The Maya Inheritance

by

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Contrary to earlier misconceptions, most aspects of the elaborate Mesoamerican calendrical system were not the product of the Mayas, but of a people known as the Zoque, whose original homeland lay on the Pacific coastal plain of what today is southermost Mexico and adjacent Guatemala – a region called Soconusco. It was in this area that some of the first stratified chieftainships in the New World arose and which already in 1500 BCE was in lively contact with similar cultures in South America, as witnessed by the pottery introduced from Ecuador and identified by Michael Coe in his early paper on Ocós (1960).

In 1973, a paper by the present author in Science identified the large Pre-Classic site of Izapa, close to the boundary between Mexico and Guatemala, as the birthplace of both the 260-day sacred almanac and the 365-day secular calendar that were ultimately diffused throughout the entire area of high cultures that we now label “Mesoamerica”. Having both been invented in the 14th century BCE, their strongest impact was felt in the Gulf coastal plain of eastern Mexico, into which people of Zoque speech began diffusing about a century later. First identified by archaeologists as a people that had erroneously been called the “Olmecs” they were soon recognized, chiefly by Mexican scholars, as the “Mother Culture” of Mesoamerica. Only with the identification of Izapa as the culture’s birthplace has it is now become apparent that the misnamed Olmecs were in fact the Zoque.

One of the hallmarks of the Zoque was their adherence to the belief that the beginning of the present world took place on a day equivalent to August 13th in the Gregorian calendar we use today. Locally, that day marked the southward passage of the zenithal sun over Izapa and initiated the sacred almanac. Everywhere that the Zoque calendar was adopted, recognition of this belief was religiously incorporated into the design or layout of one or more of the key structures of the new urban centers that arose under their influence. All that was required to accomplish this was a simple formula that was most likely passed along with the sacred almanac itself, namely “count 52 days after the sun has reached its northernmost point (the summer solstice, June 22), and mark the sun’s setting position against the horizon”. Over most of Mesoamerica, this alignment approximates an azimuth of 285.5º, or 15.5º north of west, and among the many archaeological sites at which the present author has identified this alignment are the following: (The dates in parentheses represent the years in which these discoveries were made)

- The Pyramid of the Sun at Teotihuacán, constructed ca, -150 BCE (1975);
- The “Hall of Columns” at Chicomostoc, built ca. 700 (1977);
- The entire site of Edzná, the first major urban center of the Maya, founded ca. –150 BCE (1978);

•El Caracol (“The Observatory”) at Chichén Itzá (1979)
•Temple IV, the highest pyramid at Tikal, erected ca. 750 (1979); (Others of the higher pyramids at Tikal round out what the author has labeled “an astronomical matrix “, commemorating not only the winter solstice sunrise over Victoria Peak in the Maya Mountains, but the equinoxes as well.)
•The massive Danta pyramid at El Mirador (1983)
•The sunken court of Teopantecuanitlán, discovered only in 1983 but which has been dated to 1000 BCE (1995)

Numerous other Maya, Zapotec, and Mixtec sites likewise exhibit this key orientation.

The Long Count

Unlike both the 260-day sacred almanac and the 365-day secular calendar, whose cycles were regularly repeated and physically visible in nature at their birthplace in Izapa, the Long Count was a totally abstract creation that was based on a temporal projection of the calendars into the past. It existed only in the minds of its creator and of those to whom he imparted his idea. Its units of measurement had to be easily understood by those around him, but otherwise, its structure, format, and compass were whatever he, as it creator, designed them to be. As long as it met a couple of stringent restrictions, the rest was purely a product of his imagination.

For anyone living in the Zoque society of the third century BCE, the primary constraint on such a construction was that it would had to have had its origin on a day equivalent to our own August 13. The only other constraint was that it had to extend far enough back into the past so that it would be a fair approximation of the age of the present world; of course, since no one knew how far back this might be, the Long Count’s creator was perfectly free to suggest a ‘credible’ solution of his own.

To obtain a suitable mathematical module with which he could solve his problem, the creator of the Long Count merely reversed the process of counting from the summer solstice to August 13th. Instead, he decided to count from the day of the southward zenithal passage of the sun over Izapa to a day on which he could conveniently begin his own new creation. Now, his only constraint was to mesh it with the units of agglomeration that had been earlier devised by the founder of the 365-day secular calendar. These were the uinal of 20 days, the tun of 360 days, the katun of 7,200 days, and the baktun of 144,000 days. The uinal was obviously too short an interval for his purposes and the tun was too long, but since the latter also set the dimensions for both the katun and the baktun, he decided to take a ‘portion’ of that. (Inasmuch as the concept of fractions was unknown to the Zoque, the Long Count’s designer would have considered his module as simply another unit of agglomeration.)

Therefore, his most obvious choice was an interval of 36, because that would fit evenly into a tun ten times, as well as 200 times into a katun, and 4000 times into a baktun. This module he could then safely replicate as many times as necessary to accurately fix the date of August 13 as far into the past as he wished.

For the following exposition, we will use the names of the days from our own Gregorian calendar rather than those of the Zoque calendar, but either way the results obtained would obviously be precisely the same. We would ask, "What date will we reach if we count 36 days from August 13th?" Of course, it would take the first 18 days just to complete the month of August, so the next 18 days would bring us to the 18th of September. Since September 18 will always be 36 days after August 13, by using a module of this length, we will always be able to locate August 13 as far back in the past as we need to, as long as our new count always begins on the 18th of September.

Because both John Teeple (in 1930) and the present author (in 1976) independently confirmed that the Long Count was initiated on the equivalent of September 18, -235 (although Teeple knew nothing of the August 13th constraint), it would seem very likely that the Long Count's creator consciously chose that date to formulate his module. Moreover, to achieve the 7 baktun and 6 katun length he had stipulated for his new day-count, this meant he had to make no fewer than 29,200 iterations of his 36-day interval in order for his device to reach the Maya day-number of 1,051,200, which is precisely the value he consequently assigned to September 18, -235. The fact that the Julian day number for this same date is 1,635,485 also proves that the correlation value of 584,285 days that Thompson had first worked out between the two calendars in 1927 is the only correct one. (Unfortunately, Thompson himself muddied the waters of archaeology ever since with his misadvised revision of 1935.) In any event, we can at least be thankful that the Julian calendar (in use up through the Spanish colonial period) was replaced by the Gregorian count in 1582, because the former has slipped so badly that it shows the beginning of the present Zoque world -- namely 4 Ahau 8 Cumku -- coinciding with September 8th instead of with August 13th.)

The Purpose of the Long Count

Although the designer of the Long Count succeeded in adding a temporal depth to Mesoamerican calendrical studies, albeit an imaginative and totally artificial one, it is obvious that his real purpose in creating it was to answer an existing need – in other words, it would appear that the classic situation of "Necessity being the mother of invention" had already arisen within Zoque society by the third century BCE. (One would assume that a comparable situation did not become necessary in Western Europe until some 18 centuries later, because a very similar invention, this one devised by a Dutch scholar named Joseph Julius Scaliger, did not come into being there before the year 1582. The consummate importance of both of these 'innovations', widely separated by time and space as they were, becomes apparent when we realize that, without them, we would never have been able to establish a meaningful correspondence between these two very different calendrical systems.)

Astronomical observations at Izapa had obviously continued following the initiation there of both the 260-day sacred almanac and the 365-day secular calendar in the 14th century BCE, with one of the most frightening and still unexplained mysteries being the frequent periodic eclipses of the moon. (Solar eclipses, on the other hand, were more easily explained, because the disk of the moon was usually visible at such times. However, most early peoples could not conceive of the earth's shadow having been the cause of the moon's becoming dark.)

Naturally, the Zoque sky-watchers would have found it just as difficult to work out patterns of lunar behavior with their calendars as Scaliger did with the Western calendar. One example will suffice to demonstrate this fact: let us say that the first of two eclipses occurs on January 1st and the next takes place on May 29th. We want to know how many days have elapsed between these two celestial events. (For the Zoque, of course, the day-names were different, but the problem was the same. How many days are there, for example, between 12 Cib and 4 Kan?) As long as the days only had calendar names, a tedious count was necessary whenever the distance in time between any two events was required. However, once each day had been assigned its own distinct number in a continuous sequence, all that was required was to subtract the one value from the other. This was the genius of the Zoque priest's creation –and of Scaliger's idea almost two millennia later. In the example postulated above, the Zoque would have quickly translated the difference in days into five full moons, i.e., 148 days / 29.53 = 5.

Because all eight of the earliest monuments bearing Long Count inscriptions have been discovered in a narrow band extending from western Guatemala across the center of Chiapas state into southern Veracruz on the Gulf Coast of Mexico, it is not unreasonable to assume that this innovation must had evolved somewhere within this restricted geographic area. Although none of these monuments has been found at Izapa, the fact that this place lies very near the middle of this cluster of dated artifacts suggests that it had probably continued to play an important role in astronomical studies right up until the final centuries BCE. Indeed, during the century of the Long Count's creation, i.e., from –299 to –200, no fewer than 75 eclipses were visible from Izapa, of which 27 were solar and 48 were lunar, revealing how great an importance would have been attached to finding some way of predicting them.

There is also a very interesting coincidence in timing with a similar development that was then taking place among the adjacent Maya peoples. We find that at Edzná, the earliest urban center of the latter culture, located on the edge of the largest *aguada*, or agricultural basin in all of the Yucatan, the construction of a very special pyramid had been commenced about the year –150. Although its age was established by radiocarbon dating when Ray Matheny and his team from Brigham Young University excavated the site in the early 1970's, they had simply called it "La Vieja" – "the ancient one" –- because its function remained a mystery. When the present author first visited the site in 1978, he immediately realized that the pyramid's offside location from the rest of the urban complex was due to its having marked the northernmost setting position of the moon, as observed from "Cinco Pisos", Edzná's loftiest and most commanding structure. Unaware of the existence of lunar nodes, and unable to pin down the erratic movements of the moon in any other way, the Maya had chosen to mark its northernmost setting point by erecting a special pyramid at an azimuth of 300º, or precisely five degrees beyond the northernmost setting point that the sun ever reaches at that latitude. The only reason they had done so, must have been to answer the same question that was then uppermost in the minds of the Zoque – how could the movements of the moon be fixed accurately enough to predict when the next eclipse would occur?

Before I had ascended "Cinco Pisos" to take my reading on "La Vieja", I had already determined that the entire site of Edzná had been oriented to another small pyramid that also lay some distance out in the scrub to the west of the principal complex. From the doorway of the walled court in which Cinco Pisos is situated, to a notch in a large ridge that forms an artificial horizon on the west, and finally to the top of the pyramid that lies directly behind it, the "three point" azimuth that I measured was 285º, clear evidence that the entire site of Edzná had been oriented to the setting sun on August 13th. This was proof positive that the inspiration had come from the Zoques and that the Maya had been very careful to "document its heritage". Ironically, because the Maya were the last people to come under the influence of the Zoques, they were also the only people to inherit the Long Count -- and they had obviously done so very shortly after its creation.

The reason we know this is because of "La Vieja". Even though it was not constructed until about the year –150, the preparations necessary for its erection would have to have been started close to forty years earlier, in other words about –190. This is because the moon reaches its northernmost setting point only once in about every 19 years; therefore, to confirm that the moon would actually reach the same maximum setting point each time would have taken a minimum of at least two cycles, or close to forty years. Inasmuch as we now know that the Long Count came into being in the year –235, it is obvious that the Maya must have come up with their notion as to how to pin down the moon very shortly thereafter. Not until its setting point had been firmly established could the pyramid have been constructed and the recording of the moon's movements begun.

The Early Eclipse History of Edzná

By reconstructing this period of history with the help of NASA data, the author has determined that the moon reached its next maximum setting positions in the years of –192, -173, and –154. Thus, at the very earliest, the Maya may have been able to begin their observations in the latter year, so the discussion that follows will be based on that premise.

Inasmuch as lunar eclipses only take place at the time of the full moon, the Maya's task was to count the number of such events – referred to as lunations in the astronomical literature – between the time of the maximum moonset and each eclipse, the rationale being that, if there were a pattern to the moon's behavior, it should be possible to discern it, after it had been systematically recorded for some time. Therefore, in Table 1 below, each of the lunar eclipses that was visible at Edzná between the years of –154 and –97, as documented on the NASA Eclipse Web Site, has been listed. This period embraces the first three saros cycles that the Maya would have been exposed to, each of which continued for 223 lunations and whose cumulative length was over 57 years.

As a result of this experience, the Maya would have discovered what the builders of Stonehenge had learned a couple of millennia earlier: that the northernmost settings of the full moon always take place either on or very close to the winter solstice (December 22). For the non-literate Megalithic people who erected Stonehenge, this meant marking its position against the horizon with what has since been labeled by the archaeologists as "Stone D"; for the Maya, just reaching the cusp of literacy, "La Vieja" served as their horizon marker, but they could also record their tally of full moons with bar and dot numerical glyphs on sheets of specially prepared deerskin, such as the "Dresden Codex", one of the few Maya manuscripts to escape the fires of Bishop Landa when he visited Edzná in the year 1552.

Table 1 – Early Lunar Eclipses at Edzná (-154 to –97)

Date	Julian Day Number	No. of Lunations	Saros Number
December 23, - 154	1665166	0	(Cycle Begins) *
September 14, -153	1665430	9	54
September 3, - 152	1665785	21	64
August 23, -151	1666139	33	74
January 7, - 149	1666641	50	51
July 3, - 149	1666819	56	56
December 28, - 149	1666996	62	61 #
June 21, - 148	1667172	68	66
December 16, -148	1667350	74	71
May 2, -146	1667852	91	48
October 15, - 145	1668383	109	63
April 10, -144	1668561	115	68
August 14, - 142	1669417	144	55
February 7, - 141	1669594	150	60
August 3, - 141	1669771	156	65
July 22, - 140	1670125	168	75
June 12, - 139	1670451	179	47
December 7, - 139	1670628	185	52
November 26, - 138	1670982	197	62
November 15, - 137	1671336	209	72
January 2, - 135	1671751	223	(New Saros Cycle)
April 1, - 135	1671839	3	49
December 22, - 135	1672105	12	(New Solar Cycle) *
March 21, - 134	1672193	15	59
September 14, - 134	1672370	21	64
March 10, -133	1672547	27	69
July 13, - 131	1673403	56	56
January 7, - 130	1673581	62	61 #

November 5, -128	1674614	97	53
May 2, - 127	1674792	103	58
October 25, - 127	1674968	109	63
April 21, -126	1675146	115	68
October 15, -126	1675323	121	73
February 29, -124	1675825	138	50
February 17, - 123	1676179	150	60
February 7, -122	1676534	162	70
December 18, -121	1677213	185	52
June 12, - 120	1677390	191	57
December 6, - 120	1677567	197	62
June 2, -119	1677745	203	67
November 25,-119	1677921	209	72
January 13, -117	1678336	223	(New Saros Cycle)
April 12, -117	1678425	3	49
October 6, -117	1678601	9	54
March 31, - 116	1678778	15	59
December 21, - 116	1679044	24	(New Solar Cycle) *
March 20, -115	1679132	27	69
September 14, -115	1679310	33	74
January 29, - 113	1679812	50	51
July 13, -112	1680343	68	66
January 7, -111	1680521	74	71
July 2, -111	1680697	80	76
May 24, -110	1681023	91	48
November 16, -110	1681199	97	53
May 13, - 109	1681377	103	58
October 25, -108	1681908	121	73
March 11, -106	1682411	138	50
September 5, -106	1682589	144	55
August 25, -105	1682943	156	65
February 18, -104	1683120	162	70
August 13, -104	1683297	168	75
December 29, -103	1683800	185	52
June 23, -102	1683976	191	57
December 18, -102	1684154	197	62
June 13, - 101	1684330	203	67
January 23, - 99	1684921	223	(New Saros Cycle)
December 23, -97	1685985	235	(New Solar Cycle) *

Measures a lunar cycle of 6585 days (223 lunations)

*Measures a solar cycle of 6940 days (235 lunations)

(In the table above, the Gregorian date in the first column is derived from the NASA Eclipse Website. Its equivalent Julian Day number, in the second column, was obtained from the Voyager computer program, available from Carina Software, San Leandro, CA. In the third column, the total interval in days between the starting date of each saros and the date of each individual eclipse within it has been converted to lunations by the author. In the fourth column, each lunation value has been labeled with the saros number assigned to it by NASA, a finesse that we can appreciate but was unknown to the Maya.)

In the three saros cycles reproduced in Table 1, the reader will note that the first two each experienced 19 lunar eclipses whereas the third witnessed 22. Inasmuch as each saros cycle measures less than 19 years, the average frequency of lunar eclipses over the 57-year period described was one about every 11.4 months. Precise as it is, Table 1, or such an equivalent as the Maya were able to compile, offers little evidence of a pattern reliable enough to assist in eclipse prediction.

In an earlier study I made on this subject (2008), I realized that as soon as the Maya recognized the length of the saros cycle – namely 6585 days, or 223 lunations -- they inevitably found it necessary to correct their lunation count to that interval rather than to the moon's most recent maximum setting position, which regularly recurs every 19 solar years at an interval of 6940 days or 235 lunations. Interestingly, according to the Maya Long Count, the lunar interval measures 18 tun 5 uinal and 5 kin (the latter being individual days), whereas the solar interval equates to 19 tun and 5 uinal; both of these intervals were easily manipulated within the framework of their calendars.)

What Table 1 does show is that, once the Maya were actually recording lunar eclipses and attempting to discern some pattern in their occurrence, they had every reason to question if they were really up to the challenge of what they were undertaking. The eclipses were so numerous that they barely had time to record them, much less to analyze them carefully enough to search for meaningful clues that might help to explain them. Just putting the data in order to be able to compare one saros period with another was a monumental task in itself. If nothing else, by revealing the magnitude of the confrontation that the Maya faced, Table 1 serves to clarify how slim their chances for success really were.

The Crisis at Noon: A Day in 671 CE

There was a time in Mesoamerican archaeology when the age of a site was "guesstimated" by the architectural style of it principal structures. So it was when I was doing my initial search of the literature regarding Edzná in the early 1970's. When the site was first explored in the '20s and '30s, it had been labeled "Late Classic" in age, i.e., 600-900 CE, primarily on the basis of the appearance of "Cinco Pisos". The only other citation I found at the time was one by Eric Thompson regarding the Puuc Region surrounding Edzná, but not mentioning the site itself. He noted that a one-day correction had been made to the calendar there in the year 671, and that, shortly thereafter, all the other Maya sites has fallen into line and adopted the change as well.

The latter comment strongly suggested to me that this could only have happened at Edzná, whose elegantly designed gnomon at the base of "Cinco Pisos" had first established the date of the Maya New Year back in the year 48 CE. In fact, my first comment to Ray Matheny, on meeting him in 1978, was that I had felt obliged to withdraw mention of the latter date in one of my recent papers because I had learned that "it preceded by well over 500 years the actual founding of the site itself". He quickly assured me that this was not the case, for his excavations at "La Vieja" had been radiocarbon dated to –150, so my finding had, indeed, been "right on target".

Although Thompson didn't tell us why the correction in the calendar was necessary, or how it was accomplished, the very mention of it caused me to look into the matter more closely. With the help of the Voyager computer program, I cranked the heavens back to the year 671 and set the local time to noon, when the sun should have been directly overhead on July 26th, the Maya's New Year's Day. The problem immediately became clear, because I saw that the sun had already passed the zenith. In other words, New Year's Day was now showing up on July 25th instead. Obviously the easiest solution for the Maya was to celebrate New Year's Day over again, and go on with life as if nothing had happened. Apparently this is what they chose to do, because the Long Count clearly continued without interruption, and when the infamous Bishop Landa turned up in Edzná in the year 1552, he noted that the Maya New Year was still being celebrated on the equivalent of July 26th. So much for Thompson's 'digression'.

From what I had learned from Table 1, I sensed that the Maya must have been paralyzed by an "information overload" throughout the entire span of their initial attempt at eclipse prediction. Therefore, I decided to look ahead through the NASA data to see how long this 'deluge' of lunar eclipses had continued at Edzná. The results of this investigation are summarized in Table 2 below.

Table 2 - Eclipse Frequency at Edzná, -150 to +800

Time Frame	Number of Solar Eclipses	Number of Lunar Eclipses	Total Eclipses
-150 to –100	14	22	36
-101 to –50	14	19	33
-51 to 0	13	18	31
+1 to +50	14	17	31
+51 to +100	12	15	27
+101 to +150	14	14	28
+151 to +200	14	17	31
+201 to +250	20	19	39
+251 to +300	19	22	41
+301 to +350	17	22	39
+351 to +400	15	22	37
+401 to +450	14	22	36
+451 to +500	11	19	30

+501 to +550	9	16	25
+551 to +600	13	15	28
+601 to +650	14	14	28
+651 to +700	14	16	30
+701 to +750	14	19	33
+751 to +800	16	20	36
TOTAL	271	348	619

Over this 950-year period, a total of 619 eclipses were observed at Edzná, of which 271 (43.8%) were solar events and 348 (56.2%) were lunar events. The reason for there being a higher proportion of lunar eclipses than of solar eclipses is that in every month, whether at its maximum declination or at its minimum, the moon moves through a far greater span of space than does the sun, thereby bringing it more frequently into the path of the Earth's shadow. For example, at the moon's extreme declination, it covers in one month a distance equivalent to 121% of the total annual range of the sun, and, even at its minimum declination, it travels in one month a distance equal to fully 79% of the sun's annual range. More importantly, Table 2 also illustrates that the suspected "information overload", postulated at the outset of the Mayas' observations, appears to have continued almost unabated until the late ninth century, when their society abruptly collapsed and all such observations ceased. Therefore, an in-depth examination of the last few saros cycles at Edzná seemed warranted as well, for it was precisely within that time frame that both of the Mayas' fleeting successes were achieved.

The Dresden Codex

The first of these was the so-called "Dresden Codex" that comprises a list of no fewer than 71 solar eclipses. Ironically, it got off to a rather questionable start in the year 755, beginning with a solar eclipse that the Maya recorded as having taken place on November 8th of that year. Actually, NASA has no record of such an eclipse, because it did not occur. The Maya obviously believed it did, but over the Yucatan that morning, the sun and the moon missed each other by 8 minutes in time and 2.5 degrees in space. Fifteen days later the Maya recorded a lunar eclipse that they couldn't have observed, because NASA shows that it was centered over India, and 15 days later still, they recorded a second solar eclipse – which NASA does confirm – but which probably not a single soul in the world witnessed it because it was centered over the ocean between Antarctica and South Africa.

Despite an unimpressive beginning -- that I have in earlier writings described as bordering on "science fiction" -- the Maya went on to catalogue more than three score of solar eclipses -- using, of course, their own special definition of "accuracy". It appears that early on, whether they actually witnessed a solar eclipse or not, they concluded that they almost invariably occurred with a frequency of six lunations, or 177-178 days. When I say, "almost invariably" it is because they also realized that that was not always true, because very randomly solar eclipses recurred after five lunations instead. Since the Maya priests were at a loss for knowing when one of these random events would upset their prognostications and endanger their credibility amongst the laity, they seem to have developed a “fail safe” method of keeping their authority intact. This was always to warn the masses that an eclipse “might occur” in five full moons, but when it didn’t happen, they could confidently ***guarantee*** that, at the next full moon, it definitely would. This strategy is clearly apparent when we compare the Maya dates recorded in the Dresden Codex with those established by NASA, for when they didn’t actually accord with each other within a day or two, they invariably did within one lunation. In Table 3 below we analyze the Dresden Codex in detail, and demonstrate its ‘amazing’ validity, given the fact that so few of the eclipses were actually witnessed by the Maya themselves. Here Thompson’s initial coefficient of 584,285 days is used, rather than his revised value from 1935.

Table 3 - A Comparison of Maya and NASA Solar Eclipse Dates

Maya Day #	Julian Day #	Maya Eclipse	NASA Eclipse	Visible in Edzná	Accuracy
1412848	1997133	11/8/855	12/8/755	No	•
1413025	1997310	5/4/756	5/4/756	No	***
1413202	1997487	10/27/756	10/28/756	No	***
1413350	1997635	3/24/757	4/23/757	No	•
1413527	1997812	9/17/757	10/17/757	Yes	•
1413704	1997989	3/13/758	4/12/758	Yes	•
1413881	1998166	9/6/758	10/7/758	No	•
1414059	1998344	3/3/759	4/2/759	No	•
1414236	1998521	8/27/759	9/26/759	No	•
1414413	1998698	2/20/760	2/21/760	No	***
1414590	1998875	8/15/760	8/15/760	No	***
1414767	1999052	2/8/761	2/9/761	Yes	***
1414944	1999229	7/15/761	8/5/761	No	•
1415092	1999377	12/30/171	1/30/762	No	•
1415270	1999555	6/26/762	7/25/762	No	•
1415447	1999732	12/30/762	1/30/763	No	•
1415624	1999909	6/15/763	6/16/763	No	***
1415801	2000086	12/9/763	12/9/763	No	***
1415978	2000263	6/3/764	6/4/764	No	***
1416126	2000411	10/29/764	10/28/764	No	***
1416393	2000588	4/24/765	4/24/765	No	***
1416480	2000765	10/18/765	10/17/765	Yes	***
1416657	2000942	4/13/766	4/13/766	Yes	***
1416834	2001119	10/7/766	10/7/766	No	***
1417011	2001296	4/2/767	4/3/767	Yes	***
1417188	2001473	9/26/767	9/27/767	No	***
1417336	2001621	2/21/768	3/23/768	No	•
1417513	2001798	8/16/768	9/15/768	No	•
1417690	2001975	2/9/769	3/12/769	No	•

1417868	2002153	8/6/769	9/5/769	No	•
1418045	2002330	1/30/770	3/2/770	No	•
1418222	2002507	7/26/770	7/27/770	No	***
1418399	2002684	1/19/771	1/20/771	Yes	***
1418576	2002861	7/15/771	7/16/771	No	***
1418753	2003038	1/8/772	1/9/772	Yes	***
1418930	2003215	7/3/772	7/5/772	No	***
1419078	2003363	11/28/772	12/29/772	No	•
1419256	2003541	5/25/773	6/24/773	No	•
1419433	2003718	11/18/773	12/18/773	No	•
1419610	2003895	5/14/774	5/15/774	No	***
1419787	2004072	11/7/774	11/8/774	Yes	***
1419964	2004249	5/3/775	5/4/775	No	***
1420112	2004397	9/28/775	10/29/775	No	•
1420289	2004574	3/23/776	3/23/776	Yes	***
1420446	2004751	9/16/776	10/17/776	No	•
1420643	2004928	3/12/777	3/14/777	No	***
1420820	2005105	9/5/777	10/6/777	No	•
1420997	2005282	3/1/778	3/3/778	No	***
1421174	2005459	8/25/778	8/26/778	Yes	***
1421322	2005607	1/20/779	2/21/779	No	•
1421499	2005784	7/16/779	8/16/779	No	•
1421676	2005961	1/9/780	2/10/780	No	•
1421854	2006139	7/5/780	8/5/780	No	•
1422031	2006316	12/29/780	1/30/781	No	•
1422208	2006493	6/24/781	6/26/781	No	***
1422385	2006670	12/18/781	12/19/781	No	***
1422562	2006847	6/13/782	6/15/782	No	***
1422739	2007024	12/7/782	12/9/782	No	***
1422887	2007172	6/2/783	6/4/783	Yes	***
1423064	2007349	10/28/783	10/29/783	No	***
1423242	2007527	4/22/784	5/23/784	No	•
1423419	2007704	4/12/785	4/13/785	No	***
1423596	2007881	10/6/785	10/8/785	No	***
1423773	2008058	4/1/786	4/3/786	Yes	***
1423950	2008235	2/20/787	3/24/787	No	•
1424098	2008383	9/25/786	9/27/786	No	***
1424275	2008560	8/16/787	9/16/787	No	•
1424452	2008737	2/9/788	3/9/788	No	•
1424629	2008914	8/4/788	8/6/788	No	***
1424806	2009091	1/28/789	1/31/789	No	***
1425339	2009624	---	1/20/790	No	
1425517	2009802	---	7/16/790	Yes	

Accurate to within a day = ***; Accurate to within a lunatinon = • .

Note that the final solar eclipse recorded in the Dresden Codex was on Maya day number 1424806.

The solar eclipse on Maya day number 1425517 was recorded at Santa Elena Poco Uinic in southern Chiapas state and appears to have been the last such event documented by the Maya. Although a Long Count date equivalent to January 18, 909 has been found at the site of Tonina in the same state, it has no apparent astronomical significance.

A couple of final observations on the Dresden Codex: By the time that Eric Thompson had examined the Codex in 1972, he had, of course, already dismissed the notion that the Maya were serious astronomers, so he apparently made no effort to match any of the Maya dates with the correlation he had initially advanced in 1927. It is probably just as well that he didn't, because had he realized what we know now, he would have had to reverse himself again – an understandably difficult position to be put in and one that even the early Maya seem to have eagerly tried to avoid. He concluded his analysis of the Codex by pointing out that it contained no fewer than 92 errors, most of which he attributed to mistakes in transcription, but he did not question the document's overall significance on that account. More difficult to understand was his argument that the Codex was most likely a 12th century copy of a four-century older document that had been written in Chichén Itzá, but he made no attempt to explain what value a list of solar eclipses would have had four hundred years after they had taken place.

The Final Triumph in Lunar Eclipse Prediction

Very early in my studies of the Mesoamerican calendar, I realized that both the misnamed "Olmecs" and the Maya had begun recording celestial events almost as soon as they had learned to write. My first revelation in this regard had to do with the so-called Stela C, discovered by Mathew Sterlng at Tres Zapotes in 1939 and now reposing in the National Museum of Archaeology and History in Mexico City. Although its date differed from that first recorded by Oppolzer (1877) and later by NASA (1996) by five days, I felt that this surely had to do with a 'mistake in transcription' (very much like one of the 'errors' found in the Dresden Codex by Thompson), because the circumstances of its geographic location were far too exacting to ignore. I later demonstrated in a special paper on the subject that this had indeed been the case (2012).

With respect to the Maya, my first clue came from a list of their dated monuments found in Sylvanus Morley's book *The Ancient Maya* (1948). When I compared each entry in his list against a list of lunar eclipses recorded by Oppolzer in his *Canon der Finsternisse*, I was struck by the fact that one of the Maya dates varied by only two days from one of the latter's eclipses. This naturally prompted me to examine the discrepancy more closely and once I had corrected for the differences in longitudes and the fact that Julian Days begin at noon in London whereas Maya days begin when darkness falls in Mesoamerica, it soon emerged that they both were records of the very same event. In fact, only when I learned that the Maya had recorded this eclipse eight times over -- on six different altars and pyramids at their highland site of Copán in Honduras -- did I realize how much it had meant to them. As it turned out, this appears to have been the one and only eclipse the Maya ever predicted!

However, without a word about the eclipse, epigrapher David Stuart has argued that this date marked the installation of the last king of Copán. On the other hand, Fred Espenak of NASA has confirmed that it did mark the longest total lunar eclipse of the entire 8th century, so the Maya could hardly have managed to choose a more singular occasion on which to induct their final local leader than this. Triumph though it was, it was sadly a short lived one, for within little more than a decade, all intellectual activity ceased among the Maya and their society totally collapsed. It is the last "hurrah" of these remarkable people that we will now examine.

In Table 4 below, I present a summary of the eclipse history of Edzná at the final stages of its existence as the main astronomical center of the Maya. From this, it is quite obvious that, if anything, the frequency of lunar eclipses was just as great near the end of Edzná's life-span as it was at its beginning. In the 77 years of record documented here, we find that a total of 78 eclipses were visible from the site, for an overall average that continued at the rate of one every 11.6 months.

Table 4 – The Late History of Lunar Eclipses at Edzná (684 to 763 CE)

Date	Julian Day Number	No. of Lunations	Saros Number
November 8, 686	1971931	0	(New Saros Cycle)
February 3, 687	1972018	3	83
July 30, 687	1972195	9	88
January 23, 688	1972372	15	93
December 2, 689	1973051	38	75
November 22, 690	1973406	50	85
May 17, 691	1973582	56	90
September 20, 693	1974439	85	77
March 17, 694	1974617	91	82
September 9, 694	1974793	97	87
January 13, 697	1975650	126	74
January 2, 698	1976004	138	84
June 29, 698	1976182	144	89
December 22, 698	1976358	150	94
June 18, 699	1976536	156	99
April 27, 701	1977215	179	81
April 16, 702	1977569	191	91
November 17, 704	1978515	223	(New Saros Cycle)
August 9, 705	1978780	9	88
July 30, 706	1979135	21	98
December 13, 707	1979636	38	75
June 8, 708	1979814	44	80
May 28, 709	1980168	56	90

November 21, 709	1980345	62	95
April 7, 711	1980847	79	72
March 16, 713	1981556	103	92
September 9, 713	1981733	109	97
January 24, 715	1982235	126	74
July 21, 715	1982413	132	79
January 2, 717	1982944	150	94
June 28, 717	1983121	156	99
November 12, 718	1983623	173	76
May 8, 719	1983800	179	81
November 1, 719	1983977	185	86
April 27, 720	1984155	191	91
October 20, 720	1984331	197	96
March 7, 722	1984834	214	73
August 31, 722	1985011	220	78
November 28, 722	1985100	223	(New Saros Cycle)
February 24, 723	1985188	3	83
February 13, 724	1985542	15	93
August 9, 724	1985720	21	98
December 24, 725	1986222	38	75
June 19, 726	1986399	44	80
December 13, 726	1986576	50	85
June 8, 727	1986753	56	90
December 3, 727	1986931	62	95
April 18, 729	1987433	79	72
April 7, 730	1987787	91	82
September 30, 730	1987963	97	87
March 28, 731	1988142	103	92
September 20, 731	1988318	109	97
July 31, 733	1988998	132	79
January 24, 734	1989175	138	84
November 23, 736	1990209	173	76
November 12, 737	1990563	185	86
May 8, 738	1990740	191	91
November 1, 738	1990917	197	96
March 18, 740	1991420	203	83
September 10, 740	1991596	209	78
December 8, 740	1991685	223	(New Saros Cycle)
March 7, 741	1991774	3	83
August 31, 741	1991951	9	88
February 24, 742	1992128	15	93
December 24, 744	1993162	50	85
June 8, 746	1993693	68	100
April 18, 748	1994373	91	82
October 11, 748	1994549	97	87

Septrmber 30, 749	1994903	109	97
February 15, 751	1995406	126	74
February 4, 752	1995760	138	84
July 30, 752	1995937	144	89
January 23, 753	1996114	150	94
July 19, 753	1996291	156	96
May 30, 755	1996971	179	81
March 29, 758	1998005	191	91
December 19. 758	1998270	223	(New Saros Cycle)
March 18, 759	1998359	3	83
September 11, 759	1998536	9	88
August 31, 760	1998891	21	98
January 14, 762	1999392	38	75
July 10, 762	1999569	44	80
June 29, 763	1999922	56	90

Inasmuch as it was during this period of time that the Maya scored their only success in predicting an eclipse, the question remains, how did they finally accomplish it? No doubt the first alert came on May 17, 691 when their attention was drawn to a total eclipse on what was for them a completely new saros, identified as # 90 by NASA. The fact that it was a *tota*l eclipse and that it occurred *at a lunation position where none had ever been previously seen*, obviously suggested that it deserved yet closer attention in the future. (Ironically, the Maya had in fact recorded a total eclipse at this lunation position on July 3, -149, near the very beginning of their observations, but it belonged to saros series # 56 which never again produced a total eclipse before the series totally disappeared from Edzná on February 26, 248, so it had long since been forgotten.)

The new eclipses at lunation position # 56 steadily grew in both strength and length with each occurrence, so here, at last, seemed to be an event whose arrival surely must be predictable. But, after 900 years of observation and study that had produced little in the way of results, what ‘sure-fire’ clue could the Maya sky-watchers find to guarantee that such a prediction would take place when they said it would and not expose them to the derision of the laity if it didn’t happen?

Obviously, the answer, if there was one, could only be found in the differing pattern of eclipses that began to emerge at the start of each new saros cycle. Of course, lunation position # 56 itself would not be reached for about four and a half years after each such cycle began, but the sooner a secure clue could be discerned, the longer the lead-time the sky watchers would have to inform the masses.

Once we review each of the eclipse patterns shown above, we find that the only time a total eclipse occurred in lunation position # 56 was if an eclipse had already preceded it in lunation position # 38. Inasmuch as these two positions are separated by eighteen lunations, this indicates that even though the lead-time had now been cut to a year and a half, the sky-watchers at Edzná still had plenty of time to announce the eclipse’s coming. Therefore, by the third time this happened (in the years 725-726), they were ready to proclaim its arrival in the years 743-744. However, when no eclipse occurred at lunation position # 38, they knew that it would not take place at lunation position # 56 either, so fortunately they remained mum. But the fourth time around, when an eclipse did take place at lunation position # 38 in early January 762, they were emboldened to issue an alert soon thereafter. This meant that as lunation position # 56 neared in late June of 763, all eyes of the Maya world that were still capable of looking heaven-ward no doubt did so, and just as darkness fell over Mesoamerica on the evening of June 28th, their long-awaited expectations were rewarded.

However, as we now know, this belated triumph had a bittersweet ending, for by this time Maya society itself was teetering on the edge of demise, and it is questionable whether anyone other than those at Copán took any notice of this momentous event. Certainly, when lunation position # 56 came around the next time in 781, the eclipse it spawned passed without notice. Indeed, the last Maya record of an eclipse of any kind was that of the total solar event that crossed the highlands of Chiapas at noon on July 16, 790. This one not only marked the end of an era, but also of a civilization.

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