronomical Alignments per Huaca Category

Summary

Findings show that the Inca landscape most definitely is filled with examples of astronomy used in their culture. Examples of light and shadow effects throughout the year, especially at times of the solstice, equinox, zenith and anti-zenith suns, were found at many sites.

Regarding the 8 primary solar horizon events, those at the solstices were most prominent. June solstice sunrise occurred most often, but December solstice sunrise was a close second.

Two of the Inca's primary annual festivals occurred at these two times of the year.

Astronomy was thoroughly interwoven throughout Inca society.

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Questions?