THE SPATIAL DIMENSION IN PRELITERATE TIME RECKONING

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ABSTRACT. Lacking other means of recording calendrical observations, many preliterate societies employed spatial patterns fixed on land to mark crucial dates in the annual cycle. In pre-Columbian Mesoamerica, where one of the most sophisticated calendrical systems arose, geography was important not only in defining a distinctive measure of time but also in locating and orienting many key urban structures. In southern Sweden megalithic builders erected a stone "ship" to mark solstices and to commemorate a latitude of unique importance. On remote Easter Island, two preliterate societies shared a tradition of using topographic landmarks to calibrate the seasons.

IGNORANCE of spherical trigonometry or, for that matter, of any means of recording information in written form did not prevent many early people from translating sophisticated timekeeping concepts into a spatial context. A simple awareness that a straight line may be defined by three points is all that is required to establish an accurate solar calendar, and the same principle may be employed with other celestial bodies. With two points given, the third can always be determined. If the extreme rising or setting position of a celestial body is marked against the horizon by a fixed feature of the landscape such as a mountain peak, the position of the observer can easily be extrapolated along the line joining the celestial body and the fixed feature.

On the other hand, if the observer occupies a fixed position and takes note of the extreme rising or setting position of a celestial body against the horizon, he may erect a feature in the landscape whose position is located along this line intermediate to the horizon. Another alternative would be to perpetuate the line itself in a feature, such as a ditch, a wall, a street, or a canal, marked on the earth's surface. Field investigations that I have made of preliterate societies in three widely separated parts of the world reveal that all of these methods were used to translate temporal benchmarks into spatial ones.

MESOAMERICAN SPATIAL ORIENTATION

The first example comes from Mesoamerica, where virtually all pre-Columbian societies used a 260-day sacred almanac. It was possible not only to fix the birthplace of this sacred calendar precisely in terms of astronomy, history, and geography but also to trace
its diffusion throughout the Mesoamerican cultural realm by using certain key concepts first identified in its place of origin. For example, the unique 260-day interval defined by the calendar is specific to the parallel of 14.8 degrees north latitude, a line running through southernmost Mexico and across the entire width of Guatemala and Honduras. Along this parallel a 260-day period may be measured between transits of the zenithal sun, commencing with its southward passage on 13 August, the day on which the Mayas believed that time began. The calendar could be calibrated with the same precision at any site along this parallel. However, only one archaeological center at this latitude combines the requisite age, dating at least to the Late Formative period circa 400-500 B.C., with the proper geography: a lowland tropical niche where species such as the alligator, monkey, and iguana, commemorated as day names in the sacred almanac, were found. This is Izapa on the Pacific coastal plain of southern Mexico, immediately adjacent to the Guatemalan border (Fig. 1).

Although the ancient Mesoamericans were unfamiliar with the concept of latitude, they were not unmindful of its significance. The recognition of 13 August as the beginning of time was a fact that virtually all subsequent societies commemorated not only in the alignments of some key architectural structures but also in the layouts of several principal metropolitan areas. Thus even though the greatest pre-Columbian urban center in the New World, Teotihuacán, lay on the Mexican plateau at a latitude of 19.5 degrees north and 700 kilometers distant from Izapa, the entire city was meticulously gridded to the azimuth of the setting sun on 13 August.' The same orientation characterized Edzná, the oldest important urban center of the Maya, located in the southwestern interior of Yucatán, again at 19.5 degrees north latitude and some 400 kilometers from Izapa. The sunset alignment on 13 August likewise determined the orientation of the famous Caracol, the snail-shaped observatory at Chichén Itzá, and of scores of other important buildings throughout the Mayan realm. Indeed, the loftiest structure ever built by the ancient Maya, the Temple IV skyscraper pyramid at Tikal in northern Guatemala, also commemorates this alignment as seen from Temple I in the Mayan capital.

Important as were the alignments to the sunset position on the day that time began, they were only one form of orientation practiced by the ancient Mesoamericans. Based on the antiquity of the sites at which it is found, the earliest type of astronomical alignment observed in the region appears to have been solstitial orientation utilizing the most prominent topographic feature within view. Izapa is itself located in line with the summer-solstice sunrise over Tajumulco, the highest volcano in Central America (Fig. 2). Similar locations characterize the most ancient of the Olmec ceremonial centers in the Gulf coastal plain of Mexico. Thus San Lorenzo, dating to 1200 B.C., is situated in a direct line with the winter-solstice sunset over Zempoaltepec, the highest mountain in the Oaxaca region; La Venta, founded circa 1000 B.C., is oriented to the summer-solstice sunset over Volcán San Martin, the highest peak in the Tuxtla mountains of Veracruz. In both instances, the situation of the ceremonial center depended on its relationship to a key topographic feature at the time of the solstice, whereas its specific site was dictated by proximity to a river along which building stone could be rafted to the center (Fig. 3). All told, thirty main ceremonial centers in Mesoamerica demonstrate such solstitial orientations. These apparently included two of the oldest Mayan urban centers, Uaxactún
and Tikal, both of which are aligned to winter-solstice sunrise positions over peaks in the Maya mountains of Belize. Only in Yucatán, which has no significant topographic features, were solstitial alignments built into the structures themselves, such as El Castillo and the Caracol at Chichén Itzá.

Among the ceremonial centers of Mesoamerica, two founded in the midfifth century A.D. seem to represent places built to commemorate specific latitudes (Fig. 4). One of these is Copán in the western highlands of Honduras some 300 kilometers to the south of the Mayan core area, which lay at the time in the Petén region of northern Guatemala. At the same latitude as Izapa, Copán would appear to have been consciously founded by the Maya in the most accessible place within their realm where they could calibrate the zenithal sun position on 13 August. Equally intriguing to the ancient Mesoamericans was the question of where the sun "stopped" on its annual migration into the northern desert of Mexico. To answer that question, the priests of Teotihuacán apparently dispatched an expedition into the northern wastelands sometime early in the fifth century. Chalchihuites, located in the eastern foothills of the Sierra Madre Occidental a few kilometers south of the Tropic of Cancer, was established as a result of that expedition. There, among other things, the expedition constructed slit-like trenches in the ground to mark the summer solstice sunrise over the distant peak of Picacho. That both Copán and Chalchihuites were founded within a half century of one another not only relates something of the intellectual ferment abroad at the time but also almost suggests a cooperative scientific effort between the Maya and the Teotihuacanos.
Impressive as such special-function sites as Copán and Chalchihuites are, the multifunctional site of Tikal, the Old Empire capital of the Maya, was the crowning achievement in architecturally blending time and space. As already noted, the highest pyramid ever constructed by the Maya, Temple IV, commemorated the sunset position on 13 August as seen from Temple I; additionally the location of two other high pyramids at Tikal served astronomical purposes (Fig. 5). Temple III as viewed from Temple I marks the sunset position at the time of the equinoxes, and the backsight from Temple III to Temple I could be used to calibrate the sunrise positions on the same dates. Moreover, Temple III was sited with such precision and erected to such proportions, being surmounted by a triple roof-comb that reaches to the horizon as observed from Temple IV, that it served as a marker for the winter-solstice sunrise. Temple V, located exactly at right angles to the alignment between Temples I and IV, seems to have served as a secondary check on the all-important 13 August orientation, but how it was used in this connection is not totally understood.
Fig. 3—Examples of archaeological sites that are solstitialy oriented.

Fig. 4—Fifth-century astronomical expeditions led to the establishment of two latitudinally important sites.
Also unknown is the role of Temple II, the lowest of the five high pyramids, which is located immediately across the main plaza from Temple I. Although it may have served simply as an architectural counterweight to its nearby companion, its alignment on an axis eight degrees west of north as viewed from Temple V gives it the same orientation as the principal structures of La Venta, the Olmec site constructed some 1,800 years previously. In any event, all five of the highest pyramids of the Mayan capital apparently were part of a giant astronomical matrix, conceived and built as one unified complex in the mid-eighth century.  

A final, unique illustration of the Mesoamerican propensity for fixing temporal cycles in spatial patterns was discovered in 1978 at Edzná in the southwestern interior of Yucatán. Although this ceremonial center had previously been identified as the place where the Maya reformed their calendar around A.D. 40 so that their new year would coincide with the zenithal transit of the sun at that latitude, an examination of the site revealed a hitherto unknown astronomical alignment built into the layout of the city itself (Fig. 6). A spatial relationship existed between the most commanding structure in the city, which was a five-story pyramid called Cinco Pisos, and a second, lofty pyramid erected approximately 300 meters to the northwest. The latter had been constructed to a height that caused it to intersect the otherwise featureless horizon at an azimuth of 300 degrees. Because the farthest northerly setting position of the sun throughout the Mesoamerican region is 295 degrees, the northwest pyramid of Edzná was not designed to serve a solar function. Instead, it became apparent that the northwest pyramid marked the northernmost still-stand of the moon (Fig. 7). The knowledge of such a position, though reached only once every 18.61 years, is absolutely essential to the prediction of eclipses.
Hence, like Stonehenge, the northwest pyramid at Edzná probably served as a lunar observatory. However, unlike the megalithic builders of Stonehenge, who fixed the still-stand maxima of the moon as early as the second millennium B.C., the earliest lunar inscriptions of the Maya date only to the middle of the fourth century A.D.
STONES OF ALE

The second example comes from southern Sweden and from a much earlier period than the Mesoamerican examples. On a morainic bluff overlooking the Baltic Sea stands a structure known as Ales stenar, or the stones of Ale. It comprises fifty-eight massive boulders, each with an average weight of three tons, arranged in the form of a ship some sixty-seven meters long. Although the "gunwales" of the ship are composed primarily of red granite, the bow, stern, and rudder stones consist of a more angular, beige quartzite, chosen less perhaps for its distinctive color than for its sharper angularity. Because the underlying bedrock of the region is limestone and its surficial deposits are fine-grained morainic materials, the builders of Ales stenar must have expended considerable time and effort assembling the approximately 200 tons of stone used in its construction. To be sure, some granite boulders may have been glacial erratics that had washed from the moraine itself, but even hoisting them from the foot of the bluff to the top of the thirty-meter hill a kilometer distant was no simple operation. As far as the quartzite bow, stern, and rudder stones were concerned, their sharp angularity quite precludes their having been moved by the glacier. The nearest seaside outcrops from which they could have been quarried lie some thirty-five kilometers to the northeast, near the present-day fishing port of Simrishamn, so their acquisition involved an even greater expenditure of time and labor.

Even the most casual visitor to Ales stenar immediately wonders who would have gone to such lengths to erect so massive a structure, and why. Although the explanatory tablet set up at the site by the Royal Antiquities Commission of Sweden assigns the structure a
Late Iron Age date, A.D. 400-1050, several historical, stylistic, and geographical considerations make that estimate highly questionable. Firstly, the Late Iron Age embraced a period including the great Germanic migrations and the Viking Era, both times of considerable upheaval and conflict that were hardly conducive to such an undertaking. Secondly, the supposed similarity with ship-settings, which are demonstrably of Iron Age origin, is decidedly slim. A burial was characteristic of most of the ship-settings, but none is associated with Ales stenar. Moreover, the very size and origin of the stones used in its construction are unlike those for true Iron Age structures, most of which consist of much smaller stones literally upended in situ.

The spatial aspects of Ales stenar are perhaps the most difficult to reconcile with a Late Iron Age date, first and foremost because the site lies in the midst of one of the densest areas of megalithic or Late Stone Age settlement known in Sweden. Consequently it is not surprising that the same mammoth stones were used in its construction as in the numerous dolmens and passage graves that surround it. Moreover, whereas typical Iron Age ship-settings sprawl across wooded hillsides or huddle in narrow valleys, Ales stenar is atop an open, windswept hill that commands a full 360-degree view of the horizon. Lacking any funereal association, the structure was clearly erected for a purpose very dissimilar to that of the typical Viking Era memorial. But what was that purpose?

The answer seems to lie in the broad spatial context of the structure. The first thing that impressed me was its strict axial arrangement, with obvious precision of alignment from bow to stern. A measurement of its orientation quickly revealed that the bow stone points directly at the horizon where the sun sets at the summer solstice, whereas the stern stone marks the horizon exactly where the sun rises at the winter solstice (Fig. 8). In none of the more than two hundred ship-settings found in Sweden is such an alignment discernible, nor in any of them is it likely that it was intended. At Ales stenar an astronomical function would seem to have been of paramount importance and was likely the raison d'être of the structure.

If, as I suggest, Ales stenar was constructed as a megalithic calendar, it is not the sole such device in existence. Stonehenge served this purpose and was used to predict lunar eclipses. This site also has latitudinal uniqueness; only within a few miles of the Plain of Salisbury is it possible to measure a perfect right angle between the extreme declinations of the sun and the moon. That a similar relationship exists between rising and setting positions of the sun at the solstices for a limited distance north and south of Ales stenar can scarcely be regarded as a coincidence. It would appear that the builders of the structure had consciously sought a latitude where this key relationship could be found. Finally, a Swedish astronomer has contended that the stones of Ales stenar were positioned with such care as to describe two giant parabolas and thus allowed the actual timing of the solstice to be forecast with complete accuracy. In no other ship-setting in Scandinavia is there any implication of such a mathematical function.
The final example is Easter Island in the south Pacific Ocean. There more than 240 temples, Polynesian ahu, dot the seacoast, each of them originally adorned with several of the gigantic stone heads for which the island is famous. At least three sites stand out as quite unlike all others. Each dates from the early period of settlement of the island, A.D. 400-1100, and each is characterized by a meticulously cut and fitted stonework not found on structures of later vintage. Indeed, many researchers have seen in the fine masonry of these ahus striking similarities with the workmanship of Andean cultures in Bolivia and Peru. Moreover, during the excavations carried out by the Norwegian expedition of 1955-1956, it was noted that two of the ahus at Vinapu demonstrated orientations that might have astronomical significance. It was for this reason that Vinapu was believed to occupy the distinctive site that it does: inland some 110 meters from the coast, with no easy access to it. Similarly, at the coastal site of Ahu Tepeu the facades of two ahus seemed to be aligned to within a few degrees of the summer solstice sunrise, although it was conceded that "the rising mass of [the mountain] Terevaka to the east may have caused the builders to err in their orientation. The third site, known as Ahu Te-pito-te-kura, or the navel of light, also had meticulous stonework but no discernible astronomical orientations."
Interestingly, in spite of their suggestions of astronomical associations for two of the early-period sites, no one on the Norwegian archaeological team seems to have realized that all three of these ahus show solsticial orientations to principal topographic features on the island (Fig. 9). For example, viewing the horizon from Vinapu, one quickly discovers that the most striking feature within sight is the low cone of an ancient volcano, known as Pua Katiki, which forms the northeasternmost corner of the island. The azimuth of the mountain as seen from Vinapu corresponds exactly to the winter-solstice sunrise position at the latitude of Easter Island. Similarly, Maunga Terevaka, the highest peak on the island, marks the same calendrical position as seen from the west-coast site of Ahu Tepeu. On the other hand, Pua Katiki functions as a summer-solstice sunrise marker when viewed from the north-coast site of Ahu Te-pito-te-kura and from the adjacent beach site of Anakena. Two of these orientations would seem to be confirmed by placename studies that revealed heretofore inexplicable associations between Pua Katiki and the month of June as well as links between this month, which marked the end of the Polynesian year, and the site of Vinapu. In contrast, the north-coast site of Anakena has both legendary and linguistic associations with the beginning of the year and the month of December." On the other hand, the translation of the names both of the mountain and of Poike, the peninsula on which it stands, afford suggestive insights into the functioning of this landscape feature: Pua Katiki translates as "flowery aura" (as with a sunrise), and Poike means "height; to be just seen above the horizon; or to rise in conjunction with stars. 16-17 Because both the Pua Katiki and Vinapu areas are recorded as having been settled by the Hanau Eepe, a people credited with the introduction of the stonework that has been likened to Incan masonry, a valid conclusion is that the location of Vinapu is
Tangible evidence that the Andean practice of using topographic features as calendrical markers had been introduced into the eastern Pacific as early as the ninth century A.D.

The archaeological team of the Norwegian expedition that excavated Vinapu also identified the most important Polynesian site on the island as Orongo. The center of the annual Bird Man religious ceremony, Orongo is located at the far southwestern corner of the island on the very lip of the crater of the extinct volcano Rano Kao. Situated on a knifelike scarp some 300 meters above sea level, this cult center continued in regular use until the latter half of the nineteenth century. The archaeologist who excavated the site attempted to identify a group of four holes in the rock at the edge of the cliff as "a sun observation device," but he acknowledged that the results would have been questionable. What he failed to appreciate was that Orongo bears precisely the same solstitial relationship to Pua Katiki as does Vinapu, and thus that it continued to serve the same function as a calendrical marker for the Polynesian culture that it did for the older Andean one. Additionally, its calendrical function was most likely expanded to demarcate both the summer-solstice sunrise and the equinoctial sunrises, because unlike Vinapu, which had only a vacant horizon before it at these azimuths, Orongo had the entire expanse of Rano Kao's crater against which to calibrate the annual cycle. Thus the summer solstice could be marked against the point where the crater rim falls away in an abrupt sea cliff, while the equinoctial sunrises were most likely marked by a stone cairn located at the proper azimuth on the opposite edge of the crater. Even in this faraway corner of the world where two distinct cultures - one from the Andes and the other from Polynesia - met on a small island, there is good evidence that they shared a tradition of using objects on the land to measure intervals of time.

Although the examples described in this article existed at different times and in widely separated places, they shared the common cultural characteristic of having been devised by preliterate societies. In the absence of writing, mnemonic devices in the landscape were used to record temporal events. Only in Mesoamerica had written records begun to summarize the knowledge that had been accumulated through the ages, but it was virtually obliterated by the European conquest. On Easter Island, internal struggle and collapse had destroyed any knowledge of space-time associations long before the arrival of Europeans. In Europe itself a lack of cultural continuity meant that many associations known to the builders of Stonehenge and Ales stenar are only now being rediscovered.

REFERENCES


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