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La Horca del Inca— an astronomical observatory?

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Abstract. While celebrating the International Year of Astronomy 2009, some government and private institutions in Bolivia pointed out the need to raise a petition to UNESCO and the IAU aimed at declaring the monument known as 'La Horca del Inca' (The Inca's Gallows) to be an astronomical World Heritage Site. The request was made because La Horca del Inca was assumed to be a pre-Columbian astronomical observatory. In this paper we analyze the reliability of that postulate through a twofold approach: 1) by examining the most relevant publications, both archaeological and astronomical, that conclude that the site was indeed a pre-Columbian astronomical observatory; and 2) by independently visiting and surveying the monument and its surrounding area.

Keywords. observatories: ancient, Horca del Inca

1. Introduction

La Horca del Inca (The Inca's Gallows) is an archaeological monument situated in the Copacabana peninsula, on the shores of Lake Titicaca (16.17° S, 69.08° W). Since pre-colonial times, this has been one of the most important sacred areas in the Andean region. On the western slopes of Kesanani hill to the south of Copacabana town is an archaeological complex: La Horca del Inca is its main and most suggestive structure. It comprises two huge standing rocks, set approximately one meter apart, with a third smaller rock set horizontally between them three meters above the ground, resting on artificial indentations, resembling a door lintel.

While there are plenty of publications relating to La Horca del Inca, most of them give archaeological and historical descriptions of the monument. Very few works interpret it as an astronomical observatory. It seems that the first to suggest this idea was a German researcher, Hermann Trimborn, in a study named *Archëologische Studien in den Kordilleren Boliviens*, published in 1959 (quoted by Rivera 1984: 96). However, the two main works putting forward this idea appeared in the 1980s: one by Osvaldo Rivera (Rivera 1984) and the other by Juan de la Cruz Zapata (Zapata 1983). Later published works on the subject, among them Boero (1993) and Bauer & Stanish (2001), will be not considered further as they are basically a repetition of the earlier works of Rivera and Zapata.

2. Osvaldo Rivera and the Horca del Inca

Rivera's work starts with a summary of what has been written about the monument, from the work of Ramos Gavilan, a 17th-century commentator, through to that of Carlos Mesa and Teresa Gisbert in 1973. Rivera emphasizes that the monument remains the same nowadays as it was in colonial times, and that this is also true of its name. He goes on to summarize different researchers' interpretations of the monument's function.

In the last part of his paper, Rivera presents his own research on the site, carried out in 1978, featuring a description and measurements of the monument itself together with descriptions of other man-made structures such as a possible dismantled wall, an indent in the rock for a door frame, some steps of a staircase, and the remains of rooms.

Finally, he describes his observations of sunrise over La Horca del Inca on the winter solstice, June 21, 1978, and what he took to be the spring equinox, September 21. A summary of those observations can be found in a sketch attached to the paper (see Fig. 1). He identified a hole though which sunlight would shine on the lintel at the winter solstice and a rocky protuberance 39.63m to the east whose shadow would fall on the lintel during the equinox.

What Rivera actually measured were the distances between the putative sun markers and the possible observation point, plus the diameter of the hole from which the beam of sunlight would emerge to fall on the lintel on the solstice. None of the reported observations includes data on time, or the azimuthal positions or elevations of the possible sun markers. It is reasonable to deduce that, apart from a measuring tape, the author did not use measuring instruments of any kind. The only quantifiable datum useful for an analysis of the astronomical positions is the phrase "very near to 8:00 am" (Rivera 1984: 98) describing the time when the sun appeared during the observation on June 21.

Added to this, the date of the equinox chosen wrongly. The spring equinox of 1978 actually took place at 09:25 on September 23. As his measurement was taken two days before the actual equinox, Rivera observed a shadow cast by the sun whose azimuth was approximately 1° 12′ away from that at the actual equinox.

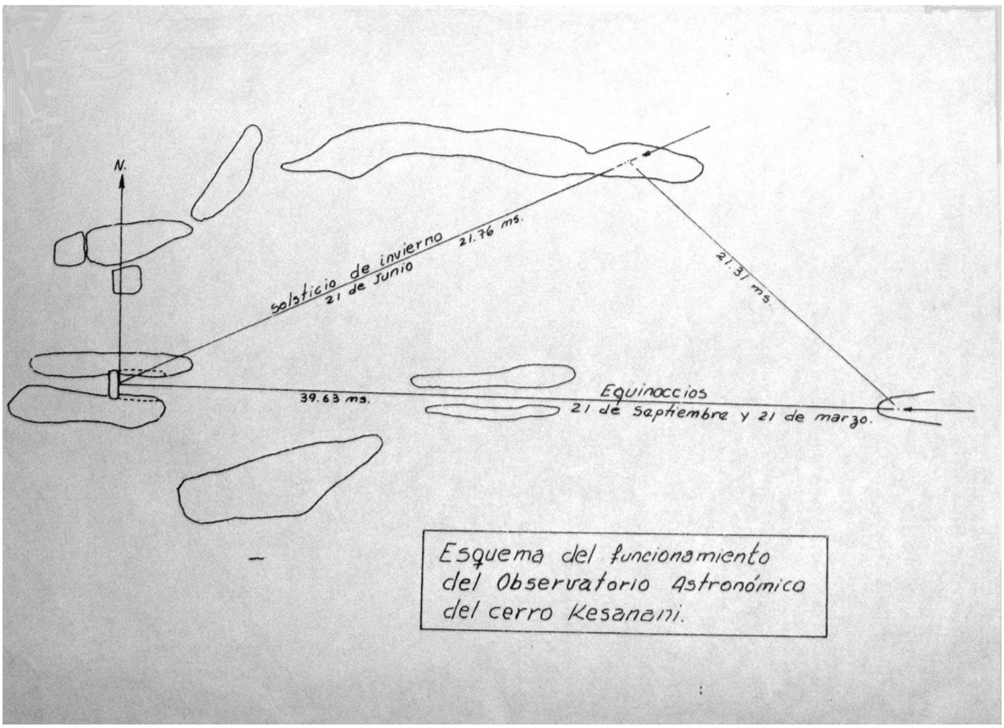

Figure 1. Sketch of Osvaldo Rivera's observations (Rivera 1984).

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Be all this as it may, the main problem we find in Rivera's work is what is known as the 'enumeration of favourable circumstances'. This happens when an author only takes into account the favourable elements—those that help to confirm his hypothesis, in this case, that the site was an 'astronomical observatory'. Rivera only describes one hole through which the sun shines, choosing it because the beam falls on to the lintel during the June solstice, without even mentioning the existence of several other holes in the vicinity. Equally, the rocky protuberance whose shadow falls on the lintel at (or, actually, close to) the equinox is only one of several nearby. This is extremely important, since it means that the possibility that the monument was an 'astronomical observatory' can be ruled out on statistical grounds. (On the importance of statistical rigor in the study of archaeoastronomical alignments, see for example Heggie 1982; Ruggles 1989; 1999.)

Added to this, Rivera does not address the question of whether the holes and protuberances were man-made or could have been caused by natural erosion processes. Meanwhile, his explicative model of an 'astronomical observatory' fails to include any of the other features described in his paper that clearly *were* man-made.

3. Juan Zapata and Kesanani Hill

The work published by Zapata in 1983 is the result of measurements taken of various archaeological and natural structures on Kesanani hill. Zapata made the measurements on behalf of Rivera and Hugo Boero in order to have "measured proof of the findings of the mentioned researchers" (Zapata 1983: 1) as well as being able to present other putative astronomical alignments discovered by himself.

We should make clear that Zapata's use, both in his title and throughout his paper, of the term *orto* ('rise') to refer at the appearance of the sun or moon is a dubious one. The expression actually refers to the moment when an astronomical body reaches an altitude of 0°. This is impossible at the Horca del Inca because it is sited on the western slope of Kesanani hill; in the case of sunrises near to the equinoxes, we have to wait until the sun is over the hill, by which time it is at a high altitude. It is generally accepted that horizon astronomy in South America—and, indeed, in the Americas in general—was based on actual observations of nature rather than geometrical abstractions (Iwaniszewski 2004; Zuidema 1988).

Zapata's work is summarized in a figure entitled "Plane projection of the surroundings of the site called 'Horca del Inca' " (see Fig. 2); a graph showing the "variation in the obliquity of the ecliptic and the maximum orbital inclination of the moon as a function of T"; and a table that summarizes the results of his theodolite measurements, together with some comments (see Fig. 3).

Comparing Zapata's sketch (Fig. 2) with Rivera's (Fig. 1), Rivera's selective bias in naming only two favourable observing points becomes evident. Zapata records 32 points—holes and protuberances in the rock—that fall within the 'solar arc' to the east of La Horca del Inca, and are equally viable *per se* as markers for astronomical alignments. Furthermore, an *in situ* observation of our own showed that even Zapata was selective: in fact there are many more potential markers for astronomical alignments (both holes and protuberances) than are shown in his plan. They are clearly due to strong erosion of the rock in the area.

The quantity of potential markers for alignments lead us to conclude that, statistically speaking, it would have been be quite a challenge to use La Horca del Inca as an 'astronomical observatory'. Even if we only take in account the 32 points recorded by Zapata, we would have 992 possible alignments, enough to record an average of approximately 2.7 phenomena each day.

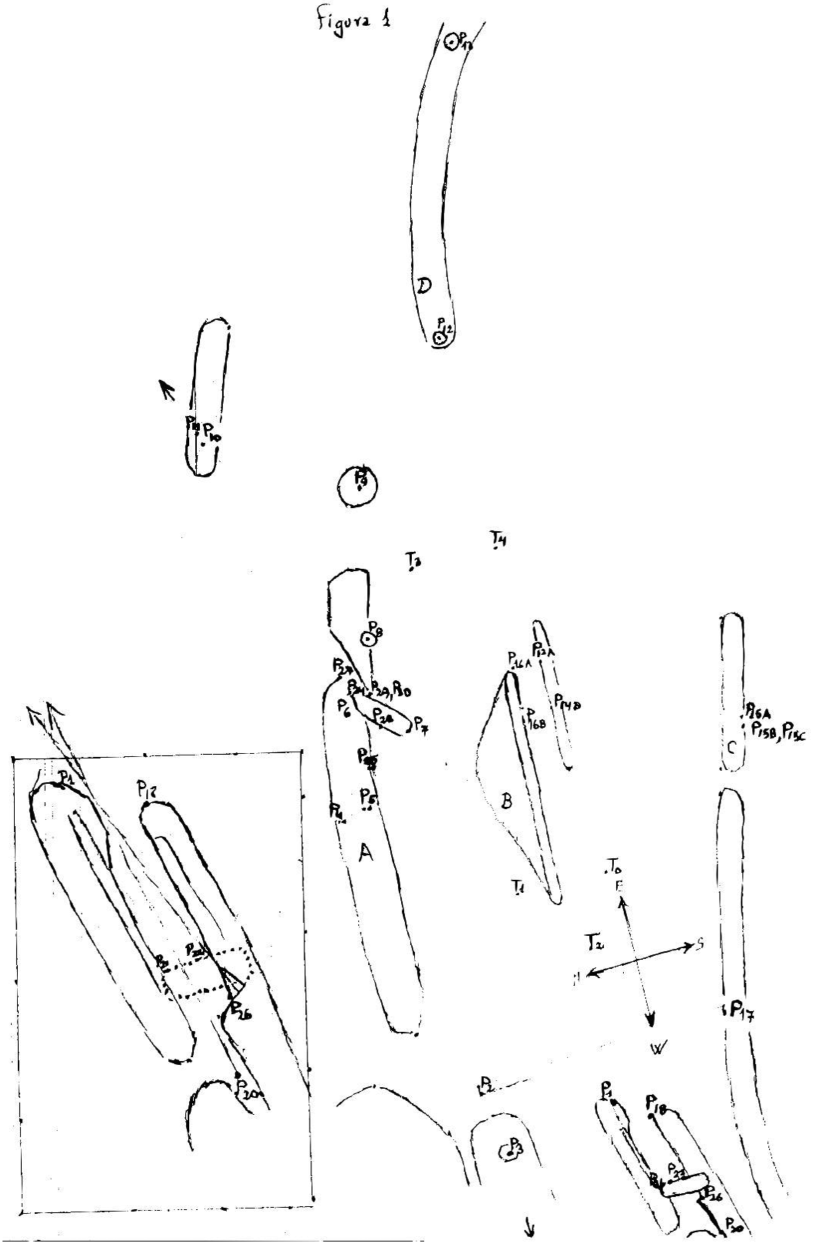

Figure 2. Sketch of Juan Zapata's observations (Zapata 1983: 2, fig. 1).

Zapata himself analyzes these 32 potential alignment markers, but only taking into account those related to the solstices, equinoxes, and major and minor lunar standstills. He lists seven alignments as signficant, two of which are those identified by Rivera, together with five more of his own. However, there is no good reason to identify this particular set of potential astronomical targets, particularly the lunar ones. We surmise that Zapata was influenced by Gerald Hawkins' studies on Stonehenge, England (Hawkins 1964); certainly there is no evidence that Andean cultures' sky perception included an awareness of those lunar events.

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TABLA I

Observador en	Observa a	Azimut medido	Astro-objeto	inclinación orbital	E. horizontal	E. vertical
P_{20}(canal)	P_{27}(punta)	250.8461	luna(salida)	18.350	0.9215	-3.0019
	P_{10}(sorif.)	251.0671	luna(salida)	18.350	0.9568	-3.1662
	P_{11}(sorif.)	251.0671	luna(salida)	18.350	0.8427	-2.7886
P_{22}(c.trav.)	P_5(orific.)	244.2049	sol (salida)	24.112	-0.0154	0.0456
	P12(punta)	267.9072	sol (salida)	(δ=0.000)	-0.0823	0.2819
P_{12}(punta)	P_4(orific.)	111.4539	luna(puesta)	18.350	1.8165	5.0926
	P_{15c}(orif.)	63.9688	sol (puesta)	-24.330	-0.4139	-1.2229

NOTAS: a) Los valores indicados en esta tabla están en unidades de grados de arco.
b) Como criterio de selección no se han tabulado alineaciones con errores horizontales mayores a dos grados (VER Hawking G. Ref. 4. pags. 65 y 267).

Figure 3. Table showing the measurements made by Zapata (1983: 4, table 1).

In a seven-column table, Zapata presents the results of his measurements, as follows:

• From a point below the lintel of La Horca del Inca, Zapata affirms that in the NE direction one can observe a point of rock containing two small holes; through these the moon would appear when at minor standstill. These data have no meaning at all, since from La Horca del Inca one cannot make any observations of rising bodies.

• Zapata also records astronomical alignments from the centre of the lintel. Confirming what was said by Rivera (1984: 98), he states that through a hole situated in a rock on the 'north' side of the monument one could see the 'sunrise' during the June solstice, while during the 'sunrise' at the equinox, the shadow of a rocky peak or protuberance should be projected on the lintel. Zapata's azimuth measurements are 64.2049° and 87.9072° for the June solstice and the equinox respectively (note that the values quoted in Zapata's table (Fig. 3) are 180° greater than these). We can deduce that the sun should appear in the June solstice marker hole at about 07:25, and not, as described by Rivera (1984: 98), "very near to 8:00 am". This half-hour discrepancy between the two researchers represents nearly 7°, approximately 14 times the sun's diameter.

• One column in Zapata's has the heading 'orbital inclination', referring to the inclination of the orbital plane to the ecliptic plane. In the case of our own planet, the orbital inclination is zero by definition. We must assume therefore that Zapata is referring to the apparent sun's declination, which at the June solstice nowadays is $+23° 26' 30''$ and in Inca times was about $+23° 31'$. But Zapata, inexplicably, quotes a value of 24.112° ($24° 06' 43''$), more than half a degree greater than the true value.

• As Rivera does not mention the hour of day when the shadow appeared to "cut the lintel halfway" during his observation of the September 'equinox' in 1978, we can only refer to Zapata's measurement. His quoted azimuth, and hence the azimuth of the sun, is 87.9072° ($87° 54' 26''$), from which we can infer that the time was 06:49:05 and the sun's altitude was $+04° 39' 28''$. The latter is inconsistent with the real horizon at the site. La Horca del Inca is situated on the Western slopes of Kesanani hill and, as can be seen from Fig. 4, the hill slope is a lot greater than 4°.

• The other alignments found by Zapata involve changing the position of the observer. The point of observation is now the rocky protuberance that casts its shadow onto the monument at the equinox. From here, Zapata concludes that the moon setting at minor

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Figure 4. View of La Horca del Inca from the rock claimed to be an equinox marker. Photograph: Emily Royer, archive SIARB.

standstill could be seen through a hole to the NW. Here, again, Zapata is trying to follow the ideas of Hawkins, and we repeat that no archaeological, ethnohistorical or ethnographic evidence shows convincingly that Andean peoples took into account the major or minor standstills of the moon.

- The final alignment referred to by Zapata was measured from the same point as the last one. He states that it should be possible to see the sunlight through a hole located in a rock to the SW, and that this sunlight would be "scattered over the entire lake beside the observatory" during the December solstice. There is no need for any comment.

Like Rivera, Zapata makes no attempt to discriminate which of the 32 points could have been produced by erosion, and which were man-made.

4. An 'astronomical date' for La Horca del Inca

None of the authors mentioned makes any reference to the age or cultural context of the monument, but the idea has begun to propagate more recently that the site has been dated by astronomical means. Thus "The construction of this Pre-Columbian astronomical centre was first attributed to the Incas, and then to the Tiwanacus; but a mathematical–astronomical calculation based on the precession of the Earth's axis, carried out by astronomers from the Cosmic Physics Institute, gives an approximate date for its creation of 1764 BC; this places the monument in the 'Chiripa' culture, which branched into the Tiwanacu culture" (Boero, 1993: 16). Writing in the newspaper *La Prensa* in 2002, Abdel Padilla states that "Following a study from the Chacaltaya Cosmic Physics Laboratory, the monument is [known to be] approximately 3450 years old" (October 27, 2002; p. 8B).

It should be mentioned that the Cosmic Physics Laboratory of the University of San Andrés does not undertake any kind of archaeological dating, and unsurprisingly neither article names their information source. This, then, can not be taken seriously. The sun's position *is* affected over the centuries by a small variation in the inclination of the earth's orbit ('obliquity of the ecliptic'), although not by the precession of the equinoxes. ¡However, this variation is so small that it can not be used to date an alignment. We should not forget that the builders did not have high-precision instruments and the precision of their alignments is unlikely to be better than half a degree. It takes about 4000 years for the sun to shift by this amount; in other words, it is impossible to determine a date by this method to within several thousand years (Aveni 2003; Hawkins 1966).

5. Conclusions

There is no convincing evidence that the archaeological monument known as La Horca del Inca was an astronomical observatory. The publications that developed this idea in the 1980s lack the rigor needed in order to be taken seriously. Yet despite this, they have become a source quoted by certain members of the Bolivian political and intellectual elite. They are not actually motived by an interest in whether La Horca del Inca really was an astronomical observatory, but rather in constructing a nationalism based on a glorious past, where the practice of astronomy provides imperious prestige.

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