ARCHAEOASTRONOMY IN MESOAMERICA AND PERU

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Archaeoastronomy is an endeavor to find out something about ancient astronomy and related matters through the use of archaeological data and the study of ancient texts. Anthony F. Aveni is an astronomer whose interest in the history of science led him, about 1971, to initiate a program of research on Mesoamerican astronomy. His own work has involved making a series of precise measurements of the orientation of ancient sites and buildings in Mexico and the Maya area, to see if he can find any astronomical significance in their alignments. He has also organized two conferences (1973, 1975) with invited and contributed papers on a variety of subjects relating to ancient astronomy, not only in Mesoamerica but in North America, Egypt, and Peru as well. He has performed the considerable feat of getting a volume of selected papers from each of the two conferences published within two years of the date the conference was held.

This essay is not a review of the two conference volumes but rather an archaeologist's assessment of recent work in archaeoastronomy in Mesoamerica and Peru, based on some of the themes touched on in the conferences. (Reference to the conference volumes will be by date of publication, 1975 or 1977, and page.) The selection of themes is arbitrary and reflects rather obviously my own interests and the limitations of my technical competence.

A common problem investigated in archaeoastronomy is one in which Aveni has specialized—the orientation of ancient sites and buildings. As examples of these studies, I have chosen two in which Aveni appears to be especially interested—Teotihuacan and the Templo Mayor of Tenochtitlan.

Teotihuacan was laid out on a grid plan with its major axis 15° 28′ east of north (Aveni's figure, 1977, p. 3). The possibility that Teotihuacan was laid out with reference to the observation of certain celestial bodies was suggested by James W. Dow in 1967.[1] Dow, working with advice from astronomer Gerald Hawkins, decided that the rising of Sirius and the setting of the Pleiades could have been used to determine the orientation of the city. He specifically rejected the hypothesis that the orientation was related to natural features of the landscape, alleging, as part of his argument, that "none of the mountains around Teotihuacan is precisely aligned with the streets" (p. 326).

In 1972, Stephen Tobriner published a carefully reasoned argument that the Avenue of the Dead at Teotihuacan, the street that forms the major axis of the city, was oriented toward a local landmark, the volcano now called Cerro

Gordo, which is the highest mountain in the region.[2] The springs on Cerro Gordo are an important source of water for the city, and Tobriner discussed the relationship between mountains and water in the iconography of Teotihuacan. He did not refer directly to the article, but his argument relates logically to Dow's allegation about mountains. Tobriner also pointed out that the alignment of the Avenue of the Dead to Cerro Gordo had been noted by Sigvald Linné in 1934.

Meanwhile, in 1971, Mexican archaeologists had discovered and cleared a long cave that has its entrance at the foot of the main stairway on the west side of the Pyramid of the Sun and runs an undulating course under the pyramid to terminate near its center. Doris Heyden, who published an interpretation of the cave in 1975, did not attempt to relate the cave to the problem of orientation. She did cite Tobriner and summarized his argument, but she also commented, "we should not overlook the orientation of Teotihuacan structures to heavenly bodies."[3] This appears to be an indirect reference to Dow, whom she did not cite.

Aveni's treatment of the Teotihuacan situation is interesting (1977, p. 5). His own observations confirmed those of Dow, whom he cited, but he concluded that the Pleiades constituted a better candidate for an astronomical reference than Sirius. He mentioned a "Teotihuacan cross" (possible alignment marker) on Cerro Gordo and says of the line connecting this cross with one in a building near the Viking Group that it "forms a nearly perfect right angle with one of the east-west Teotihuacan axes. . . . No astronomical explanation is offered for this direction although the bright star Dubhe has been suggested as a stellar reference (Dow 1967, p. 330)." What Dow said on that page was "the star Dubhe was 1.6° from the declination aligning it with the north-south orientation of Teotihuacán." He said nothing about Cerro Gordo or the cross on it. Indeed, he probably did not know of the existence of the cross, as Horst Hartung speaks of it as "recently found" in a contribution to the first conference volume (1975, p. 192). Aveni did not discuss the significance of Cerro Gordo itself or cite Tobriner's paper (although he did use Heyden's article which summarized Tobriner's argument).

Aveni says: "Among the nonastronomical hypotheses for the orientation of Teotihuacan, that of Heyden (1975) must be given serious consideration. She suggests that the Pyramid of the Sun may have been deliberately placed above the location of a multichambered cave. Furthermore, a line from the center to the mouth of the cave nearly coincides with the direction of the Teotihuacan east-west axis." The second sentence represents an observation by Aveni, not by Heyden. What Heyden said about the cave was: "The existence of this cave must have been known when the Pyramid of the Sun was built, inasmuch as the entrance to the 103 meter long tunnel coincides with the middle of the pyramid's original central stairway (discovered by Acosta during Son et Lumiére [*sic*] installations) and the tunnel itself ends in a series of chambers almost directly under the center of the pyramid" (p. 131). Even her discussion of Tobriner's argument does not emphasize the orientation question.

What Aveni has done, whether intentionally or not, is provide the missing element in an argument that the orientation of Teotihuacan can be fully

explained on the basis of local topography, without reference to astronomical alignments. Tobriner's argument alone is incomplete, because it does not provide a southern reference for the orientation of the Avenue of the Dead toward Cerro Gordo. If the Pyramid of the Sun was constructed first, as seems to be the case, it was probably aligned with relation to the east-west orientation of the long cave under it. The planners who laid out the Avenue of the Dead made it parallel to the front of the Pyramid of the Sun and in line with Cerro Gordo, thus, as it were, tying together the ancient cave and the mountain.

Let us turn now to the Templo Mayor of Tenochtitlan. In the *Proceedings* of the 1912 International Congress of Americanists, Aveni found an abstract of a study by Alfred Maudslay on the position and extent of the temple enclosure.[4] Maudslay quoted in English translation a passage relating to the Templo Mayor which he attributed to Motolinía (Toribio de Benavente). The Templo Mayor consisted of two buildings on a high base; it is called "Huicholobos" in this passage: "Motolinía says that the festival called Tlacaxipeualistli 'took place when the sun stood in the middle of Huicholobos, which was at the equinox, and because it was a little out of the straight, Montezuma wished to pull it down and set it right'" (Maudslay, p. 175; compare Aveni, 1975, p. 172, and 1977, p. 7). As Aveni recognized, this passage is of considerable importance; it may well be the only passage in the sixteenth-century literature on Mesoamerica that specifically relates the orientation of an identifiable building to a celestial event (see the comment by Coe, 1975, p. 13). It does not matter very much that the passage in question is not by Motolinía; it is part of what Kubler and Gibson (see below and note 8) called "Motolinía Insert I," an account of the Mexican year that is quite different from Motolinía's own version.[5] Maudslay's translation is reasonably accurate.

In an article published in *American Antiquity* in 1976, Aveni and Sharon Gibbs reported a measurement of the orientation of the Templo Mayor, 7° 30′ south of east, and attempted to explain how the sun might have been seen rising between the two buildings of the Templo Mayor at the spring equinox.[6] There is a summary of the argument by Aveni in 1977, p. 7. The argument is an extraordinary piece of misdirected ingenuity, since the problem, according to Montezuma, was that the sun was *not* rising directly in the middle of the temple at the equinox, although he thought it should. If we assume that Montezuma knew what he was doing, the problem that Aveni and Gibbs should have addressed is why the Templo Mayor was not properly oriented in Montezuma's time. Could it have gotten so high, with repeated rebuilding, as to throw the traditional observation off?

The passage from the Motolinía Insert I is important for another reason. It raises serious questions regarding the "received" interpretation of the Mexican calendar as presented, for example, by Michael Coe (1975, pp. 10–13). According to this interpretation, the Mexicans recognized a day-count year of 365 days, made up of 18 *veintenas* (or "months") of 20 days each, plus 5 "days without name" at the end. Assuming no intercalation of extra days, the 365-day year would gain on the seasons by a factor of 13 days every 52 years (1975, p. 11).

Coe referred his readers to the articles by Alfonso Caso and Henry Nich-

olson in volume 10 of the *Handbook of Middle American Indians*.[7] Caso's article is a comprehensive account of the Mexican calendar, based in part on a number of earlier studies he had published. In an independent review of the early literature on the 365-day year, George Kubler and Charles Gibson pointed out some of the discrepancies in the evidence.[8] Their study is in part a critique of Caso's earlier work, but it did not lead him to make significant changes in his interpretation. Coe does not cite the Kubler and Gibson study, and his own presentation follows the Caso line. Whether from conviction or in the interests of harmony, Nicholson, writing on religion, did not disagree with Caso on the basic structure of the Mexican calendar. Nevertheless, his comments on the relationship of the calendar to the ceremonies of the agricultural year are fundamentally incompatible with the Caso system and with Coe's statements based on it.

If ceremonies relating to events in the agricultural cycle, like planting, had even approximately fixed dates in the calendar, the calendar could not have been allowed to drift very far from the solar year. Extra days must have been intercalated, whether or not we have specific evidence on how the intercalation was done. This suggestion is obviously not new; Kubler and Gibson refer to "uncertainties regarding the presence or absence of native intercalation" (p. 21). The passage from the Motolinía Insert I regarding Montezuma and the Templo Mayor suggests a correlation of the spring equinox with the festival that gave its name to the twenty-day month of Tlacaxipehualiztli. This correlation is plausible in terms of the assignment of agricultural rituals to twenty-day months made by Nicholson. Equinox observation would be a simple way to determine when an intercalation was needed and would explain the lack of a formula like the European leap year.

To move on to the Maya area, it should be noted that archaeoastronomy, like other kinds of research on the ancient Maya, is both complicated and assisted by the fact that the Mayas had a system of writing of which, according to David Kelley's estimate, about a tenth can be read with some assurance (1977, p. 57). This fraction includes Maya numbers and the complex calendric calculations made for purposes of divination. Some numbers record the dates of events, particularly ones relating to the lives of the ruling families of Maya cities. Some arithmetic is still unexplained, and the two volumes edited by Aveni include articles that seek to interpret the figuring in astronomical terms. More decipherment will utlimately provide a key as to what the now unexplained calculations are about; I am not optimistic that archaeoastronomy will make further significant contributions to the decipherment problem.

As is well known, the ancient Maya had a very accurate method of dating events, the so-called "long count." This had dropped out of use by the time of the Spanish conquest, and there has been much scholarly debate over how to correlate long-count dates with ones in the Christian reckoning. According to Gibbs (1977, p. 27), S. G. Morley suggested in 1920 that identification of the record of an astronomical event (such as an eclipse) in the Maya inscriptions would lead to a solution. Gibbs goes on to explain that most other students of the correlation problem interested in an eclipse solution have preferred to study

the tables of dates in the Dresden Codex, looking there for patterns of dates in the Maya system that could be related to historic eclipse intervals. The results so far have not been particularly convincing, and archaeologists generally continue to use the Thompson correlation, which is based on historical rather than astronomical considerations. Morley's point was, of course, well taken, but I have little confidence that eclipse dates can be convincingly identified without more decipherment.

Peru is represented in these conference volumes by two contributions, both of which have some general interest for a review of archaeoastronomy. The first is a brief discussion by Gerald Hawkins of the desert markings at Nasca on the Peruvian coast (1975, pp. 151–57). Following his archaeoastronomical investigations at Stonehenge, Hawkins made a massive investigation of the theory, advanced by María Reiche and others, that the linear desert markings at Nasca represented astronomical alignments. The results were convincingly negative, and Hawkins so presented them in his official report to the National Geographic Society, which financed the work, as well as in the summary cited above.[9] In this investigation, Hawkins worked strictly by the astronomical evidence. The only criticism his work calls for is his attempted use of surface finds of broken pottery to date the markings (1975, pp. 153–54). His final qualification, "Nor can we be sure that the pottery is contemporaneous," reflects my indication, when he consulted me about the date of the pottery, that surface pottery could not be relied on to date the construction of the markings. Dating the markings might be done by archaeological study, but no archaeologist accompanied Hawkins on his Nasca expeditions.

The second contribution on Peru is an article on the Inca calendar by R. T. Zuidema, which appears at the end of the 1977 volume. Aveni says of it, "This is a landmark paper, the first thorough inquiry into Inca astronomy in modern times" (1977, p. xiii). This statement is acceptable only if one equates making observations with a theodolite with "inquiry into Inca astronomy." The fact is that very little of this article will stand close scrutiny, and any reader who wants to work with it should check all references to sources with great care. Furthermore, the article is about the Inca calendar, and astronomy is discussed only insofar as Zuidema considered it relevant to his theories about the Inca calendar.

The basic reason why such discussion must involve astronomy is that this calendar was controlled by observation of the solstices. In the southern hemisphere, the sun rises and sets furthest to the north on the horizon at the June solstice and furthest to the south at the December solstice. Determination of the solstices by horizon observation at either sunrise or sunset is a simple matter and requires no equipment, as long as the horizon is irregular and all observations pertaining to a given solstice are made from the same point. The Incas used the horizon observation method and erected sets of markers on the western horizon at Cuzco to indicate the points of solstice setting and some times of importance to the agricultural year (there may have been additional sets of markers, but the number is not important for the present discussion). The markers were destroyed after the Spanish conquest because they were connected

with native religious ritual. All attempts to find traces of the markers on the ground have failed. The quest may be hopeless, since there has been severe erosion on the hills around Cuzco since the sixteenth century.

One of the Spanish texts that provides information on the horizon markers is a list of the shrines of the Cuzco area. The list is preserved in Bernabé Cobo's *Historia del Nuevo Mundo*, a work finished in 1653 but based on earlier sources.[10] The shrines in this list are assigned to *ceques* (lines), which are grouped in a complex pattern. Zuidema thinks this pattern is related to the Inca calendar, and I do also, although I disagree with him about the details of the relationship. Three sets of horizon markers on the west side of Cuzco appear in Cobo's list of shrines. One indicated sunset position at the beginning of *verano* (the usual term used in Cuzco Spanish for the dry or cold season), while the other two indicated times for planting. Zuidema supposed that the set of verano markers indicated the June solstice, but both the dry season and the cold season in Cuzco regularly begin much earlier than June 21–22. We do not, in fact, know what date any of the three sets of markers indicated, either in the Inca calendar or the European. Hence, Zuidema's entire effort to elucidate the Inca calendar by making azimuth measurements to supposed shrines is an exercise in futility.

Part of Zuidema's argument involves assuming that the ceques were straight lines. All appear in Cobo's list to radiate from the Temple of the Sun, and if they were straight lines, one could imagine exploring the possibility that at least some were astronomically aligned with the Temple of the Sun as the center of observation. Some of the ceques may indeed have been straight lines, but some certainly were not. For example, the set of verano markers is listed as a shrine on the sixth ceque of Chinchaysuyu. Some of the previous shrines on this ceque can be located on or near a line running up the Quebrada de Saphi. A prolongation of the Saphi line falls well outside the segment of the horizon in which the sun can set at any time between the solstices. As described, this ceque must have had at least one substantial bend in it. Zuidema's map (1977, p. 252) simply ignores the line up the Quebrada de Saphi.

Only one source, an anonymous writer of about 1570, specifies the place where horizon observations of the sun were made in Cuzco. He says that the observations were made from the *osno* (*'usnu*; the author describes it as a stone pillar) in the middle of the plaza.[11] At that date, a reference to the plaza should refer to the colonial and modern Plaza de Armas, or rather its somewhat larger Inca predecessor. Zuidema discussed this passage but does not seem to have realized its full implications. Observations of ceque alignments on straight ceques would have had to be made from the Temple of the Sun, where the ceques converged. If the observation of sunset position was made from any other point, then the ceque alignments, even if they were as straight as Zuidema claims they were, are irrelevant to the problem of astronomical control of the calendar. It would not be necessary for the solstice observation markers to be classified as ceque shrines or even to be located on ceques.

I undertook this assessment of some of the recent work in archaeo-astronomy in Mesoamerica and Peru out of concern that a preoccupation with other problems might have led me to neglect promising new developments in a

field that was already claiming attention over a hundred years ago. Unfortunately, there appears to be about the same imbalance between enthusiasm and scholarly rigor that characterized the field when William Bollaert was looking for ancient American astronomy in the 1860s, give or take a computer.

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NOTES

1. James W. Dow, "Astronomical Orientations at Teotihuacán: A Case Study in Astro-Archaeology," *American Antiquity* 32, no. 3 (July 1967):326–34.
2. Stephen Tobriner, "The Fertile Mountain: An Investigation of Cerro Gordo's Importance to the Town Plan and Iconography of Teotihuacan," in *Mesa Redonda, Teotihuacan* (México: Sociedad Mexicana de Antropología, 1972), pp. 103–15.
3. Doris Heyden, "An Interpretation of the Cave Underneath the Pyramid of the Sun in Teotihuacan, Mexico," *American Antiquity* 40, no. 2 (Apr. 1975):131–47.
4. Alfred P. Maudslay, "A Note on the Position and Extent of the Great Temple Enclosure of Tenochtitlan and the Position, Structure, and Orientation of the Teocalli of Huitzilopochtli (Abstract)," in *International Congress of Americanists, Proceedings of the XVIII Session, London, 1912* (London, 1913), part 1, pp. 173–75.
5. Fray Toribio de Benavente, Motolinía, *Memoriales o libro de las cosas de la Nueva España y de los naturales de ella . . .* , Edmundo O'Gorman, ed. (México: Universidad Autónoma de México, Instituto de Investigaciones Históricas, 1971), Serie de Historiadores y Cronistas de Indias, 2; Insert I occupies pp. 50–54, and the reference to the Templo Mayor is on p. 51.
6. Anthony F. Aveni and Sharon L. Gibbs, "On the Orientation of Pre-Columbian Buildings in Central Mexico," *American Antiquity* 41, no. 4 (Oct. 1976):510–17.
7. Alfonso Caso, "Calendrical Systems of Central Mexico," in Robert Wauchope, ed., *Handbook of Middle American Indians* 10 (Austin: University of Texas Press, 1971), pp. 333–48; Henry B. Nicholson, "Religion in Pre-Hispanic Central Mexico," same volume, pp. 395–446.
8. George Kubler and Charles Gibson, *The Tovar Calendar; an Illustrated Mexican Manuscript* ca. *1585. Reproduced, with a Commentary and Handlist of Sources on the Mexican 365-Day Year*. Memoirs of the Connecticut Academy of Arts & Sciences (New Haven, 1951).
9. Gerald S. Hawkins, "Prehistoric Desert Markings in Peru," in *Research Reports . . . 1967* (Washington, D.C.: National Geographic Society, 1974), pp. 117–44.
10. Bernabé Cobo, *Historia del Nuevo Mundo*, Marcos Jiménez de la Espada, ed. (Sevilla: Sociedad de Bibliófilos Andaluces, 1890–1895, 4 vols.), tomo 4, pp. 9–47 (lib. 13, caps. 13–16). Zuidema used a reprint published in 1956 in the Biblioteca de Autores Españoles, vols. 91–92. The reprint omits a shrine (11 on the sixth ceque of Chinchaysuyu) which is named and described in the original edition. Zuidema made a gratuitous emendation instead of checking the earlier publication (1977, p. 242).
11. Anonymous, "Discurso de la sucesión i gobierno de los Yngas," in Víctor M. Maurtua, ed., *Juicio de Límites entre el Perú y Bolivia; Prueba Peruana*, tomo 8, *Chunchos* (Madrid, 1906), pp. 149–65. The reference is to p. 151. There is an incomplete edition from another copy of the manuscript (and hence with different errors) ed. by Julio A. Luna González-Polar, *El Cuzco y el gobierno de los Incas* (Lima: D. Miranda, 1962). In this edition, the reference is on p. 30.