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ASTRONOMICAL CONSIDERATIONS IN THE AZTEC EXPRESSION OF HISTORY

Eclipse data

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Abstract

In this paper, we present a complete list of eclipses documented in the Mexica manuscripts. We use this list together with information in the chronicles to outline a possible method used by Mexica chronologists for linking historical with retrodictable cosmic events that were deliberately chosen to fit historical circumstances. Solar events, particularly eclipses, figure prominently in a scheme that stresses the recurrence of like-in-kind events positioned at multiples of the Xiuhmolpilli (52-year) cycle. Thus, both the foundation of the empire and calendrical adjustments related to the fictional chronology of World Ages are connected to eclipses that were visible at Tenochtitlan and that fell either at the solstices or the equinoxes.

> The history of it was saved, but it was burned when Itzcoatl ruled in Mexico. A council of rulers of Mexico took place. They said "It is not necessary for all the common people to know of the writings; government will be defamed, and this will only spread sorcery in the land; for it containeth many falsehoods."
> (Sahagún 1950–1982:Book 10:191)

Anyone thumbing through the Aztec-period pictorial histories is immediately struck by the way in which the events of human and cosmic history are mixed together and conflated. Pictorial scenes coupled with year-bearer glyphs depict such social occasions as battles, conquests, famines, and feasts as if these were inseparable from such natural phenomena as eclipses, "smoking stars," earthquakes, and floods. The Franciscan chronicler Fray Toribio de Benavente, better known as Motolinía, tells us that:

> They wrote down and painted the notable things that happened or were seen in the sky or on the land, such as an eclipse of the sun or the moon, as well as comets or any other new sign; then when they began a new fifty-two year cycle, they put down the house of the year, and the masters of counting began to record all of the things worth remembering, wars, the deaths of eminent persons, earthquakes, famines, numerous deaths, and the like. (Motolinía 1971:390)

An obvious difference between Aztec time and our own lies in the repetitive, cyclic nature of the former. Although sometimes oversimplified, as Farriss (1987) has shown, we know that this emphasis on cyclicity was ancient and deeply rooted in the Mesoamerican cultural tradition. That two basic time cycles—the *tonalpohualli* (260 days; Table 1) and the *xihuitl* (365 days; Table 2)[1]—were pan-Mesoamerican in distribution, thus testifying to the continuity of this philosophy of time in all regions.

The discovery that a commensuration principle united several distinct spheres of temporal experience led to extensive use of the *tonalpohualli* as an expression of the contact experienced between the phenomena of human culture and the world of nature (Aveni 1989:197–203). For example, 260 days approximates the gestation cycle of the human female, as well as the length of the agricultural cycle in many regions. In addition, several astronomical periods fall close to 260 days. These include the average morning- and evening-star intervals of the planet Venus, the time the Sun spends south of the zenith in southern Mesoamerica, and the eclipse half year of 173.5 days, which resonates in a 3 to 2 ratio with the *tonalpohualli* (thus, $3 \times 173.5 = 2 \times 260$). The Moon is further implicated by the fact that nine lunar synodic months (265.8 days) are also a close approximation of the *tonalpohualli*. Coincidences of this type made it possible to attach eclipses or the aspects of Venus to particular name days in the cycle. Accordingly, we may think of the *tonalpohualli* as reflecting the convergence of a multitude of repetitive rhythms experienced both inside and outside of the human body.

The process leading to a solar-based calendar in Mesoamerica cannot be traced with any precision. It seems to have been completed at least several centuries before the end of the first millennium B.C. As in ancient Rome, a solar calendar may have arisen

[1] Together these formed the calendar round of 52 years = $73 \times 260 = 52 \times 365$ days. This was the interval between performances of the New Fire rite in years named 2 Reed.

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Table 1. The days of the 260-day Tonalpohualli count

Number	Nahuatl	English	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Cipactli	Crocodile	1	8	2	9	3	10	4	11	5	12	6	13	7
2	Ehecatl	Wind	2	9	3	10	4	11	5	12	6	13	7	1	8
3	Calli	House	3	10	4	11	5	12	6	13	7	1	8	2	9
4	Cuetzpallin	Flint	4	11	5	12	6	13	7	1	8	2	9	3	10
5	Coatl	Serpent	5	12	6	13	7	1	8	2	9	3	10	4	11
6	Miquiztli	Death	6	13	7	1	8	2	9	3	10	4	11	5	12
7	Mazatl	Deer	7	1	8	2	9	3	10	4	11	5	12	6	13
8	Tochtli	Rabbit	8	2	9	3	10	4	11	5	12	6	13	7	1
9	Atl	Water	9	3	10	4	11	5	12	6	13	7	1	8	2
10	Izcuintli	Dog	10	4	11	5	12	6	13	7	1	8	2	9	3
11	Ozomatli	Monkey	11	5	12	6	13	7	1	8	2	9	3	10	4
12	Malinalli	Grass	12	6	13	7	1	8	2	9	3	10	4	11	5
13	Acatl	Reed	13	7	1	8	2	9	3	10	4	11	5	12	6
14	Ocelotl	Jaguar	1	8	2	8	3	10	4	11	5	12	6	13	7
15	Cuauhtli	Eagle	2	9	3	10	4	11	5	12	6	13	7	1	8
16	Cozcacuauhtli	Vulture	2	10	4	11	5	12	6	13	7	1	8	2	9
17	Ollin	Movement	4	11	5	12	6	13	7	1	8	2	9	3	10
18	Tecpatl	Flint	5	12	6	13	7	1	8	2	8	3	10	4	11
19	Quiahuitl	Rain	6	13	7	1	8	2	9	3	10	4	11	5	12
20	Xochitl	Flower	7	1	8	2	9	3	10	4	11	5	12	6	13

out of a conscious desire to bureaucratize time.[2] Thus, political elites would have patterned time by aligning key historical events with cosmic occurrences, so that they would be perceived as directly linked to the sources of power in the cosmos.

The *xihuitl*, once established, consisted of 18 20-day "months,"[3] plus five days (see Table 2). Individual years appear to have been named for the *tonalpohualli* day falling on the first day of the first month among the lowland Maya, or, as in most other regions, for the last day of the eighteenth month. Because 365 divided by 20 leaves a remainder of 5, only 4 of the 20 day names can be applied to the year. Those used in Tenochtitlan and most other central Mexican city-states at the time of the Conquest were Rabbit (Tochtli), Reed (Acatl), Flint (Tecpatl), and House (Calli). Dividing 365 by 13 leaves a remainder of 1, so that the year-bearer coefficients always advanced by 1. This system yields a total of 52 individually named years called the *xiuhmolpilli*, or "binding of the years" (Table 3).

The name of the first month in Tenochtitlan at the time of the Conquest is open to some question. Most early chroniclers, including Sahagún (1950–1982, Book 2:1, 42), Motolinía (1971:51), and Durán (1967:1:239–240), state that Atlcahualo (also called Cuahuitlehua) occupied this position, and that Izcalli was the last. The *Codex Magliabechiano* and *Codex Tudela* are in accord, as well. However, Caso's analysis of well-established correlational

Table 2. The names of the months in Tenochtitlan

Number	Month Name
I	Izcalli
II	Atlcahualo or Cuauhuitlehua
III	Tlacaxipehualiztli
IV	Tozoztontli
V	Hueitozoztli
VI	Toxcatl
VII	Etzalcualiztli
VIII	Tecuilhuitontli
IX	Hueitecuilhuitl
X	Tlaxochimaco or Nexochimaco
XI	Xocotlhuetzi
XII	Ochpaniztli
XIII	Teotleco
XIV	Tepeilhuitl
XV	Quecholli
XVI	Panquetzaliztli
XVII	Atemoztli
XVIII	Tititl

Note: Izcalli is the first month of the year based on Caso's (1967) interpretation of the Codex *Borbonicus* (1974). Atlcahualo is named as the first month of the year in many early post-Conquest sources.

[2] This cycle-building process typically begins with attempts to apportion or account for all parts of the seasonal cycle, rather than just those related to human actions, which once had been named after the lunar months in which they occurred. In older forms of the Roman calendar, the remainder of the year, during which people were idle or inactive, had been left both unmarked and unnamed. Such 9-, 10-, or 11-month years exist in many societies that were less hierarchically structured than urban Tenochtitlan and other Mesoamerican city-states. In many cases, the lunar-based year, falling well short of the 365-day solar year, is restarted by the sighting of a natural phenomenon keyed to the solar cycle (e.g., the appearance of the Palolo Worm in the Trobriand Islands, the flooding of the Omo River in Ethiopia, or the heliacal rise of the Pleiades in Cuzco (see Aveni [1989] for a detailed account). It is likely that the midnight sighting of the Pleiades overhead, mentioned by Sahagún, was an artifact of this bureaucratic "clock-setting" that emanated from a similar short-count calendar cycle.

[3] Although not obviously related to lunations, the term for this period in several Mesoamerican languages also meant Moon (e.g., in Nahuatl, *metztli*; in Yucatec Maya, *uinal*), so that there may have been an archaic connection.

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Table 3. The Xiuhmolpilli or 52-year cycle

1 Rabbit	1 Reed	1 Flint	1 House
2 Reed	2 Flint	2 House	2 Rabbit
3 Flint	3 House	3 Rabbit	3 Reed
4 House	4 Rabbit	4 Reed	4 Flint
5 Rabbit	5 Reed	5 Flint	5 House
6 Reed	6 Flint	6 House	6 Rabbit
7 Flint	7 House	7 Rabbit	7 Reed
8 House	8 Rabbit	8 Reed	8 Flint
9 Rabbit	9 Reed	9 Flint	9 House
10 Reed	10 Flint	10 House	10 Rabbit
11 Flint	11 House	11 Rabbit	11 Reed
12 House	12 Rabbit	12 Reed	12 Flint
13 Rabbit	13 Reed	13 Flint	13 House

dates (see later) seems to prove that Izcalli must have been the first rather than the last month of the calendar year. Strong supporting evidence comes from a list of months found in the third part of the *Codex Borbonicus*.[4]

One of the major problems in comparative chronology deals with the question of how indigenous time counts can be affixed to our own Christian (originally Roman) calendar. Aztec sources indicate that the siege of Tenochtitlan came to an end when Emperor Cuauhtemoc surrendered to Cortes on the day 1 Snake 2 Xocotlhuetzi in a year named 3 House; this was Friday, August 13, 1521, in the European (Julian) calendar (Caso 1967:47; Tena 1987:42–44).[5]

Even given this equation, we must still deal with the problem of how Aztec history, expressed as cyclically repeating interconnected social and cosmic phenomena, was transposed into the linear band of western timekeeping. Because no linear time frame similar to the Maya long count was used, we cannot always be certain where specific events should be placed in a so-called "real time" sequence. In a few texts, narrative continuity served this purpose. The *Leyenda de los soles* (1992), for example, contains an unbroken sequence extending from the creation of the world in the tenth century B.C.[6] up to A.D. 1558. Other examples include the *Historia de los mexicanos por sus pinturas* (1941) and *Tira de la peregrinación* (*Codex Boturini* 1944), all of which used a continuous year-count format. Unfortunately, many important post-Conquest texts employed a cut-and-paste technique in which dates and events from several sources were sometimes mixed together in the wrong order. Isolated dates found on sculptures or in architectural settings can be assigned to a specific 52-year cycle only when the archaeological context or stylistic tradition is well understood.

Somewhat different problems arise when we ask how the Aztecs reckoned the position of the seasonal year in relation to the *xihuitl*, that is, how "real" astronomical and "fabricated" canonic time were linked. Because the seasonal year is 365.2422 and the calendar year 365 whole days in length, slippage between the two accumulates at a rate of approximately 1 day every 4 years, 13 after 52, and a full 20-day "month" after 83, with the cyclic pair realigning after 1,508 calendar years.[7] Thus, if the first day of the first Aztec month, let us say 1 Izcalli, fell on January 26, 1513, it would fall on January 25 in 1517, on January 24 in 1521, and so on. Extrapolating backward to Tenochtitlan's "official" founding date (2 House 1325), we find that 1 Izcalli would have fallen on March 14, two days after the spring equinox.[8]

At this rate of divergence, calendar time would soon be out of joint with the seasons. This was the case with the Roman calendar in the time of the Julius Caesar, resulting in the Julian reform and, once again, the Gregorian reform of 1582. The Julian reform added one extra day every four years, but this produced a slight overcorrection, because the actual discrepancy between the true and canonic years grows at the rate of .2422 rather than .25 days every year. The Gregorian reform introduced rules and amendments of a more complex nature, fine-tuning the system so that natural and canonic time will coincide almost perfectly for thousands of years.

Although Aztec and other Mesoamerican calendar priests, as Caso (1971:346) remarks, "surely knew the duration of the astronomical years . . . they did not make a Julian correction, and consequently, did not introduce the leap year." He goes on to observe that "The fact that the several cycles were considered coincident—*tonalpohualli*, the moon, the synodical revolution of Venus—made it impossible to compute the leap year" (Caso 1971:348).[9]

The Maya approach, for which far better documentary evidence exists, was to track points in the 365-day (or any other) time cycle by referring to fixed points in the 260-day count. Both the Mayas and the Aztecs pegged the 260-day cycle to the 365-day "year" through the use of year bearers. In doing this, they used a procedure that could also be applied, with appropriate modifications, for purposes of eclipse prediction. Thus, in the *Dresden Codex* eclipse table, specified dates in the 260-day count served as warning days, even though completely different cycles were involved. In this case, the ability to express the position in one time cycle by referring to that in another solves the problem of slippage as well as any leap-year mechanism, but without breaking the arithmetical sequence of the day count.

Still another way to align "time counted" with "time experienced" would be to add or delete months. The Babylonians, who

[4] Although the dating of the *Codex Borbonicus* is still in dispute, it may be the only Aztec pictorial manuscript painted before the Conquest. All others show clear evidence of their colonial origin, probably as copies of earlier, but now lost, pictorial texts. Robertson (1959:86–93) was initially convinced that the *Codex Borbonicus* was painted some years after the Spanish Conquest. A set of notes sent to Calnek by Martha Robertson soon after the untimely death of her husband indicates that he had modified his earlier opinion, in favor of the view that it was *probably* completed before the Conquest.

[5] All dates referred to in this study, unless otherwise specified, are Julian.

[6] This date is reached simply by counting back from 1558. The text itself contains adequate calendrical information for this purpose.

[7] This is because $1507 \times 365.2422 = 1508 \times 365 = 550,420$ days.

[8] Over the course of Aztec history calculated from this point, the total slippage would have been about 48 days, slightly less than two and one-half 20-day months. Thus, $1517 - 1325 = 192$; $192 \div 4 = 48$.

[9] Aguilera and Galindo T. (1991) and Tena (1987) are among the scholars who advocate the possibility of an intercalation. We agree with Caso; however, even if he was wrong, the only effect upon our analysis would involve eclipses that actually occurred in Izcalli, so that the name of the year would be in some doubt. None of the eclipses listed in our Table 4 falls in Izcalli, therefore, their identification with specific named years would not be changed. Consequently, as it is not central to the argument of this paper, we have chosen to omit a more detailed consideration of the correlation problem.

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were as exacting in calendrical matters as any bureaucratic society inserted a double month when needed in order to align the lunar count with the solar year. Imagine, if you will, that from time to time our own calendar repeated the month of December. Edmonson (1988:111–116), arguing that all Mesoamerican calendars operated on an unbroken, astronomically geared time count, suggests several hypothetical methods for calendar correction.

Having given a brief background sketch of the essential characteristics of the Aztec understanding of time, together with some of the problems and pitfalls confronted by modern scholars who study world calendars, we turn next to a review of our own recent efforts at linking Aztec history with retrodictable cosmic events.

STRUCTURE AND PATTERN IN AZTEC HISTORY

The Aztecs of Tenochtitlan gained independence and commenced their own career of imperialist expansion with a victory over the Tepanecs of Azcapotzalco in the year 1 Flint 1428. A newly independent people may feel the need to revise or even reinvent their own history, and this is precisely what the Aztecs seem to have done. The burning of historical texts mentioned in the epigraph to this paper would have occurred sometime between 1428 and Itzcoatl's death in 1440. For obvious reasons, we cannot know precisely how earlier records were eventually changed. We do know, as Umberger (1981:13) remarks, that in the final versions "a number of events of early history were assigned to dates with important positions in the 52-year cycle and that certain types of events were recorded as occurring in years of the same name."

This type of chronological patterning in Aztec history is well illustrated by the following events assigned to years named 1 Flint:

1. The beginning of the Aztec migration from their ancient homeland, Aztlan.
2. The birth of Huitzilopochtli, their chief tutelary god, at Coatepec near Tula.
3. Their arrival at the site of their future capital city, Tenochtitlan.
4. The enthronement of Acamapichtli as the city's first king.
5. The winning of independence and beginnings of empire.

The present inquiry specifically examines the degree to which, in their rewriting of history, the Aztecs consciously pegged such events to cosmic phenomena and the manner in which this might have been done. Such an inquiry is fraught with difficulty, because Itzcoatl's revisions may themselves have been rewritten many times over by later kings. Whatever the specific rationale, it is clear that historical chronologies were routinely manipulated, particularly those applied to events more than two or three generations in the past. The possibility that such astronomical events as equinoxes, eclipses, or planetary alignments were also taken into account has not yet, to our knowledge, received serious consideration. We nonetheless suggest that societies convinced of the repetitive nature of history—that the present and future are somehow embedded in the past—may well have accepted the close patterning of historical and cosmic events as a matter of course.

The twelfth book of Sahagún's (1950–1982) *Florentine Codex*, for example, opens with a description of eight omens presaging the Spanish Conquest. Of these, three were celestial events, whereas the other five were magical or miraculous in greater or lesser degree. The first set included a phenomenon described as a "tongue-of-fire, like the light of dawn," seen at night in the east in the year 4 House 1509 (Sahagun 1950–1982, Book 12:1).[10] A solar eclipse in 1510, represented in the *Codex Telleriano-Remensis*, also falls in the same period of time (Table 4).

These and similar events would have been recorded in the quasi-journalistic format of continuous year-count annals, which would have supplied the raw materials used when realigning major social events with "religiously correct" dates in the calendar. If these happened to be juxtaposed with an equinox, eclipse, or planetary conjunction, so much the better. Umberger (1981:Figure 1) provides a useful *xiuhmolpilli* table showing some of the ways in which like-in-kind events were deliberately positioned at the junctions of the four quarters (*tlalpilli*) of the 52-year cycle. In a few cases, (e.g., the creation of fire in 2 Reed, the birth of the Sun in 13 Reed, and the founding of Tenochtitlan in 2 House), major events were displaced from these junctions by ± 1 year. The linking of like-in-kind events to a particular year in the 52-year cycle, however, would have been no more than a first step when revising historical chronologies. It was also necessary to stipulate the specific cycle in which the selected event would be placed, as well as the number of cycles separating like-in-kind pairs of events. The fact that the conquest of Azcapotzalco in 1 Flint 1428 followed the founding of Tenochtitlan by two *xiuhmolpilli* cycles minus one year strongly suggests that at least one, and probably both, of these dates was contrived with this objective in mind.

Fixing Beginnings in Aztec History

In an earlier paper (Aveni et al. 1988:294–297), we discussed connections between the founding myth, architectural design, and the urbanistic plan of Tenochtitlan. The ethnohistorical record includes numerous allusions to locative schemes that offer clues to the kinds of astronomical events that may have been involved in the setting or resetting of the Aztec time clock. Motolinía (1971:51), for example, writes that rites performed during the ceremonial month named Tlacaxipehualiztli ("The Flaying of Men") were keyed to observation of the equinoctial Sun over the Templo Mayor. He goes on to say that Motecuhzoma (Xocoyotzin? [reigned 1502–1520]) found the temple to have been misaligned and ordered it torn down and rebuilt. That a solar event should figure so prominently in this context is no surprise. The Aztec ideology of war and conquest emphasized the close relationship between the Sun's annual movements and the political course of the Aztec state.

We analyzed the scenario that might have been involved in this "pinning down" of astronomical time in the following terms:

1. The Mexica laid out their earliest structures in an east-west direction. Mountain peaks on the east and west horizons may have served as the original reference points.
2. The earliest temple exposed by archaeological excavation, probably constructed between 1370 and 1390, was no more than 10–12 m in height (Matos 1982). As the city prospered and the Aztec empire expanded, new and progressively higher temples were built directly over the first. Measurements by Aveni et al. (1988) showed that the original orientation remained substantially the same from the beginning until the Conquest. Any significant increase in height would have presented something of a problem when actually observing the equinoctial Sun. The realignment described by Motolinía may have been Motecuhzoma's response to this problem.

[10] The *Codex Chimalpopoca* (1992:122) says that a "cloud banner" began to appear in the east in 4 House 1509, and by the next year (5 Rabbit 1510) "It seemed like fire. The people were extremely terrified."

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3. When they wished to incorporate the equinox alignment into their ceremonial structures as an enduring principle, they laid out the west-facing Templo Mayor so that, when viewed by an observer at the base of the temple along an axis positioned approximately 7° south of east, the equinox Sun, viewed progressively over a higher horizon and shifting farther to the south as it rose higher in the sky, would appear in the notch between the two temples on its summit platform.

At the time of the Conquest, Tenochtitlan was divided into Great Quarters by avenues extending from the gates of its ceremonial precinct. Whether this equinoctially based quartering was represented in the earliest city plan or was introduced later still awaits archaeological investigation. In any case, the choice of 2 House 1325 as the city's foundation date, as discussed below, was very possibly influenced by the fact that the first day of the year was a very close approximation to the actual day of the spring equinox.

In seeking out candidate cosmic events for an Aztec beginning, however, a wide range of meteorological and geological occurrences, such as floods, droughts, earthquakes and volcanic eruptions, are also available for consideration. It is, however, usually impossible to find independent, reliable evidence affixing these to specific calendar dates. At the same time, many periodically recurrent astronomical events, such as eclipses, planetary conjunctions, meteor showers, and perhaps a few comets, can be easily identified with a high degree of precision and reliability. Fortunately, phenomena of these kinds figure importantly in the documentary record of the codices and chronicles (e.g., Quiñones Keber 1995:318–23). Do they reveal patterns bearing a clearly defined relationship to the patterned calendrical dates found in early historical texts?

We approached this problem by first compiling a detailed working list of cosmic events as recorded in central Mexican historical texts. Our long-term objective is to find the extent to which celestial phenomena may have served as temporal anchors for purportedly historical events, and whether the like-in-kind natural events selectively recorded in these texts were deliberately positioned at intervals dictated by the numerical structure of the calendar system. In particular, we have tried to sift out all identifiable astronomical phenomena that would have been visible in this region of Mesoamerica. Previously available lists include partial inventories by Aguilera and Galindo T. (1991), Berger (1994), Köhler (1989),[11] Quiñones Keber (1984, 1995), Milbrath (1995), and Weitzel (1950). Our own compendium takes these into account, adding several revisions and new identifications. This article deals primarily with the eclipse record, which happens to be the most amenable to independent verification.

We hypothesize that calendrical adjustments were frequently geared to the 52-year *xiuhmolpilli* or one its multiples, and that both equinoxes and visible eclipses were considered when determining the chronological placement of specific like-in-kind events. In some instances, these were undoubtedly based on the accumulation of records kept by generation after generation of Mesoamerican astronomers. In others, some type of formula-based back calculation must have been used, although precisely what it was we cannot say.

[11] We disagree with the assignment by Köhler (1989:291) of many "smoking star" events found in the codices to comets. Many of the examples of comets he cites from astronomical sources would have been scarcely visible.

Ixtlilxochitl's Toltec *Relaciones* provides an unusually clear illustration of the close articulation of historically defined time periods with astronomical phenomena. This important chronicler based his work on a now-lost pictorial text cited as *La historia y crónica de los tultecas* in a 1608 legal deposition (*Testimonio*) (Ixtlilxochitl 1985:I:518). This was paired with a second pictorial cited as *La crónica de los reyes chichimecas*,[12] which carries the count of years forward to the year 13 Reed 1427.

The Toltec *Relaciones* cover the period from the creation of the world in a year named 1 Flint to the destruction of Tula (also in 1 Flint) 6,136 years later. The Chichimec *Relaciones* add 260 years, for a total of 6,396. Figure 1 is a simplified time line representing the succession of World Ages or Suns, their durations expressed both as years since creation (Creation Years, hereinafter abbreviated CY) and in *xiuhmolpilli* and their multiples, where required.

The following observations, based on the chronology of Toltec history, offer clues to the ways in which the Aztecs and their central Mexican neighbors went about structuring and restructuring historical time. The duration of World Ages, in the first instance, is always a large multiple of the standard 52-year cycle. Significant turning points within each age were spaced at intervals of one or more 52-year cycles or, in some instances, 13-year subunits called *tlalpilli*. The "standing still" of the Sun in 8 Rabbit CY 4779, supposedly until it was bitten by a mosquito, is an interesting but unexplained departure from this norm.

The durations assigned to the first three World Ages were 1716, 1716, and 1560 years, respectively. Expressed as *xiuhmolpilli* multiples, the corresponding numbers are 33, 33, and 30. The fourth age was to be the last, and was therefore still "in progress," so to speak, and is subdivided into shorter intervals of time. Toltec history extends through two 572-year subperiods of the Fourth Sun; the fall of Tula, in 1 Flint CY 6137, dates to the first year of a third subperiod. It should be noted that $572 \times 3 = 1{,}716$, so that the projected duration of the fourth World Age would have been the same as that of the first two.

Ixtlilxochitl provides the following description of a calendar reform said to have taken place in Huehuetlapallan, ancient seat of the Toltec people, probably located near the port city of Coatzacoalcos in southern Veracruz according to Jiménez Moreno (1954–1955:225):

> In the year 5,097 after the creation of the world, which was 1 Flint, Toltec sages, astrologers, and [masters of] all other arts, assembled in their capital city, Huehuetlapallan, where they ex-

[12] This is currently known as the *Codex Xolotl*. Its present repository is the Bibliotheque National de Paris. Reflecting a widely held perspective among manuscript scholars, one of our referees commented that conclusions based on data found in this source had better remain speculative. So far as Ixtlilxochitl is concerned, much criticism has centered on his supposedly confused chronologies. This, however, is largely an artifact of the way in which Chavero "reorganized" material found in Ixtlilxochitl's manuscript collection (or rather, in copies made by Boturini and his successors, because the original handwritten texts seem to have been lost). The real question is whether Ixtlilxochitl's transcriptions of pictorial manuscripts were accurate, and how we understand the chronological material preserved in this fashion. Dibble found Ixtlilxochitl's reading of the *Codex Xolotl* to have been substantially correct, but with occasional, and usually understandable, misreading of a few name glyphs. The same may have been true of his reading and transcription of the now-lost *Historia tulteca* manuscript. Our reconstruction of the chronology is based on the sequence of year names and references to the number of years separating key events, rather than on Ixtlilxochitl's commentaries and correlational dates.

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> amined the happenings, calamities and movements of the sky since the creation of the world, and [accomplished] many other things . . . among which was the adding of a leap year in order to adjust the solar [i.e., calendar] year to the equinox . . . [and] it had been one hundred and sixty-six years since they had adjusted their years and times with the equinox . . . when the sun and moon were eclipsed and the earth trembled . . . which was in the year of 1 House. (Ixtlilxochitl 1985:I:265)[13]

The statement that Toltec sages had reviewed the "movements of the sky" since creation *before* adjusting their calendar to an equinox suggests that they were attempting to commensurate true solar and canonic calendar years. The correct ratio based on modern scientific measurement is 1,507 to 1,508 (as discussed earlier). Applying this to a period of 5,096 years (the last complete year before 1 Flint CY 5097), we see that $5{,}096 = 3 \times 1{,}508 + 572$. This might have passed unnoticed had the number 572 not been identified as a singularly important number in the triadic composition of the first and second World Ages and the first two subperiods of the fourth.

Ixtlilxochitl (1985:I:420, 531; II:13) repeatedly emphasizes the importance of this interval by stating that 572 years was the duration of the empire governed by the Tula Toltecs. Now, the slippage between calendar and Sun after 5,096 years would therefore have included three full returns of the Sun to the original equinox, plus .378 of the next cycle. At that point in time, the calendar year would be 139 days ahead of any observed solar event, such as the equinox. Whatever else it may mean, the designation of 1 Flint CY 5097 as a calendar-reform year strongly suggests that the "leap year" adjustment mentioned by Ixtlilxochitl was based on prior discovery of the 1,507 to 1,508 ratio. We do not yet know precisely how this ratio, once confirmed, was transposed into the fictional chronology of World Ages preserved in the original pictorial text.

Was the revised ratio implemented by undertaking an actual calendar reform? Some interesting coincidences support the historical authenticity of such an occurrence, while identifying the most probable date. First of all, counting back from the year 13 Reed 1427 takes us to the year A.D. 1 Flint 129. The name of the first day in terminally named 1 Flint years is 6 Rain. We found that this was precisely the name of the day of the fall equinox in the correct year (September 24, 129).[14] The odds that this might happen by chance are 1 in 110,000 (or 1 in 55,000 if both equinoxes are considered). Secondly, the reliability of this identification is confirmed by Ixtlilxochitl's reference to a double eclipse 169 years later, in 1 House CY 5266 (A.D. 298). We discovered that a lunar eclipse took place on December 5, followed by a solar eclipse (70% of totality) on December 20.[15] Despite the great antiquity of the reference involved, the record of this rare pair of events may have been deemed important enough to be preserved as part of the historical record more than a millennium later. Indeed, the likelihood

Table 4. Eclipse references in central Mexican sources A.D. 1198–1523

European Year	Eclipse Date	Local Time	Magnitude	Mesoamerican Year	Mesoamerican Day	Mesoamerican Month	Reference/Comment[a]
1198[b]	8/04/1198	8:24	<1	5 Rabbit	5 Rabbit	10 Panquetzaliztli	H: Plate XXIII
1301[c]	2/09/1301	10:00	98	3 Flint	9 Snake	7 Atemoztli	E: Plate 9, visible
1404[d]	1/12/1404	12:28	30	2 Reed	5 Movement	4 Atemoztli	G: 76, visible
1455[e]	4/16/1455	17:35	38	2 Reed	7 Rain	6 Tozoztli	G: 130
1473[f]	10/21/1473	9:04	—	7 House	10 Wind	19 Teotleco	Tq I : 173
1475[g]	4/05/1475	17:52	—	9 Reed	8 Reed	20 Tlacaxipehualiztli	Tq I: 181
1476[h]	8/19/1476	6:39	<1	10 Flint	3 Eagle	17 Tlaxochimaco	A: 105; C: 209; F: 115; I: 37r; Tq I: 181; V: CXVII
1478[i]	—	—	—	12 Rabbit	1 Movement	unknown	C: 210
1479[j]	6/19/1479	16:44	<1	13 Reed	10 Water	16 Etzalcualiztli	A: 105–6; D: 47; H: Plate LXX; J
1481[k]	5/28/1481	9:12	75	2 House	4 Flint	15 Toxcatl	F: 117, visible
1490[l]	12/11/1490	15:36	<1	11 Rabbit	4 Wind	14 Panquetzaliztli	F: 118
1492[m]	4/26/1492	11:36	40	13 Flint	12 Lizard	6 Hueitozoztli	A: 113; F: 118; H: Plate LXII, visible
1493[n]	3/17/1493	16:56	<1	1 House	12 Water	6 Tlacaxipehualiztli	F: 118
1496[o]	8/08/1496	15:36	96	4 Flint	4 Water	11 Tlaxochimaco	A: 119; B:157; C:225; F:119: I40v; V: CXXIV, visible
1499[p]	6/08/1499	18:48	70	7 Reed	11 House	10 Etzalcualiztli	Tq I: 192, visible
1504[q]	3/16/1504	6:08	15	12 Flint	12 Death	8 Tlacaxipehualizli	F:120; H: Plate LXXIX; Tq I:196, visible
1505[r]	7/30/1505	15:52	<1	13 House	6 Deer	4 Tlaxochimaco	D: 51
1507[s]	1/02/1508	8:24	30	2 Reed	8 Reed	20 Atemoztli	F: 122; I: 42r; Tq I: 210; V: CXXIX, visible
1510[t]	11/01/1510	13:04	20	5 Rabbit	2 Deer	19 Tepeilhuitl	I: 42v; V: CXXX
1516[u]	12/23/1516	7:30		11 Flint	10 Monkey	13 Atemoztli	A: 121
1523[v]	10/08/1523	—	—	[5 Reed]	[7 Monkey]	[18 Teotleco]	D:62

[13] The interval between 1 Flint and 1 House years must be either 13 or a multiple of 13. The number 166 in this text has been corrected to 169 in Figure 1.

[14] The count is based on the CY time line in Figure 1. The September 24, A.D. 129, equinox date was found using the Voyager program. Day names are based on the equation 1 Snake = August 13, 1521 (which agrees with the standard Maya correlation 584, 283).

[15] The pair of solar and lunar eclipses occurring on June 25 and July 11, A.D. 298 would have been recorded in the preceding year, 13 Flint (A.D. 297–298).

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Note: Aztec calendar years begin in the European year cited in the table, but extend into the following year (e.g., 5 Rabbit 1198–1999). The day and month designations listed here are based on the correlation of the Aztec calendar by Alfonso Caso. They do not appear in the designated sources, unless otherwise stated in the notes to this table.

[a]A, Chimalpahin (1965; 3ª Relación); B, Chimalpahin (1965; 6ª Relación); C, Chimalpahin (1965; 7ª Relación); D, *Codex Aubin* (1963); E, *Codex Azcatitlan* (1949); F, *Codex Chimalpopoca* (1945, 1992); G, *Codex Huichapan* (1976); H, *Codex Mexicanus*, I (1952), *Codex Telleriano-Remensis* (Quiñones Keber 1995); J, *Manuscrito mexicano* 40 (1981); Tq I, Torquemada (1975; *Monarquía indiana*), vol. 1; V, *Codex Vaticanus A* (1964).

[b]Aguilera and Galindo T. (1991:6) identify this with an eclipse that occurred in the year 6 Reed on July 24, 1199, thus implying that the eclipse listed in our table would not have been visible in central Mexico. The codex, however, plainly represents two figures as standing on a 5 Rabbit cartouche, with their eyes fixed on the sky. Voyager (1992) indicates that the 1198 eclipse would in fact have been visible in the Valley of Mexico and for some distance farther north.

[c]Aguilera and Galindo T. (1991:62) relate a monstrous figure devouring the sun in the lower right on this plate to the year glyphs 3 Flint through 5 Rabbit drawn in the upper right. The visual context implies that an eclipse was seen just as the Aztecs were leaving Yohualtecatl, a large hill near Guadalupe. The best choice among the three years is therefore 3 Flint; thus the eclipse listed in the table.

[d]Aguilera and Galindo T. (1991:62) note that the cartouche enclosing a 2 Reed year glyph had been almost completely erased, and that the Aztec ruler, Acamapichtli, and a banner had been drawn in just above. They do not comment on Acamapichtli's presence more than 10 years after the presumed date of his death. The reference to an eclipse in this year appears in a written gloss ("eclipse del sol") near the upper left corner of the empty cartouche.

[e]Aguilera and Galindo T. (1991:63) also choose this eclipse date, which occurred, significantly, in a 2 Reed New Fire year.

[f]Torquemada (1965:I:173.1) cites an eclipse in the fifth year of Axayacatl's reign (1478–1480) "which was a bad omen for this Mexican nation, because Totoquihuatzin, King of Tacuba (Tlacopan) died soon thereafter."

[g]Torquemada (1965:I:181) mentions the wounding of Axayacatl in battle and violent earthquakes in the sixth year of his reign (1474), followed by a solar eclipse the next year (1475). The only visible eclipse in the region occurred on April 5.

[h]This eclipse is mentioned in four sources. Aguilera and Galindo T. (1991:63) opt for a total eclipse on February 13, 1477, at 2:24 p.m., but the corresponding Aztec date is 12 Reed 10 Izcalli, which falls on 11 House 1477. They state that there was no visible eclipse in 1476. Voyager, however, identifies a partial eclipse visible through much of the morning in the vicinity of Tenochtitlan. The *Codex Telleriano-Remensis* (Quiñones Keber 1995) shows the sun with a "small bite," which is consistent with the actual appearance of the eclipse listed in our table. The towns of Ocuillan, Cuauhnahuac (Cuernavaca), Tenantzinco, and Chontalcohuautlan fell to the Aztecs during this year. Torquemada (1965:I:181.2) describes a battle in which Axayacatl was wounded in the sixth year of his reign, and says that an eclipse of the sun occurred one year later.

[i]Chimalpahin (1965) states that an eclipse occurred and all the stars were visible on the day 1 Movement in this year. However, there were no visible eclipses in this year of the Aztec calendar. Either he was in error, or the original reference may have come from a text using a non-Aztec calendar system; e.g., he could have misread a pictorial source or cited a text that used a different calendar system. In any case this datum is one of few that goes unexplained.

[j]Aguilera and Galindo T. (1991:64) opt for an eclipse on December 1, 1480, but the corresponding year in the Aztec calendar is 1 Flint rather than 13 Reed. Because no fewer than four independent sources state that the eclipse did occur in 13 Reed, the penumbral eclipse on June 19, 1479, one incidentally close to the solstice, is the one we favor. A gloss in the *Codex Aubin* links the eclipse to the death of the ruler Axayacatl. The towns of Xiquipilco and Tochcalco were conquered during this year.

[k]According to Chimalpahin (1965) this was the year of Axayacatl's death and Tizoc's enthronement. Axayacatl's death is more frequently assigned to 1 Flint 1480. However as Boone (1992:50–51) has pointed out, annals histories sometimes indicate the "year of death" of a ruler and the "first full year in office" of his successor, which can cause a slippage of a year or two when pictorials are translated into alphabetic histories.

[l]A major battle in Huexotzinco and the dedication of a temple in Cuauhnahuac (Cuernavaca) also occurred in this year.

[m]Aguilera and Galindo T. (1991:65) suggest no alternatives to the date in the table. Chimalpahin (1965) writes that there was much "suffering and hunger" during the year. The towns of Acatlan and Xicochimalco were conquered.

[n]The peoples of Ayotochcuitlatlan and Xaltepec were defeated in the course of this year.

[o]A second minor eclipse (less than 1%) occurred at (9:20 a.m. on January 3, 1497 (9 Movement 19 Atemoztli). Of the 1496 event, the *Codex Chimalpopoca* (1945, 1992:119; third *Ralación*) speaks of "an eclipse of the sun," while Chimalpahin (1965; seventh *Relación*) writes of "a complete eclipse of the sun, so that it was as dark as in the deepest night, and the stars were seen with complete clarity." Chimalpahin (1965:119; third *Relación*) also reports earthquakes that "threw down the houses and opened the earth in many places." Torquemada (1965:I:192) probably refers to this eclipse when he writes that the great inundation in 1499 "had been announced by an eclipse of the sun."

[p]Torquemada (1965:I:192) states that a major inundation in this year was followed by "a great famine. . . . [and] it seemed to them, that this had been announced by an eclipse of the sun that had occurred."

[q]The *Codex Chimalpopoca* (1945, 1992:120; third *Ralación*) states that this eclipse occurred on a day named 13 Death. The date of the eclipse listed in our table would have been 12 Death in the Aztec calendar. This may simply have been a scribal error.

[r]The *Codex Aubin* (1963) simply states that 13 House was a year in which the *tzitzimitl* descended. These were demonic beings that might descend to earth during an eclipse.

[s]A continuous line in the *Codex Telleriano-Remensis* (Quiñones Keber 1995) connects the year name, sun, a warrior, and earthquake signs. The pictorial scene also represents the completion and dedication of a temple at Huixachtitlan (Cerro de la Estrella) where the last 2 Reed New Fire rite was performed in this year. The drowning of 1,800 men in the Tucac River beyond Iztocan on the road to the Mixteca is also mentioned. The *Codex Chimalpopoca* (1945, 1992) mentions the "decimation" of Teuctepec and Iztitlan. Torquemada (1965:I:210) states that the New Fire ceremony had been performed in the month of December "and then there was an eclipse of the sun."

[t]The *Codex Telleriano-Remensis* (Quiñones Keber 1995) in representing this eclipse explains that "they never took much account of eclipses of the moon, but only those of the sun, because they said that the sun ate the moon when this happened."

[u]There were no visible eclipses in the year cited by Chimalpahin (1965). The original reference may have been recorded in a different calendar system.

[v]The *Codex Aubin* (1963) states that an eclipse occurred in the year 5 Reed 1523. A written gloss next to a sun sign reads "8 Uct" (8 October). Although there was no solar eclipse during this year, October 8 was the date of a new moon when a solar eclipse might be expected.

WORLD AGE	CY	YEAR	EVENT
Subperiod IVc	**Codex Xolotl spans 260 years to 13 Reed 1427 [CY 6396])**		
	6137	1 Flint	Tula destroyed; Topiltzin flees to Huehuetlapallan
IV. TLETONATIUH	5682	1 House	Tula founded
(Fire-Sun)?	5679	1 Flint	Tulantzinco founded
Subperiods IVa & IVb			
572+572=11x52+11x52	5565	1 Flint	2nd Toltec migration begins in Huehuetlapallan
	5266	1 House	Sun and Moon eclipsed; severe earthquakes
	5097	1 Flint	Calendar year adjusted to the equinox
	4993	1 Flint	Fourth World Age begins
III. TLALCHITONATIUH	4779	8 Rabbit	Sun "stands still" for a day
(Earth-Sun)			
1560=3x10x52	3433	1 Flint	Third World Age begins
II. EHECATONATIUH	2237	1 Flint	Toltecs settle in Huehuetlapallan
(Wind-Sun)	2133	1 Flint	Languages diverge; 1st Toltec migration begins
1716=3x11x52			
	1717	1 Flint	Second World Age (Sun) begins
I. ATONATIUH			
(Water-Sun)			
1716=3x11x52	1	1 Flint	First World Age (Sun) begins

Figure 1. Creation year (CY) time line, based on Ixtlilxochitl's Toltec *Relaciones*.

that we are dealing with random chance in this case appears not to be very high.

We have found no convincing explanation of how an actual recalibration process might have been carried out at this early date; however, we note parenthetically that both the date and the probable geographical location, near Coatzacoalcos, correspond well with the time period and region linked with the epi-Olmec tradition of southern Veracruz and adjacent regions. An eclipse recorded on La Mojarra Stela 1 shows that historical records were being punctuated by astronomical events in the inscriptions at this early time period (see, e.g., Justeson and Kaufman 1992).

Equinoxes, Eclipses, and the Proximate History of the Aztec Empire

The evidence summarized to this point suggests that the Aztec framework for recording long periods of time would have been founded on the pursuit of the Sun, and that the joints in this framework would probably have included solar eclipses and equinoctial events. We turn next to records from the later cycles in Aztec history, where we find the same kinds of events in a pivotal role.

In Table 4 we list 21 references to solar eclipses gleaned from Aztec-period records, together with their dates and the sources in which they are mentioned. (The magnitude listed in the table is the percentage of the solar disk covered at maximum eclipse.) References to such other events as earthquakes, droughts, military conquests, and the deaths of rulers will be found in the notes to this table.

Nineteen of the 21 events in Table 4 can be identified with actual eclipses. Of the remaining two, one (Number 8) is likely to be a misdated reference to either eclipse number 6 in 1475, 7 in 1476, or 9 in 1479.[16] The second (Number 21) is a false (perhaps mistaken or miscalculated?) reference found in the *Codex Aubin*. The day cited in this text is October 8, 1523. This was the day of a new Moon, when a correctly calculated eclipse might have occurred, but in this case there was no actual eclipse in the calendar year.

Our preliminary survey indicates that more than 65 visible solar eclipses would have taken place over the period of historical record for Tenochtitlan, and many more if this were extended back to the first recorded eclipse (Number 1) on August 4, 1198. If we compare our list of actual with the list of historically recorded eclipses, it is immediately clear that Aztec skywatchers did not invariably select the most obvious, impressive eclipses. We found, for example, that eclipses recorded for the years 1504, 1508, and 1510 would not have been particularly impressive events in this region. They may have been chosen only because they bracketed the great New Fire ceremony performed in the year 2 Reed 1507. We suggest that calendar keepers were choosing only those eclipses that happened to occur in proximity to other events

[16] Chimalpahin's (1965:21) seventh *Relación* mentions this eclipse together with a reference to the wounding of Emperor Axayacatl in a battle at Xiquipilco. The sources cited in Table 4 assign the latter event to the same year as the eclipse dated 12 Rabbit 1478; we believe that Chimalpahin mislabeled the year. The central Mexican histories frequently disagree on the exact dates for specific events.

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(some historical, some invented) that were to be highlighted and emphasized.

Note that fewer than half the eclipses cited in Table 4 were actually visible from Tenochtitlan. Most of them fall within the 40 years that preceded contact. The schedule of these observed later events may have served as the resource material that set the pattern for retrodicting eclipses. We are not suggesting that the Aztecs were able to single out prehistoric eclipses that were actually visible at Tenochtitlan, only that, as the Maya had done in the famous Dresden lunar table, they had managed to discover warning periods or intervals during which eclipses might occur. Indeed, many eclipses were visible (assuming clear weather) at Tenochtitlan that were not cited, perhaps because they did not occur at times of historical significance. We consider it highly likely that many visible eclipses cited by the Aztecs have not been discovered either because the records were lost or destroyed or because they have been confused in our minds or theirs with other natural events.[17]

Our approach in searching out the possibility of the rhythmic repetition of sky events has been conservative in that we have considered all events that could possibly have been observed, rather than limiting our database to the most spectacular phenomena. Anyone who witnesses even a partial eclipse, however, will be struck by the most unusual appearance of the solar disk when "bitten by the Moon."

One of our most intriguing results was a possible link between the most frequently recorded date for the founding of Tenochtitlan (2 House 1325) and a total eclipse one hour before noon on April 13, 1325. The first day of this calendar year, as previously remarked, was March 14, or two days after the spring equinox. Immediately after sundown on the same day, a vertical alignment of three closely gathered major planets—Mars, Jupiter and Saturn—would have been seen in the western sky. In addition, the rarely observed planet Mercury lay just below and to the side of the Pleiades, a celestial timing device that played a key role when it crossed the celestial meridian on the night of a New Fire rite.[18]

These circumstances and the selection of a year named 2 House, which was the next year after 1 Flint, suggest that Aztec historians may have chosen this particular founding date when reinventing their history during or after Itzcoatl's reign precisely because the calendar date was reinforced by just these astronomical events. The events noted above might have been gleaned from earlier astronomical records or, if these were unavailable, could have been easily reconstructed through back calculation—a useful tool for narrowing the search for an astronomically suitable date in records compiled a century or so later. With respect to the planets, it would only be necessary to know the time interval separating a given planet's appearance in the same position relative to the rising or setting Sun. Eclipse prediction requires no more than recognition of the normal (6-month) and abbreviated (5-month) lunar semesters over which these phenomena occur. This knowledge was certainly available to calendar specialists long before the Aztecs appeared on the scene.[19]

The data relating to eclipses documented in Aztec-period sources suggest a tendency to select events spaced at intervals that were whole multiples of the *xiuhmolpilli*, not unlike those that bracket the creation epochs found in Ixtlilxochitl's account. Thus, the interval between the first and second of the eclipses listed in Table 4 (1198 and 1300) is only three years short of 2×52 years. Also, the third (1404),[20] fourth (1455), and fifteenth (1507) eclipses occurred in years named 2 Reed, in each of which a New Fire rite was performed.

By far the largest number of eclipses is to be found in historical records covering the last 50 years or so before the Spanish invasion. Even so, the interval between potentially significant eclipse events frequently approximates 52 years. The date of a near total eclipse (81%) on May 28, 1481, is just 84 days short of 3 *xiuhmolpilli* after the founding-year eclipse in 1325. Adding to the like-in-kind nature of the two phenomena, a close conjunction of Mars and Jupiter occurred 5 days after the 1481 eclipse, on June 2. This eclipse also may have been thematically linked to a series of "smoking-star" events 52 years later, beginning in 1533.[21] (The practice of recording information in continuous-year-count-annal format was maintained during much of the early Colonial period, but with European script eventually replacing pictorial scenes and glyphic entries.)

Still another example of like-in-kind astronomical events can be found in the pictorial record of a total solar eclipse in 4 Flint 1496 (*Codex Telleriano Remensis* [Quiñones Keber 1995:40v]; see also *Codex Vaticanus A* 1964:93v) that unquestionably coincides with an actual eclipse on August 8, 1496. The pictorial representation is unusually realistic. It shows a partially eclipsed Sun that appears to be setting behind a mountain visually similar to those actually found on Tenochtitlan's western horizon. Although sun disks are sometimes shown with pie-shaped bites in other codices, the *Codex Telleriano Remensis* provides a far more realistic representation of an eclipse event; it is unique in providing a clear view of the horizon with the stars shining above it. The eclipse maximum (approximately 96%) would have occurred late in the afternoon (at 3:00 P.M. local time). The eclipse would have just concluded as the Sun descended behind the mountainous western horizon (3° elevation). Adding to the spectacular nature of this celestial performance, the planets Venus and Mars would have been visible just 10° apart in the glow of dawn the following morning.

[17] For those who might be interested, we list here the dates of all eclipses not already mentioned that were visible from Tenochtitlan between 1400 and contact: 8/28/1402, 1/12/1404, 6/26/1405, 4/4/1410, 8/7/1412, 11/8/1417, 9/19/1419, 1/12/1423, 6/26/1424, 10/30/1426, 2/22/1430, 11/30/1434, 4/5/1437, 3/25/1438, 7/7/1442, 5/17/1444, 6/28/1451, 6/17/1452, 9/29/1456, 7/29/1459, 9/9/1466, 8/29/1467, 6/28/1470, 2/13/1477, 12/1/1480, 3/26/1484, 3/16/1485, 1/13/1488, 10/21/1511, and 9/30/1521.

[18] While Jupiter and Saturn had been dancing around in Taurus in close conjunction since the spring equinox, Mars had entered the scene scarcely a week before the eclipse date. Mercury would have appeared shortly thereafter.

[19] See Aveni (1980:88–92) for a discussion of the relatively simple methods for fitting together planetary commensurations.

[20] This eclipse occurred during the calendar year named 2 Reed, which did not end until February 21, 1404.

[21] A series of five "smoking star" events was recorded in the *Codex Telleriano Remensis* for the years 1533, 1534, 1535, 1537, and 1539 (Quiñones Keber 1995:44v–45v). Earthquakes were recorded in connection with the first and fourth. A gloss attached to the 1533 event reads, "And they show smoke aiming from the star they call *citlal choloha*, which is the one we call Venus, a star they consider to be very important" (Quiñones Keber 1995:275). Later glosses also identify these images with Venus. A Moon-Venus conjunction search revealed that the crescent Moon passed very close to Venus in these years. Moreover, this six-year interval of close conjunctions was preceded by a three-year gap, and followed by a five-year gap, during which no close conjunctions ($< .4°$ separation) occurred. Although the instant of the closest appearance of Venus and the Moon was not visible in each case, we believe that pre-Hispanic astronomers were surely capable of anticipating such events.

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Table 5. Like-in-kind eclipses visible an integral number of Xiuhmolpilli apart in Tenochtitlan of which at least one event is recorded as an eclipse

Date	Distance between Pairs of Dates	Eclipse Events	Year Bearer	Source	Historical Events
4/13/1325	57,024 = 3 × 52 × 365 + 84 days	total solar eclipse; planetary lineup in the West involving Mars & Jupiter	2 House	no detectable record	foundation of Tenochtitlan
5/28/1481		partial solar eclipse; close conjunction in West involving Mars & Jupiter	2 House	see note k, Table 4	
6/25/1340	57,023 = 3 × 52 × 365 + 83 days	partial solar eclipse; close conjunction in West involving Mars & Jupiter	4 Flint	no detectable record	
8/8/1496		(nearly) total solar eclipse; conjunction of Venus & Mars in the East	4 Flint	see note o, Table 4	conquest of Zoltepec
3/14/1355	56,846 = 3 × 52 × 365 − 94 days	partial solar eclipse	6 Reed	no detectable record	
11/1/1510		partial solar eclipse	5 Rabbit	see note t, Table 4	siege of Icpatepec
6/17/1452	18,900 = 52 × 365 − 80 days	partial solar eclipse	12 Flint	no detectable record	
3/16/1504		partial solar eclipse	12 Flint	see note q, Table 4	famine, death of Itzcoatl(?)

It may also be noted that there had been a pair of partial eclipses, each near a solstice, in 1340, three *xiuhmolpilli* before the 1496 event. The first, on January 26, was followed after sunset by a planetary lineup consisting of Mercury, Venus, Mars, and Jupiter. Although no record of the 1340 eclipse and planetary alignment appears in currently available sources, the coincidence linking these very similar astronomical combinations in years named 4 Flint was probably noticed. Table 5 summarizes these possible sets of like-in-kind eclipse events within an Aztec calendrical framework.

CONCLUSIONS AND FUTURE DIRECTIONS

The evidence summarized to this point suggests that the Aztecs restructured their history by establishing close links between certain natural events and particularly important beginnings pertaining to their state, such as the founding of the city, the gaining of independence, and major conquests. Using the relative exactitude with which it is possible to pin down real eclipses in absolute time, and taking advantage of references to solar eclipses in the Aztec records, we suggest that Aztec chronologists selectively recorded visible eclipses that served as "punctuation marks" bracketing real historical events spaced at intervals determined by the *xiuhmolpilli* cyclic framework. We have been able to match 15 of 21 eclipse records with events visible in Tenochtitlan. On the other hand, we have been unable to find any reference to many total eclipses as prominently visible in the same region. There were, for example, at least seven such eclipses of magnitude 80% or more in the fifteenth century alone. Although the Aztec historical corpus is far from complete, we nonetheless suspect that these phenomena may have been passed over deliberately because they did not occur at a significant position in the *xiuhmolpilli* cycle.

Our strategy has consisted of using surviving sources to derive as much as can be reasonably learned about the ways in which very rare like-in-kind eclipse events separated by some whole number of 52-year cycles may have been involved in the restructuring of historical chronologies. Although far from conclusive, we believe that sufficient evidence exists to justify continuing investigation of the extent to which social and cosmic events were conflated.

What implications does the study of solar eclipses have for our understanding of the Aztec use of like-in-kind events in general? Using a more extended list of sky events as a reference frame, we have now begun the more arduous process of extrapolating backward and forward through pictorial manuscripts and prose texts with the goal of identifying all such events. We are also looking for potentially repeatable patterns, especially those that may be correlated with events in the history of the Aztec state. Our solar eclipse data is now substantially complete. We are currently compiling a list of the more impressive planetary conjunctions and lineups that occurred at or near the time of a given eclipse, as well as all historically recorded comets that may have been noted by Aztec astronomers. Once complete, a master chart of this kind will greatly facilitate continuing investigations of the relationship between cosmic and historical events as conceived within the Aztec temporal framework.

RESUMEN

Nosotros presentamos una lista completa de eclipses que están documentados en los manuscritos mexicas. Usamos esta lista junto con la información de las crónicas para mostrar un método usado por los cronistas mexicas que enlaza los eventos cósmicos históricos con los eventos cósmicos retrodictables que fueron escojidos para coincidir con las circunstancias históricas. Los eventos solares, particularmente los eclipses, figuran en un esquema que enfatiza la repetición de eventos similares que coinciden con los múltiplos del *xiuhmolpilli* (el ciclo de 52 años). Así la fundación del imperio y los ajustes caléndricos relacionados con la cronología ficticia de las edades mundiales son conectados con los eclipses que fueron visibles en Tenochtitlan y que cayeron en los solsticios o los equinoccios.

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