GEOGRAPHICAL DIFFUSION AND CALENDRICS IN PRE-COLUMBIAN MESOAMERICA

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ABSTRACT. Of paramount importance to the cultural and religious life of the pre-Columbian civilizations of Mesoamerica was a complex calendrical system of both a 260-day sacred almanac and a 365-day secular count. This article examines the development of a level of astronomical sophistication by the Olmecs and Mayas in the core of Mesoamerica that allowed them to predict eclipses. Concurrently, on the northern periphery of the region, because of spatial-temporal lag in diffusion, the Toltecs and Aztecs were only beginning to evolve their much cruder versions of the same fundamental time-count.

ON the eve of European settlement of the New World, the most advanced civilizations on the North American continent were geographically concentrated in a region that embraced central and southern Mexico, Guatemala, and the western fringes of Honduras and El Salvador. This region, which has come to be called Mesoamerica, was characterized by a relatively dense urban settlement supported by an intensive sedentary agriculture based on maize cultivation. To the north, on the and Mexican plateau and beyond the pale of farming, wandered the Chichimecs, or "dog people," nomadic hunters and gatherers tempted by the grand cities clustered to the south in the productive volcanic basins. The physical limits of Mesoamerica's southern boundary were not as sharply defined, for there they ran almost imperceptibly through the rain forests and across the mountains of eastern Honduras and northern Nicaragua. Yet the cultural frontier was nearly as abrupt as in the north, for almost within sight of the pyramids and palaces of the Maya lived small, tribally organized groups of subsistence farmers and hunters whose only role in the life of Mesoamerica was a minimal trade connection.

Although the material culture of Mesoamerica was transitional between the stone and metal ages, its spiritual culture was in many ways more sophisticated. However, central to all the people's existence, be they Olmec, Zapotec, Maya, or Aztec, was an essentially uniform religion. At the core of that religion lay two calendars, a 260-day sacred almanac and a 365-day secular count, that determined not only the cyclical rituals and ceremonies of social interaction but also the day-to-day performance of duties. The
book burnings by the Spanish conquistadores were so thorough that it has taken scholars scores of years of painstaking reconstruction to piece together some understanding of what the native American intellect had actually produced in these calendars.

For a historical geographer studying Mesoamerica, one of the highest priorities has been to locate the cultural hearth of the region, to find out where the calendar first emerged, how it came into being, and how it diffused to become one of the most important common denominators of the entire realm. The two case studies presented here form part of an ongoing effort to use the geographer's spatial perspective to examine clues that otherwise may have gone unnoticed or unappreciated. The first study illustrates how two eclipses that occurred during the pre-Columbian period allow the so-called Mayan calendar to be calibrated precisely with the modern one. The second case study discusses the diffusion of the calendar into the northerly margins of Mesoamerica and the spatial and temporal dilution of the calendric system engendered by that diffusion. In both studies, computer techniques are used to provide iterative searches of dates and astronomical configurations.

TWO PRE-COLUMBIAN ECLIPSES

On the morning of 31 August in the year 32 B.C., the inhabitants of central Mexico awoke to a frightening event: except for a narrow band of light encircling its disk, the rising sun was completely dark. Not until well into the morning was the glowing orb bright and whole again. What the prehistoric Mexicans had experienced was an annular solar eclipse. Not until 1887 was any record of that event published in a Western scientific monograph, and then it was buried in a list of no fewer than eight thousand solar and fifty-two hundred lunar eclipses spanning the period from 1208 B.C. to A.D. 2161. That monumental volume, the work of Theodor von Oppolzer (1887), has since been verified by computer analysis. Only now is the possible significance of the 32 B.C. event in unraveling the prehistory of Mesoamerican calendrics beginning to suggest itself.

An indigenous record of that same event came to light in 1939 with the excavation of the Olmec site of Tres Zapotes, on the coastal plain in southern Veracruz, by Matthew Stirling, working under the auspices of the National Geographic Society (Fig. 1). At that time, his crew of diggers turned up a carved stela bearing what seemed to be a Mayan long-count date, and, because it was the third artifact to be discovered during that field season, it was labeled simply "Stela C." Yet Stela C was no ordinary find: when it was transcribed, it was found to be the oldest Mayan date discovered until that time (Stirling 1939). Only one older long-count inscription has been located in the subsequent half century.
Stela C immediately became the focus of archaeological controversy. The stone had been broken, so that the first number of the inscription, the so-called baktun value, was missing. Most archaeologists were prone to believe that the number must have been a seven, because no long-count inscription had ever been found that predated baktun seven, a period extending from about 360 B.C. to circa A.D. 40. If they were correct and the baktun value had been a seven, then the resultant date would equate to 32 B.C. However, because the inscription was written with Mayan numbers and would have predated by more than three hundred years the oldest long-count inscription found anywhere in the Mayan core area of settlement, other archaeologists argued that it had to represent a later diffusion from the Petén region of Guatemala into the Gulf coastal plain of Mexico, and, therefore, the missing number was most likely an eight.

Ultimately, Stela C was to become one of the primary pieces of evidence in establishing not only the antiquity of the so-called Olmec civilization but also that this culture, not the Maya, had been responsible for developing the calendrical, mathematical, and hieroglyphic systems that had initially been attributed to the Maya. With the fortuitous discovery of the missing piece of Stela C in 1969, the long debate over the inscription's age was finally resolved: the baktun value was indeed a seven (Coe 1977).

In part because Stela C has so long been the center of controversy, no real attempt has been made to determine what its date may have commemorated. However, in its full form, the inscription can be transcribed as 7.16.6.16.18, which equates to Mayan day number 1,125,698. If this is added to the correlation factor currently favored by archaeologists (Thompson 1935), the corresponding Julian day used by Western astronomers is 1,709,981. That, in turn, equates with the date 3 September 32 B.C., or three days later than the annular solar eclipse. If anyone in the archaeological community
had been aware of the eclipse date, and it certainly is mentioned nowhere in the literature, then the three-day hiatus between it and the inscription of Stela C would have led them to dismiss the inscription as having been the record of some civil event rather than an astronomical one.

There is more to the close correspondence of the two dates than an interesting coincidence of history. That Stela C was found at Tres Zapotes, Mexico, compounds the question with a coincidence of geography: this Olmec ceremonial center lay immediately in the path of the eclipse in question. That the Olmecs would have failed to observe a day without sunrise or to record it as an event of singular importance is more unlikely than the alternatives that present themselves, namely that they made an error in recording the date or that the correlation value now used to equate Mayan chronology with the modern calendar may be in error.

Because of the numerical system that the Olmecs employed, there is a distinct possibility that the inscription could have been rendered incorrectly. The Olmecs not only were the first people in the world to conceive of zero and the principle of place notation, but also devised a system of numerals with which they could record any number by using either one or both of two symbols. A dot symbolized a one, two dots a two, and so forth to four, thereafter a bar represented a five, a dot and a bar equaled six, two bars was ten, and so forth. If the carver of Stela C inadvertently added a dot or a bar too many, the date would have been off by as little as one day or as much as five days. In any event, such an error is more likely to have been the mistake of an illiterate worker than the miscalculation of an astronomer priest.

As regards the correlation value currently accepted by archaeologists as the one that most accurately equates Mayan dates with present-day ones, the basic formula was devised in 1905 by a newspaper publisher, John T. Goodman (Thompson 1960). Using historical evidence, Goodman argued that to convert Mayan day numbers into the Julian day numbers would require the addition of 584,283 days. In 1926 a Mexican astronomer, Juan Martínez Hernández, suggested a one-day revision in the formula, to 584,284 days, and a year later the British archaeologist J. E. S. Thompson, using lunar data and the Venus calendar, suggested yet another day's correction, to 584,285 days. Because all three researchers came independently to the same basic formula, give or take a few days, the correlation bears all three of their names and is usually abbreviated GMT.

In 1935 Thompson, revising his calculations by two days, decided that 584,283 was the accurate number. Implicitly, he likewise abandoned the astronomical basis on which his first calculation was predicated, and he even went so far as to dismiss any suggestive astronomical association with the GMT as coincidental (Thompson 1960). Returning to Thompson's initial astronomically based formula changes the Julian day number correlating with the Stela C inscription from 1,709,981 to 1,709,983, which equates to 5 September 32 B.C. Instead of being three days off the date posited by Oppolzer, the inscription varies five days from it, or the equivalent of one Olmec bar symbol. Had the stonecutter inserted one bar too many in the last numeral, making it an
eighteen instead of thirteen? Certainly, that is more likely than for him to have miscarved it by putting in an extra three dots.

This reading of Stela C might seem to require a greater stretch of the imagination than merely accepting a coincidence of time and space on the Mexican coastal plain in 32 B.C. In that regard, it is worth noting that Thompson himself enumerated no fewer than ninety-two errors in the transcription of the Dresden Codex, a Mayan eclipse-warning book dating to the mid eighth century, but neither he nor any other scholar has suggested that such inaccuracies invalidate the book itself (Thompson 1972). A reasonable conclusion is that one of the oldest calendrical inscriptions ever found in Mesoamerica was a record, albeit an inaccurate one, of a solar eclipse.

What happens when the Dresden Codex is examined to determine how the Maya fared in predicting eclipses? One striking fact is that the three dates on which computations of the codex are based accord with no eclipses in the Mayan area, especially if Thompson's corrected value of 584,283 is used. However, if his initial value of 584,285 is applied, the equivalent dates are 8 November, 23 November, and 8 December 755. Because of the fifteen day intervals between them, it has been suggested that the three dates most likely represented two full moons bracketing a new moon, or a lunar eclipse separating two solar eclipses (Makemson 1943). Subsequently, it has been argued that these dates must have resulted from calculation rather than observation, because no eclipses were visible in Mesoamerica on any of the dates mentioned (Lounsbury 1978). However, on 8 November 755, the sun and the moon did rise eight minutes apart over the Yucatán, and with an angular separation of less than 2.5 degrees, so on that date there was a near miss to a solar eclipse in the Mayan area. Fifteen days later, a total lunar eclipse did occur, but it was visible only in the half of the world centered on India. Still another fifteen days later, a partial solar eclipse occurred over the ocean between South Africa and Antarctica, where probably not a single human witnessed it. In other words, by 755 the Mayas had apparently worked out the motions of the moon with such precision that they knew when an eclipse might occur, but they still could not be certain where. Although the base dates recorded in the Dresden Codex could not have provided the Maya with much confirmation or gratification after their long years of study, the figures do strongly suggest that the initial Thompson correlation value is the correct one.

A second piece of evidence comes from Copán, a ceremonial center in the highlands of western Honduras that has long been recognized as one of the principal Maya sites for astronomical study. There, a single date, rendered as 9.16.12.5.17 in the Mayan long count and thus corresponding to Mayan day number 1,415,637, is recorded no fewer than eight times on six different altars, stelae, and buildings (Carlson 1977). On that date, a total lunar eclipse occurred at Copán, immediately after sunset. Oppolzer recorded this eclipse as having reached the midpoint of its totality at 1:10 Universal Time, or at 1:10 a.m. on the morning of 30 June 763. At that moment, London, where the count of both calendar and Julian days is initiated, was only halfway through the Julian day 1,999,923. This means that at Copán, located near 90º W longitude and thus six hours behind London, the time was 7:10 p.m. on 29 June, and the Julian day number was

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1,999,922. Adding the initial Thompson correlation factor to the Mayan day number yields precisely that Julian value.

Further confirmation of the accuracy of the initial correlation value may be found in the repeated orientation throughout Mesoamerica of key structures and, in some instances, of entire ceremonial centers to the sunset position on 13 August, the date that corresponds with Julian day 584,285. It has been demonstrated that Teotihuacán derived its grid plan from such an alignment (Malmström 1978; Chiu and Morrison 1980). That same orientation is found in the design and placement of buildings at numerous other sites, including the observatory El Caracol at Chichén Itzá and the loftiest pyramid ever built by the Maya, Temple IV at Tikal (Malmström 1981).

The two eclipses described here, separated by more than 800 kilometers in space and almost 800 years in time, essentially encapsulate the entire intellectual history of pre-Columbian Mesoamerica: the whole spectrum of progression, from the first awe-inspired record of a day without sunrise to the triumph of ordering the apparent chaos of the heavens. That all these advances in an indigenous people's understanding of its world should have been lost with the collapse of the Mayan civilization less than a century later is a tragedy whose dimensions are only now becoming apparent.

**EVOLUTION OF THE AZTEC CALENDAR**

A more complicated correlation problem, and one that underscores issues of geographical diffusion, arises when the Aztec calendar is considered. Virtually all scholars agree that the basic structure of the calendrical systems used by the Aztecs can be traced to a common Mesoamerican origin dating well before the beginning of the Christian era. Yet considerable debate has focused on several apparently unique aspects of the Aztec versions, such as the date on which the solar year began, the derivation of the Aztecs' fifty two-year cycle of "year bearers," and the origin of their special ceremony of renewal called the "binding of the years." The remainder of this article investigates these distinctive characteristics of the Aztec calendar.

Like all other Mesoamerican cultures, the Aztecs employed two calendars: a 260-day sacred almanac, called the tonalpohualli, and a 365-day secular calendar, termed the xihuitl. The former consisted of a combination of thirteen numbers and twenty day-names; the latter comprised eighteen months, each of twenty days, followed by a five-day period called nemontemi. In a monumental study of pre-Columbian calendars, Alfonso Caso (1967, 39-40, 94) noted that, of some forty-two sources dating from the sixteenth through twentieth centuries, fourteen state that the Aztec calendar began with the month of Atlcahualo, another fourteen prefer the month of Tlacaxipehualiztli, seven cite the month of Izcalli, three the month of Tititl, two the month of Atemoztli, and one each the months of Panquetzaliztli and Toxcatl. Thus no fewer than seven of the eighteen months have been suggested as the starting point for the Aztec year, with initial dates ranging from early November through mid-May. Even the two earliest chroniclers, the Spanish clerics Sahagún and Durán, disagree: the first cites a beginning Julian-calendar date of 2 February; the second, 1 March.
The Aztecs lacked a fixed point, such as the birth of Christ used by Western cultures, from which to count years. Instead, they identified each year by the day of the sacred almanac on which it ended; a year was not counted until its completion. Inasmuch as the 260-day sacred almanac and the 365-day secular calendar ran concurrently, each succeeding solar year began 105 days later according to the religious count. It thus would take 18,980 days, or fifty-two 365-day years, to arrive back at the same starting point in each of the counts. Hence all Mesoamerican peoples conceived of time as repeating itself in fifty-two-year cycles. In each of these bundles, or xiuhmolpilli, all thirteen numerals of the sacred almanac would be repeated four times, always in combination with only one of the same four day-names. Furthermore, depending on when the sequence began, the same four day-names, or year bearers, would recur in new combinations with the thirteen numerals until the entire cycle of fifty-two years had been completed. In the case of the Aztecs, the cycle began with 1 Rabbit and was followed by 2 Reed, 3 Flint-knife, and 4 House, moving to 5 Rabbit, 6 Reed, and so on, ending when the numeral 13 coincided with the day-name House. Thus, each year in a given bundle of fifty-two had its own distinctive name. Also, because the average life expectancy at the time was relatively short, few people ever experienced a second year of the same name in their lifetimes.

To commemorate the end of the one fifty-two-year cycle and the beginning of another, the Aztecs had a special ceremony called the binding of the years. For reasons known only to them, this ceremony was held not at the end of a year 13 House, the final year in the cycle, nor even at the end of 1 Rabbit, the first year, but at the end of the second year, 2 Reed. Most likely this ceremony had to do with a tribal myth that after a great flood had destroyed the earth, it took the first year to raise the heavens again, and that in the second year a feast was prepared for the gods and fire was acquired for the first time (Krickeberg 1980, 24). The rekindling of all the fires in the empire is known to have been a fundamental part of the ceremony. Its timing was dictated by the passage of the Pleiades through the zenith, an event that occurred annually at around midnight near the end of October or the beginning of November.

EQUATING AZTEC AND CHRISTIAN CHRONOLOGIES

To establish the origins of the distinctive characteristics of the Aztec calendar, it is first necessary to adopt a workable equation of correlating Aztec time counts with modern ones. Caso (1967, 48-55) undertook such an effort and showed through numerous cross-references to events of the conquest that the fall of Tenochtitlán, the Aztec capital, occurred on 13 August 1521, a day that the Aztecs called 1 Snake. The year was 3 House, which was the sixteenth year in the bundle that had started with 1 Rabbit in 1506 and whose binding-of-the-years ceremony had occurred in 2 Reed, or 1507, the last such event the Aztecs were to celebrate.

Even a cursory examination of the key astronomical events of 1521 reveals that none coincided with an Aztec day-name of any importance, although both the northward zenithal passage of the sun and the summer solstice fell on days that included the names
of year bearers, specifically Flint-knife and Reed (Table I). Perhaps more important is the recognition of 30 October as the last day of the sacred almanac. The first day of the

<table>
<thead>
<tr>
<th>EVENT</th>
<th>A.D. DATE</th>
<th>AZTEC DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st day of sacred 260-day cycle</td>
<td>12 Feb.</td>
<td>1 House</td>
</tr>
<tr>
<td>Name of year</td>
<td>3 May</td>
<td>3 House</td>
</tr>
<tr>
<td>Northward zenithal passage of sun</td>
<td>18 May</td>
<td>5 Flint-knife</td>
</tr>
<tr>
<td>Summer solstice</td>
<td>22 June</td>
<td>1 Reed</td>
</tr>
<tr>
<td>Southward zenithal passage of sun</td>
<td>26 July</td>
<td>9 Deer</td>
</tr>
<tr>
<td>Zenithal passage of Pleiades</td>
<td>30 Oct.</td>
<td>1 House</td>
</tr>
<tr>
<td>Winter solstice</td>
<td>22 Dec.</td>
<td>2 Buzzard</td>
</tr>
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Buzzard

religious count thus necessarily fell 260 days earlier, on 12 February. That date in the present Gregorian calendar coincides with 2 February in the Julian count, which implies that the Spanish cleric Sahagún, the earliest of the European chroniclers, was correct in his determination of the start of the Aztec year.

Perhaps most disquieting is that both the beginning and ending days of the year 3 House fell on days named 1 House, whereas the actual occurrence of the day 3 House was on 3 May, when nothing of astronomical significance took place. Thus a question arises: when did the zenithal passage of the Pleiades coincide with a day bearing the same name as the year in which it occurred? Or, to be more specific, pinpointing the origins of the Aztec time count requires a determination of when the zenithal passage of the Pleiades occurred on a day called 1 Rabbit, the first of the Aztec year bearers.

**REASSESSING THE AZTEC TIME COUNT**

The reason such a question arises at all is that the Aztecs employed a value of 365 days for the length of their secular calendar, although the true length of the solar year is about one-quarter of a day longer than that. Because they failed to make any adjustment for this discrepancy, their time count naturally slipped forward approximately one day every four years, so that by the end of any fifty-two-year bundle, the celebration of a given event shifted backward in their sacred almanac by thirteen days.

To address this issue, I designed a computer program that paired the Julian and Aztec calendars against one another, using as the starting point Caso’s correlation of the Aztec 1 Snake with the Julian date 13 August 1521. I ran the program backward until a day named 1 Rabbit was found in a year with the same name that also coincided with a date in late October or early November, when the Pleiades were crossing the zenith near midnight.
The Aztecs recorded that their first celebration of the binding of the years occurred in 1091, if one accepts Padre Tello as the authority (Codice Botturini 1975, 4), or in 1195, if one uses the chronology of Krickeberg (1982, 43). Yet the computer search revealed that neither of these dates met the specified requirements, at least using the Caso correlation. In fact, the only time a year named 2 Reed ended on a day called 2 Reed was on 5 November 779, which means that the previous year, 1 Rabbit, or 778, must have been the precise point in history when the unique ideas of naming years for the day on which they ended and of binding them in fifty-two-year groups were first launched.

Although the question of the Aztec calendar's date of origin had now been answered, the result raised another question that was equally important and disturbing. If Caso's correlation equation was correct, why did it not place the nemontemi, or five-day unlucky period, anywhere near 5 November, when the zenithal passage of the Pleiades occurred? His correlation starts the nemontemi on, of all dates, 13 August. Surely if this event heralded the beginning of a new cycle of years, it would have been most appropriate that the five-day unlucky period immediately precede the zenithal passage of the Pleiades, at least on the initial occasion.

This inconsistency prompted an examination of some of Caso's other fundamental assumptions, because his correlation equation seemed unassailable. The most questionable were his assertions that the year began with the month of Izcalli and that the nemontemi had immediately preceded that. On further investigation, I found that with Caso's configuration of the Aztec year, the nemontemi would never again be as close to the zenithal passage of the Pleiades as it was in 779, because by the time of the last binding of the years in 1507, it had slipped forward to the very beginning of the sacred almanac on 12 February. During that same period, the Pleiades had precessed from a declination of 19º 48', a point directly overhead at Tenochtitlán, to a declination of 22º 29', which would put them overhead at the latitude of the city of Tampico by 1507.

Thus, although Caso's correlation had provided a tool by which it had been possible to establish the beginning date of the Aztec time count, it still did not satisfy the realities of history, at least as they have come to be known. If the nemontemi had immediately preceded the zenithal passage of the Pleiades on that initial occasion, it was necessary to find an alternative correlation that not only would demonstrate the fact but also would not do violence to the chronology of conquest events that Caso had so painstakingly worked out.

The key to the solution is the part of the year in which the Aztecs actually placed the five-day unlucky period. If they directly copied Mayan practice, they would have placed it after their month of Huey Tecuilhuitl, which was the equivalent of the last month of the Mayan year, Cumku. That they did not do so is readily apparent, as very few conquest events correlate with such a time count. If Caso's correlation is to be brought into line with reality, a shift in the placement of the nemontemi from 13 August to early November is required, which would retard it by eighty days or four Aztec months. This means that if the five unlucky days are placed after Huey Tozoztli, the
nemontemi would have occurred from 1 to 5 November, with the new year beginning on 6 November. When this formula was incorporated into the computer program, the last day of nemontemi always fell on a day with the same name as the year.

This discovery has several implications. First, it implies that, contrary to the belief of numerous scholars, the last of the five unlucky days, not the year's 360th day, provided the name for the year. Furthermore, if 5 November marked the end of the year in 778, then the beginning of the year would have fallen 260 days earlier, on 18 February. However, in the first score of years of such a time count, the lack of an intercalated day for leap years resulted in the forward slippage of the Pleiades passage by five days, just as it did for the nemontemi. Thus, by 800, the zenithal passage of the Pleiades had already moved to the equivalent of 30 October, as had the last day of the five-day unlucky period. Clearly, for the astronomer-priest, an age of innocence was fast drawing to a close. A time count seemingly perfectly attuned to the rhythms of the heavens was already awry; if the priests were to continue using the Pleiades to pinpoint the binding of the years, they would have to reconcile the choice to the fact that the nemontemi would no longer immediately precede its zenithal passage. They had to decide whether the end of the year was marked by the last day of the nemontemi or by the passage of the Pleiades, and they opted for the latter.

If these interpretations are correct, the secular new year would have had to begin in the month of Toxcatl, whose feast Sahagún recorded as having been the principal one of the entire year (Sahagún 1990, 71). It has been observed that many similarities exist between the feast to Toxcatl and the binding-of-the-years ceremony (Seler 1902, 162-300; Krickeberg 1980, 182). Caso (1967, 40) rejected the idea. However, as a result of the continued, uncompensated slippage of the 365-day secular calendar, the first day of the Aztec year moved progressively forward, so that, depending on the time frame to which any given chronicler or researcher had reference, almost any or all of them could have been correct. In any case, by the time of the Spanish conquest, the nemontemi had shifted from November to May, whereas Atlcahualo, which Sahagún had identified as the first month of the year, then began in early February, exactly as he reported.

Perhaps the most interesting implication of these findings is that the calendrical innovations predated the Aztecs by a full three centuries. That, in turn, would mean that the innovations were the product of the Toltecs, who had preceded the Aztecs in an earlier southward wave of migration onto the Mexican plateau. The Aztecs were quite candid in acknowledging their cultural debt to the Toltecs, whom they admitted were the first people to count and to determine the number of days in the year (Krickeberg 1980, 46). Moreover, it is clear from the timing of the start of the fifty-two-year cycle and the binding-of-the-years ceremony that the Toltecs began the development of their own calendrical count very shortly after they or their near-Chichimec relatives had overrun and burned the great metropolis of Teotihuacán in the mid-eighth century. That they had simply taken over the calendrical system that they had encountered there is amply shown by the fact that the Toltec-Aztec day count varies by only two days from the sacred almanac of the Maya and by only one day from the Mayan secular calendar.
In the process of constructing their own calendar from the dimly understood remnants of a time count they had absorbed by conquest, the Toltecs not only unconsciously garbled some of its basic concepts but also purposefully added some of their own distinctive embellishments. Although Teotihuacán, in common with the Olmecs and Mayas, employed a starting date for the sacred almanac that was fixed in the landscape by the sunset position fifty-two days after the summer solstice, on 13 August of the Gregorian calendar (Malmström 1978, 114), the Toltecs chose as their starting date for the same 260-day count a point fixed in the landscape by the sunrise position fifty-two days after the winter solstice, or 12 February of the Gregorian calendar. This choice was revealed by measurements made in January 1991 at Chalchihuites, an astronomical site on the Tropic of Cancer in the northern desert of Mexico (Fig. 2). Originally constructed in the mid-fifth century A.D. by an expedition sent from Teotihuacán, Chalchihuites had been reoccupied and partially rebuilt in the ninth and tenth centuries, most likely by the Toltecs. Lacking optical instruments and written means of recording their observations, the original builders had sliced several trenches through the ground and plastered them with adobe to give them some measure of permanence. Although the main trenches were aligned with mountain peaks on the eastern horizon to mark sunrise positions at the time of the summer solstice, one unexplained trench has an azimuth orientation of 105.5º, or 15.5º to the south of east. This is the azimuth at which the sun rises on 12 February, the date that marks the fifty-second day after the winter solstice.

One of the merits of choosing the winter solstice as the starting point for the fifty-two-day count is that a complete cycle of the 260-day sacred almanac would bring it back to the same day-number and name on the equivalent of 30 October, which coincided with the zenith passage of the Pleiades. With two calendars of such fluidity that they were always slipping out of phase with the solar year, it is small wonder that the Pleiades provided the one steadfast celestial benchmark on which the Toltecs could rely. It takes no great stretch of the imagination to understand why, to these people, the reappearance
of the Seven Sisters at their appointed time and place in the heavens became a symbol of the earth's renewal for another fifty-two years.

Another difference between the calendar used in Teotihuacán and that developed by the Toltecs and inherited by the Aztecs was that the former employed the Olmec and Maya convention of using dots to symbolize numbers less than five and a bar for the numeral five, but the Toltecs, and the Aztecs used dots to record all numbers. This practice would appear to have been an inheritance from the Zapotecs and Mixtecs, who did the same thing several centuries earlier. However, the greatest single difference between the Olmec and Maya calendars on the one hand and the Toltec and Aztec calendars on the other was the latter's lack of a long count. The Toltecs and Aztecs had so little grasp of the dimension of the time that their traditions fixed the birth of the sun as A.D. 726, a curiously significant date for the present study, because it preceded by only one bundle of years the creation of their own calendar in A.D. 778 (Krickeberg 1980, 209). Nevertheless, without the continuous time count that the Olmecs had developed in 236 B.C., neither the Toltecs nor the Aztecs were ever able to perform the complex calculations necessary for the prediction of eclipses. The skill remained unmastered until the demise of their civilization.

GEOGRAPHICAL AND HISTORICAL EXPLANATIONS

There can be little doubt that the unique calendrical creations of the Toltecs and Aztecs grew directly from their geography and history. The time counts to which they fell heir had evolved near the far southern margins of Mesoamerica and had diffused over more than one thousand kilometers of space and through more than a millennium of time to arrive essentially intact and unmodified on the plateau of Mexico by the second century B.C. Although the very layout of Mesoamerica's greatest pre-Columbian metropolis was proof positive of the calendar's overwhelming importance, Teotihuacán, despite its great technological, architectural, artistic, and commercial prominence, seems to have contributed little to further development of the calendar during more than seven centuries of grandeur. One should not overlook the expedition in the mid-fifth century A.D. to locate the Tropic of Cancer, the place "where the sun stood still" in the northern desert. Nor is it impossible that astronomer-priests from Teotihuacán may have prompted the Mayas to launch a similar expedition about the same time to locate the parallel of latitude where the 260-day interval between zenithal sun passages could be measured, a journey that resulted in the founding of Copán. The destruction of Teotihuacán by Chichimec nomads in the mid-eighth century A.D. sent refugees fleeing southward and eastward to places like Xochicalco, Cholula, and El Tajín, in all of which calendrical knowledge was at least preserved, if not enhanced, in the following centuries. That the Toltecs were eager to become "civilized" is evidenced by their experimentation with the calendar within two decades of their destruction of Teotihuacán; on the other hand, the ability to create and maintain a civilization was much harder to come by, because their innovations of year bearers and the binding of the years both preceded the founding of their capital at Tula by almost two centuries.
Although Tula was closer geographically to the original home of the Toltecs than was Teotihuacán, the former was also far more exposed to the vagaries of climate and to the attacks of nomads. Whether its abandonment in 1168 is attributable to natural causes such as drought, to invasion by new waves of Chichimecs, or to both, it is interesting to note that this date coincides perfectly with the beginnings of the Aztec migrations southward and eastward. In two years the survivors of Tula had taken over Cholula, and soon thereafter they had founded their first main settlements in the valley of Mexico at Tenayuca and Colhuacán. Although the Aztecs pressed into the valley about the middle of the thirteenth century, not until the late fourteenth century were they unified and strong enough to found their own settlement at Tenochtitlán.

By the time the Aztecs had acquired their calendar it had undergone serious modification, due to both spatial and temporal attrition. The winter solstice had been exchanged for the summer solstice to mark the beginning of the sacred almanac. In the process the entire time count had been shifted by half a year, and an alignment to the sunset position on 13 August had been exchanged for one to a sunrise position on 12 February as a means of calibrating it. Rather than having frozen the beginning day of their secular calendar, as the Maya had done on 26 July, the Toltecs had frozen both ends of their sacred almanac, making 12 February and 30 October the key dates in their time count. They had likewise exchanged the zenithal passage of the Pleiades for the zenithal passage of the sun. It is perhaps in this latter regard that we see the role of geographical location most strongly manifested in the Toltec and Aztec calendar, because no other people in Mesoamerica lived so directly beneath the path of the Pleiades. For a newly acculturated Chichimec trying to bring some order into his world of chaos and confusion, there was probably no other celestial phenomenon that seemed to hold more promise of security and stability than did this remarkable and easily identifiable cluster of stars, and on them he pinned his fortune.

CLOSING REMARKS

In these two case studies, the panoply of Mesoamerican pre-Columbian intellectual development unfolds in miniature. Two peoples, the Olmec and the Maya, located geographically in the very core of the region's innovative activity, early began a quest to fashion some understanding of the physical environment in which they lived. Their efforts were long and tortuous but ultimately rewarded with a measure of success. Without ever recognizing the sphericity of the earth, they had grasped enough knowledge of celestial mechanics to enable them to predict eclipses. Almost synchronously with this triumph of native American accomplishment, two other groups, the Toltecs and the Aztecs, were moving from the periphery closer to the core of the region. As refugees from the desert, in both a physical and cultural sense, they briefly and fragmentarily became acquainted with civilization. The victims of geographical isolation, they would always remain the intellectual "poor cousins" of the Olmecs and the Maya.

Looking back at the entire span of cultural florescence in pre-Columbian Mesoamerica, it is sadly ironic that the intellectual ferment begun with a zenithal sun passage over Izapa, on the Pacific coastal plain of southernmost Mexico, on a 13 August
in the fourteenth century B.C., should have ended in the fury of blood and fire on the causeways of the Aztec capital on another 13 August, in A.D. 1521. The apocalyptic fall of Tenochtitlán marked the end not only of a religion, a calendar, and a culture but of an entire civilization.

REFERENCES


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