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On the Intihuatana at Machu Picchu

Translated from German by Esther Laubsch (Leipzig)

The Intihuatana stone, which is the subject of the following paper, is situated in the ancient Peruvian city Machu Picchu about 2400 meters above sea level (fig. 1). Deep below the Intihuatana stone flows the river Urubamba and not far away Cusco, the old capital of the Incas,



Fig.1 View of Machu Picchu from southwest. - Photograph: Sabine Heinz, March 7th 2011 (with kind permission)

is located. Built approximately in 1450, the grounds of the Intihuatana stone were (re)discovered by the US-American archeologist and explorer Hiram Bingham (1875-1956) in 1911. Initially, the explorer was on a mission to find the last place of refuge of the Incas before the Spanish invasion, the legendary “Vilcabamba“. However, on July 24 in 1911, in the middle of the Andean Peruvian jungle, about 20 kilometers away from the place he was looking for, Bingham hit upon the remains of a city completely covered by jungle plants.¹ After the excavation of Machu Picchu, which was arranged by Bingham, it became obvious that the

¹ Hiram Bingham. *Lost City of the Incas*. London: Phoenix, 2011. 179ff.

Spaniards had never reached this place. Perhaps they weren't aware of its existence. This would explain why, unlike all other places of the Inca people, the site outlasted the time of Spanish occupancy without being destroyed.

Since the discovery of Machu Picchu archeologists, historians, experts in South America Studies as well as ethnologists have undertaken a wealth of attempts to uncover the secret of Machu Picchu, to unravel the function and meaning of this place and deriving conclusions about the culture of the Incas. A number of these studies focus on the Intihuatana stone as the center of a solar observatory (fig. 2).



Fig. 2 – View of the „observatory“

“Intihuatana“ is a word of the Quechua language and means “place to which the sun is chained”. The term refers to a rock construction on a platform at the highest point of the ancient city. This so-called solar stone was obviously chiselled out of a bigger rectangular piece of rock and was presumably used for casting shadows (fig. 3).

A few decades ago, the astronomer Rolf Müller (1898 – 1981) already dealt with the Intihuatana stone. In the 1920s he only by coincidence became aware of the subject when he stayed for a couple of months at the outpost of the Potsdam Astrophysical Observatory in order to undertake a survey (“Durchmusterung”) of spectra of southern stars. It was only at a much later visit, when Müller took exact measures of the rock for publications.² He found that the two largest sides of the Intihuatana stone are located 25.5° resp. 27.5° north of the western direction (fig. 4a /4b), hence, that they are directed at the points of the sunrise and sunset at the time of the solstices, i.e. at the beginning of wintertime and summertime.

² Rolf Müller. Sonne, Mond und Sterne über dem Reich der Inka. Berlin, Heidelberg, New York: Springer, 1972. 30ff.



Fig. 3 – View of the Intihuatana stone (background). - Photograph: Dieter B. Herrmann

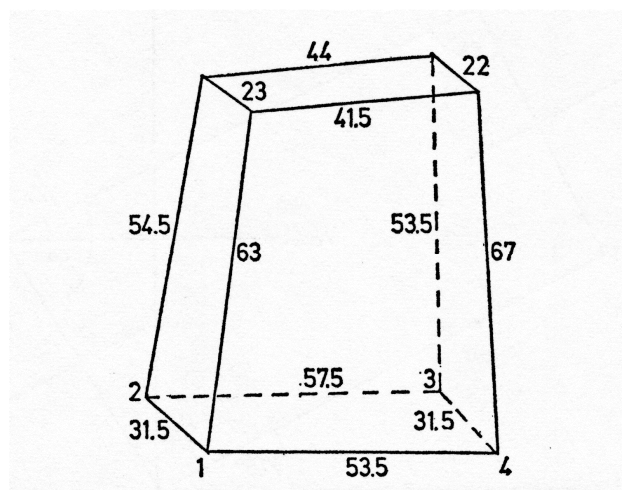


Fig. 4a – View and measures of the Intihuatana stone (the numbers are centimeters) by Mueller (with kind permission of the publisher Springer-Verlag, Heidelberg)

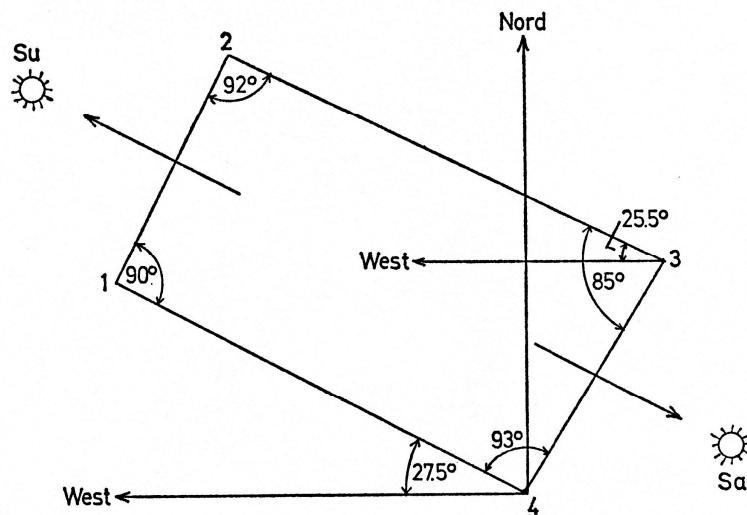


Fig. 4b – Outline of the surface of the socket by Mueller (with kind permission of the publisher Springer-Verlag, Heidelberg). sa= sunrise, su = sunset, Nord = north

Because of the platform the gnomon is placed on, the dates between summertime and wintertime could be defined fairly accurately by means of the shadows. The angular deviation of the direction of the stone and the true points of sunrise and sunset amount to only approximately 1° . Müller further established that the east-west direction is almost identical with the diagonal of the ground area.

Completely unexpected and inadvertently I blundered into the flock of interpreters of this site. I thought over a hypothesis uttered by the local guide Giancarlo Gallegos Peralta from Cusco. He claimed that the rock wouldn't cast a shadow at the Peruvian summer solstice, which is on December 21 every year.³ Machu Picchu is located at a latitude of -13.2° . At the Peruvian summer solstice, however, the sun is at the southernmost point of the ecliptic with a declination of about -23.5° – i.e. on the Tropic of Capricorn. Thus, the sun cannot be at the zenith on this date – the crucial prerequisite for a shadowless rock. However, the rock could stay without a shadow if it had an inclination corresponding to the direction and position of the sun at the summer solstice. When my stay at the Intihuatana was over, and when I became aware of this alternative, I asked myself whether it was possible to derive conclusions in retrospective, e.g. by means of photographs. Searching all photographs, indeed, revealed one shot which showed a tiny shadow of the sun rock (fig.5). Knowing the exact time the photo was taken, the position of the sun for the geographic position of the rock at this time can be determined. Taking into consideration the measures by Müller and applying trigonometrical theorems, an approximate inclination of the rock can be established.

The time the shot was taken can be seen in the EXIF-file. However, the reliability of the internal camera clock time needs to be established. This can be done by finding a photograph taken by the same camera depicting a watch. Since the photograph showing the watch was not taken with my camera, my camera is now used to take a photo of a radio-controlled clock. In this way the EXIF-file of my camera can be calibrated. By comparing both cameras, the one having taken the photograph of the Intihuatana stone and my camera, the adjustment can be made exact to a few seconds.

Having established the time the photograph was taken, the latitude of the sun at the geographic position of the solar rock has to be found out. The local time (apparent time) is of course not identical with the Peruvian time on the watches. Whereas the Peruvian time refers

³ Giancarlo Gallegos Peralta. El Sol Cenital en Machu Picchu. 2008. Web. Dec.14, 2011
<<http://es.scribd.com/doc/3664418/El-Sol-Cenital-en-Machu-Picchu>>

to the 75th western longitude, the sun rock is located at 72°33' western longitude. The difference can be adjusted by means of an astronomical calculating programme, called "Easy Sky". It tells the exact position of the sun when fed with the coordinates. Further sources of error can be deviations with regard to celestial mechanics between 2011 and the time of the erection of Machu Picchu or deviations of the direction of the stone from the geographical north (in which the sun is culminating). Those error sources, however, can be disregarded, as rough calculations show.



Fig. 5 – The Intihuatana rock on March 9th 2011, 11:02 am Peruvian time. - Photograph: Anna Schmadalla (with kind permission)

The result of this admittedly rather confusing but logical procedure is the insight that the Intihuatana stone has an inclination of about 14 degrees. Consequently, the Intihuatana stone can never be without a shadow at the southern summer solstice. But at which date, considering its geographic position, is the rock truly without a shadow? Our program "Easy Sky" calculates the two upper culminations of the sun at the spring equinox and the autumnal equinox, that is in Peru, September 23rd and March 21st. On these dates, the rock faces directly the sun, which is then located exactly on the celestial equator. The inclination of the southern surface of the Intihuatana stone correlates closely with the latitude of Machu Picchu.

Interestingly, Mueller, having intensively studied the rock for weeks, does not say a word about the inclination of the rock, more so, none of the literature known to me states this fact. The only hint, an almost random remark, of the determination of the equinoxes by the Inca people I found in the book by William Prescott (1796 – 1859) "History of the Conquest of Peru" (first published in 1847 in Boston).

It says "The period of the equinoxes they determined by the help of a solitary pillar, or gnomon, placed in the center of a circle, which was described in the area of the great temple, and traversed by a diameter that was drawn from east to west. When the shadows were scarcely visible under the noontide rays of the sun, they said that 'the god sat with all his light upon the column.'"⁴ This is a clear paraphrase of the Quechua term "Intihuatana", the site to which

⁴ William Prescott. Die Eroberung Perus. Leipzig: Dieterich (344), 1975. 70.

the sun is chained, which was written down sixty four years before the (re-)discovery of Machu Picchu. Because of its specific measures, which distinguish the rock from a simple gnomon, the Intihuatana stone shouldn't have cast a shadow around the days of the equinoxes. The sun indeed seemed to be "chained". Moreover, the great celebrations often lasted over a couple of days – the days of the equinoxes – as long as the sun was "chained".⁵ Prescott, who himself had never been to Peru, based his work on the study of almost all Spanish colonial writings. Until today Prescott's conclusions have been supplemented and to some respect been seen more critical. However, his basic thoughts are acknowledged and considered valid until the present time.⁶ The validity of his findings finds expression in the numerous reprints of his book alone in the years 2009 and 2010.

To me it seems obvious that the Intihuatana stone in Machu Picchu was deliberately constructed with an angle of about 13 degree, as I found out, for the purpose of determining the dates of the equinoxes. In Quito, on the other hand, which is located almost exactly on the equator and which was conquered by the Inca people in the 15th century, vertical columns were sufficient, as the sun at this latitude will pass through the zenith on the dates of the equinoxes.

Concluding, the discovery of the inclination of the Intihuatana stone can be valued as a further piece of the mosaic in the current scientific discussions about the ruins of Machu Picchu. In this discussion a turn is apparent from interpreting Machu Picchu as the royal residence of the Inca Pachacuti⁷ with all related functions. Rather, arguments in favor of the place having functioned as a pilgrimage site become dominant – a site which especially served for honoring the Sun God. Thus, the exact astronomic observations at Machu Picchu were very likely religiously motivated.⁸ This assumption is supported by the fact that the solstices as well as the equinoxes used to be extensively celebrated in the entire country. The focus of the celebrations were especially the numerous sun temples. Religious customs as well as ceremonies and their sacrifices of flowers and fruits were connected with the four corner dates of the astronomic year – just as the agriculture of the Inca people.

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⁵ Ibid p. 56

⁶ Peter Neumann. Afterword. William Prescott. Die Eroberung Perus. Leipzig: Dieterich (344), 1975. 361.

⁷ The ninth Inca Pachacuti, Inca Yupanqui, ruled from 1438 to 1471.

⁸ Giulio Magli. At the Other End of the Sun's Path. A New Interpretation of Machu Picchu. Web. Dec. 20, 2011 <<http://arxiv.org/abs/0904.4882>>