

# Calendrical stelae of dzibilchaltun: gnomonic knowledge and power

## Abstract

One of the aspects that suggest the existence of a Power, being this religious or political, is the presence of calendrical structures. The obsession of time measurement and their manifestations can be identified easily in the Maya culture. Examples such as “El Castillo” in Chichen-Itza, “El Templo Redondo” of Mayapán, among many others, show the knowledge that our Mayan ancestors had about apparent motion of the Sun around the Earth. This study analyses, from a gnomonic point of view, the set of three Stelae of Dzibilchaltún that were erected in the structures Str. 47, Str. 48, Str. 49. The almost exact orientation towards the North-South direction reflecting a gnomonic intension (they are facing to the midday Sun and it was considered a god) and their heights are indications of an intentional calendrical erection. This fact can be understood, especially, if one takes into account their location (latitude 21.09° and orientation 187° of azimuth) because the shadow of a gnomon in the Solstice of winter is equal to his height and the corresponding ‘gnomonic factor’ is equal to one unit. The priest-astronomer or the member of the elite that knew their features could predict the arrival of seasons of the year just looking at Stelae and at their shadows; deducting them through the relative size of the shadows at, for example, the solstices: Then, there must have been elite that had the gnomonic knowledge and used it to prevail.

**Keywords:** time, mesoamerica, gnomonic factor, power, rituals

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## Introduction

Similarly to as it did elsewhere in Mesoamerica, the astronomical knowledge was intimately linked to the rites and religious myths of the people. Despite the spatial and temporal distances in which different cultures in the Mesoamerican region were developed, they shared a central worldview in that time, their knowledge and measurement was central. The observation of the sky and its manifestations was a way of communicating and establishing direct contact with the gods.<sup>1</sup> The rituals were part of the power structure in which the rulers and priests, through them, can perpetuate its presence generation after generation. Consequently, rituals cannot be seen as elements that preserve or embody a set of religious beliefs, rather should be seen as builders, creators, or religious beliefs modifiers.<sup>2</sup> We remember these ideas about the rites or rituals because Maya stelae includes scenes of ceremonies or events linked to dances or other activity of the elite,<sup>3</sup> closely linked to the dates of the calendar. Stelae are one of the best known and frequently cited expressions of Maya monumental sculpture and had its boom in the classic period (around dC 250-850).<sup>4</sup> There are vestiges and manifestations of the most varied forms and content, however, others which are not carved and engraved can also be found. These structures, whose glyph ‘Lakam-tun’ which could be translated as “banner stone” or “Stone sign”, was discovered during the past century. Their assimilation as a ‘flag’ or ‘sign’ is appropriate because the glyph is often represented in sculptures such as Yaxchilan Stela 11.<sup>4</sup>

Thus, stelae and calendrical dates are closely linked to the power structure. However, only observation of the sky and the record by decades of the passing of the days could allow with the help of the numeric system based on twenty (Sistema vigesimal, in Spanish), to consolidate a calendrical system. To do so, it required not only a social organization that would allow the existence of the priest-astronomer people who would take the accounts and the celebration of the rituals,

but also a ruling elite that fused them to exercise power. Itself that would allow the Organization of people for the erection of temples and buildings, monuments and stelae, in short, of the production of all materials in which such knowledge is Burberry. Indeed, among the Maya, the astronomer-priest played an important role in the social structure; He was ah miatz your ximbal (the “wise in the way of the stars”),<sup>1</sup> responsible for regulating earth-based activities from the actions in the sky. Among those events occurring in the sky, it is impossible not to consider those attributed to the Sun, during its Ortho and Sunsets, whether in moments of its completion, while crossing, every day, the meridian line. But, as Renfrew says, unfortunately, “archaeologist cannot observe beliefs: one can work with vestiges, consequence of actions.” In favourable cases... these vestiges are the result of actions whose interpretation may be plausible as a result ‘of’ a religious belief”.<sup>2</sup> In other cases, this is impossible. But in general, you can be confident on instruments and simulations that may shed light on actions or motives that gave them origin. The calendar or, better still, the calendars were the better finished products of this “man’s relationship with the gods” through the priest-astronomer. Elaborate models to understand diverse kind of cycles in nature had, in Mesoamerica, an expression that is superior in many respects to the conquerors, to conjugate the sky objects and meteorological cycles with others created mathematically. In the Maya area, in particular, cycles were covered under the long count, the tzolkin (a 260-day cycle) and the haab (a cycle of 360 days and 5 bad old days or “unnamed”), which provided one of the most accurate ancient Calendrical systems.

The Calendrical system, linked to the rituals and the existence of the ruling elite are the more finished expressions of the existence of an established power in the Maya zone of Mesoamerica. It will be through the analysis of a concrete example at Dzibilchaltun that we will analyse this relationship: the three stelae aligned S4, S5 and S6, located in structures str. 47, str. 48, Str.49, respectively. The objective of the following analysis is to provide, based on a study of some features

of the stelae S4, S5 and S6, located in their platforms, an argument on the possible gnomonic based design of the set; in particular, a possible measurement of the solstices and the Sun's zenith pass. In addition, we suggest their use as part of a ritual in a phase of Dzibilchaltun in which virtually no new buildings were built. At the end of the paper, it will be clear that gnomonic as the knowledge of shadows, could have been used by the elite at Mesoamerica; in particular, the array of Stelae of Dzibilchaltun, could confirm this assertion.

## Methodology

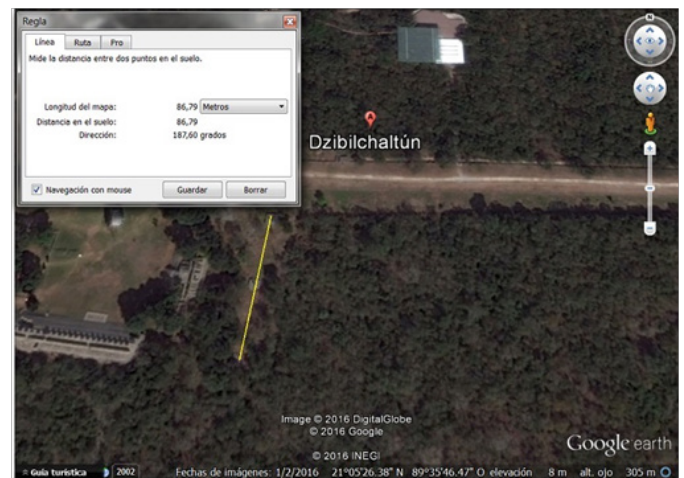
In this study a concept relating the shadows of a gnomon (Stele, post of staff) at solstices known as gnomonic factor ( $fg$ ) was used.<sup>5</sup> This factor has been used by the author in the analysis of monuments and architectural vestiges in several cultures from Egypt to Greece and with examples on Stonehenge and New grange to mention few of them. The gnomonic factor can be calculated directly as the difference between Winter Solstice shadow (WSs) and the Summer Solstice shadow (SSs), from the location of the place under consideration (Latitude ( $\phi$ ) and Longitude) with the aid of the obliquity of the ecliptic ( $\alpha$ ), through the following expression:

$$fg = WSs - SSs = \frac{1}{\tan(90^\circ - \phi - \alpha)} - \frac{1}{\tan(90^\circ - \phi + \alpha)}$$

For the shadow out of the meridian (primed values below), the use of the program Stellarium was used.<sup>6</sup> Dzibilchaltun, Yucatan, Mexico Located halfway between Merida and Progreso in Yucatan, Mexico, Dzibilchaltun appears on the map as a small town that developed over several centuries. With a name whose meaning could be translated as "Where there are writings on flat stones",<sup>7</sup> this Mayan city really represented a great settlement of several tens of square kilometres. We could say: "Place where there are messages in the flat stones"; messages encrypted in the stelae of the site. Despite its proximity to the coast (actually is a third of the distance between Merida and Progreso), the city gets very little rain water. For that reason, also, clear days are most numerous as in Progreso but less than in Mérida. The central site of about 500 square metres area, was inhabited by an elite of important characters and there was, in addition, a development of small concentrations of population satellites around extending in an area of 4 to 6 square Kilometres and more.<sup>8</sup>

The resident population of Dzibilchaltun in the decadent period was scattered. Most of them lived in areas away from the centre of the site and, surely, in houses made from perishable material. One of the most clear evidence of the sparse population is the near-absence of burials in that period<sup>9</sup> and the fact that a small percentage of the archaeological remains recovered during the excavations are blooming modified period or the Decadent, strictly speaking.<sup>8</sup> Ritual activities, main orientation of the city in this period, continued even once the Spanish conquest had already arrived. An open hood that Spaniards rose probably in order to redirect the religious activities of the site, may constitute a testimony of the ritual vocation of Dzibilchaltun. While the architectural developments of the Decadent period covering dC 1200-1540, were geared to improve and renovate the structures that already existed in previous periods, specific structures erected in this period can be identified. Many of them were part of residential areas made of perishable materials; however, the str. 47, str. 48 and str. 49,

with its stelae appear to have been designed with a ritual orientation.<sup>10</sup> Some of the works related to ritual activities that stand out in this period are, for example, the tunnelling of the str. 1 on its West to reach and open side space towards the facade of str. 1-sub structure, to allow access to the central Chamber and, the construction of the altar facing the ancient entrance to the enclosure.<sup>9</sup> Thus, in this period, Decadent, in which important structural changes were made, it can be identified a purely ritual structure at Dzibilchaltun which consist of three small platforms with stelae (mentioned above, str. 47, str. 48, str. 49) and described in detail below; they appear to have been planned as part of a comprehensive plan. The design of stelae set suggests that they were carved at the Early Period II. The distinguished feature of these stelae is their location on a platform specifically designed for each of them and apparently all in conjunction. In Mayapán, another site in the North of the Yucatán Peninsula, has numerous stelae, but only a few are placed on platforms built custom. There is no doubt that in Mesoamerica, the most prolific region in the uprising of such structures is the Maya region. As stated by Susan T. Evans, thanks to the decipherment of the language, it is clear that the members of this culture referred to them as "big rock" or "rock sign" and explain the methods used for their erection.<sup>11</sup> But the set of stelae analysed here are, also, special because the structures and their orientation are in the direction North - South; although, as it will be seen later, it is necessary to specify that its axis would point to a more precise direction: azimuth  $187.6^\circ$ ,<sup>12</sup> as shown in Figure 1.



**Figure 1** Google Earth picture depicting the orientation of Stelae (yellow line); in the rectangular window the azimuth could be read (Dirección:  $187.6^\circ$ ).<sup>12</sup>

It is not unreasonable to think that the use of stelae might be related to measurement and registration of the passing of time. If in other regions of the world, such as Babylon or Egypt, the movements of the Sun were observed and recorded through the use of the gnomon, understood it as a straight upright stick placed on a horizontal surface.<sup>13</sup> In these cultures the development of a calendar was also related to the crop rising and collecting. The Mayan stelae could well have played a similar role in Mesoamerica. Where, we can also say, there was an extensive use of walking sticks and ceremonial staffs that eventually could be used as gnomons. Poles, staffs and stelae could be used in these latitudes as devices to record the time and might well have

evolved from the stake or rod of wood used as a tool for cultivation.<sup>3</sup>

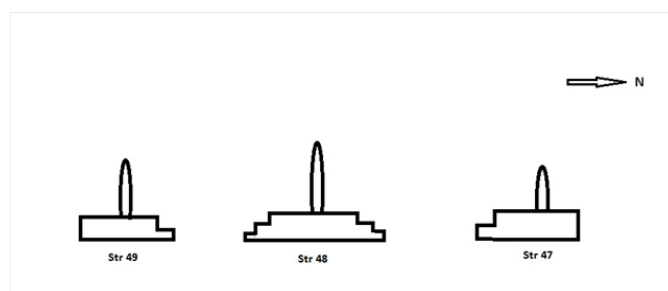
## Calendrical stelae

At the beginning of the Sacbe1 leading to the “Templo de las Muñecas”, it is possible to see three structures aligned in a direction almost North - South. These structures, called str. 47, str. 48 and str. 49, found around 20 meters East of the structure str. 42 as shown in Figure 1. In the centre of each of the three structures stelae are placed (S4, S5 and S6, respectively); all of them have been dated to the Decadent period of Dzibilchaltún, as was stated above. Two of the platforms, str. 48 and str. 49, were studied by Adrian D. Anderson<sup>3</sup> and by findings in filler of the structures and the way in which the blocks of rock were joined with mortar, a technique not found in most ancient structures of the site, allowed him to assign a date within that period. The structure str. 47 was released until the 2001-2002 season of Dzibilchaltún Archaeological Project<sup>14</sup> with only few ceramic objects found.

Characteristics of the stelae, in terms of shapes and finishes, are different from those present in other areas of the Mayan culture. They are thin contrails without apparent engravings and with its rounded top edge. Rather, assumes that the rugged faces of contrails may have been softened with a layer of stucco, although, according to Anderson,<sup>3</sup> the day of the excavation is no longer appreciated any rest from it. While the three structures are similar, they differ in several aspects: the presence of stairs and the heights of the stelae placed in them. With regard to the steps, it can be said, as it appears now after the archaeological recovery, that str. 48, located between the other two structures, has two stairs: one to the North, facing the str. 47 and another to the South with a view towards str. 49. For its part, the str. 47 and str. 49, possess a single staircase looking each towards the str. 48; that is, the str. 47 with stairway to the South, same that was proposed by archaeologists<sup>14</sup> and the str. 49 their way northward, whose evidence realize Anrews IV and V Andrews.<sup>8</sup> In Figure 2, you can see the Schematics of this set (the dimensions are not to scale). We already mentioned above that alignment of the platforms and therefore of the stelae, is in the direction North - South; although it is important for our argument to define a more precise guidance: azimuth 187.6°; alternatively, the shadow of a gnomon produced by the Sun on the winter solstice would be observed with direction of 7.6° to the Northeast,<sup>12</sup> as shown in Figure 1. We must emphasize that the shadow should be equal to the gnomon due to the fact that the elevation of the Sun would be, at that moment, of 45°.

Another relevant aspect is that the three structures are almost rectangular: str. 48 with sides of 490 (West), 510 (East), 580 (North) and 635 cm (South); Str. 49 with sides of 540, 520, 610 and 580 cm, in the same order (6); str. 47 was rebuilt of quadrangular shape with sides 640 (East-West axis) by 690 cm (North-South axis).<sup>14-16</sup> In Table 1, the basic of dimensions of stelae are collected as they were reconstructed in 2002. In it has noted that, the heights of the same and the general direction that is not in the direction exactly North-South but slightly East of North. We wish to emphasize the importance of the midday for the Maya: one day (day and night part) was from the noon sun; crossing the Sun on the meridian line, we would say now. This day received the name of uay. They should have had methods for determining that precise moment receiving the name of Zu huy kin (or noon point);<sup>17</sup> According to Barrera Vasquez, the Maya could refer

to that moment with the expression Pochek' Bo'oy, which literally means “where the Sun makes right shadow”.<sup>18</sup> This simple expression tells us that they had used any vertical element (stelae, posts, poles, rods) whose shadow they observed to determine when this were right or straight; i.e., the Mayans must have had the concept of element that we now call gnomon as an indicator. Therefore, that midday Sun should have played an important role in ceremonies and rituals, in the Decadent period as well as in the Classic one. There would be ritual ceremonies daily but, above all, start and end of the year. Here it is possible to suggest, also, the important role played by the days of solstices because their sites on the horizon where the orthos and the corresponding sunsets, were called by them as “the corners of the world”.<sup>19</sup>



**Figure 2** The Diagrams show the array of stelae over their platforms emphasizing their orientation and position of stairs (from right to left S4, S5 and S6). See table 1 for their dimensions.

**Table 1** Stelae's dimensions

Concept	Stelae		
	S4	S5	S6
Long (cm) <sup>14</sup>	255	312	319
Width (cm) <sup>14</sup>	102	90	115
Thickness (cm) <sup>14</sup>	23	23	25
Height (cm) <sup>14</sup>	205	245	234
Orientation (°) <sup>12</sup>	187.6	187.6	187.6
Latitude (°) <sup>12</sup>	21.092	21.091	21.09
Longitude (°) <sup>12</sup>	89.596	89.596	89.6

Thus, combining both meanings we can, now, establish that it was worth valued the moment of culmination of the Sun at the winter solstice as a turning point. In addition, as you can see in Table 2, in Dzibilchaltun, the Sun is exactly between the horizon and the zenith; that is, it has an elevation of 45°. This position involves a platonic gnomonic factor equal to zero (fgp=0).<sup>20</sup> In terms of the summer solstice, the Sun practically is at the Zenith: the Maya say Kaz chumuc kin.<sup>21</sup> The days of the passage of the Sun by the zenith, dates of the calendar of utmost importance in the Maya culture, can be appreciated with the help of the stelae. The corresponding dates are the day 26 May and 18 July and in those days contrails cast no shadow at noon. The idea introduced above stating that the set of stelae was planned as a whole for a ritual objective, is supported when the results of the measurements of the shadows of contrails and their respective heights. For example, the length of the shadows of S4 at solstices plus

its thickness (234,047 cm in Table 2) is equal to the height of the stele S6 (234.0 cm); also, the sum of the shadows of stele S6 at the solstices (244,097 cm in Table 2) is equal to the height of S5 (245,0 cm). In addition, these coincidences correspond to the moments in which the Sun appears aligned with the azimuth 187.6°.

**Table 2** Heights and shadows of stelae

	S4	S5	S6
WS	45.382	45.409	45.41
WS'	45	45	45
WSs	202.29	241.527	230.7
WSs'	205	245	234
SS	87.553	87.553	87.55
SS'	87.529	87.529	87.53
SSs	8.762	10.471	10
SSs'	8.846	10.572	10.1
WSs+SSs	211.05	251.998	240.7
WSs'+SSs'	213.85	255.572	244.1
WSs+SSs+e	234.05	274.998	265.7
WSs'+SSs'+e	236.85	278.572	269.1
fg	1.0295	1.0286	1.029
fg'	1.0431	1.0431	1.043
fge	1.1417	1.1224	1.135
fge'	1.1553	1.137	1.15
fgp	-0.013	-0.014	-0.014
fgp'	0	0	0

SX, sun's elevations at solstices; W, winter; S, summer; SXS, corresponding values of shadows; fg, gnomonic factors; ', primed values are for the general orientation of structures

## Conclusion

One of the forms of expression through sculptures reflecting the existence of ritual acts and calendrical records is the erection of stelae richly decorated with boom in the Classic Maya period. In them, in addition to the commemoration or registers of cycles (Katuns), the rulers appear dressed in rich clothes and carrying canes decorated or ritual (staffs). In the period called Decadent of Dzibilchaltún, apparently, this custom was relegated and therefore you can find smooth stelae which could well have been worked in a previous period and which may have been erected with a goal in mind. In addition, political or religious power in a society becomes evident when there is in it the record of time and hence the prevalence of a calendrical cycles. With the Maya, a sophisticated system of counting the days with the long count, the year Haab and the Tzolkin period, make more than evident the existence of an elite with priests-astronomers or astronomers-priests who wield true power. In Dzibilchaltun, at the time known as Decadent period, some years before the conquest, the City developed a ritual vocation manifested in little new construction.

They include the lifting of three structures (Str.47, Str.48 and Str.49) with stelae, allegedly originating in the Early Second period, whose dimensions and orientation suggest a gnomonic goal. Their orientation reflects the search for the observation of the Sun at an elevation of 45° in the winter solstice with the shadow of contrails equal to its height and with the heights of them related one with each other's shadows: sum of shadows of S4 equal to S6 and the height of S5 equal to the shadows of S6.

As the observation of shadow of a gnomon, or as in the present case of Stelae, can be considered as a geometric activity because it involved continuous elements, it is logical to suppose that the dimensions of these shadows should try to be counted (or better still, related) in terms of the element that produces them (the length of the gnomon). It is possible to state here, then, taking into account the relationship between the shadows of contrails and their heights, a concrete expression of which John Stillwell addresses when considering the differences between geometry and arithmetic: their differences are only apparent because a deep relationship exists between them, as exemplified by the Pythagorean Theorem.<sup>22</sup> Finally, we can suggest that the Calendrical stelae of Dzibilchaltún, analysed here, would be an example of a type of construction with ritual objectives and social projection of the existence of an elite that detained the power, as León Portilla says, "the Mayan sages of the classical horizon were not the first or the only ones that devoted its attention to the issue of the Time, [but] they were the ones with the most haunting interest developed that it might have been inheritance of ancient Mesoamerican culture, to create chronological systems with modules and computations of a precision that today seems implausible".<sup>23</sup>

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## Conflict of interest

Author declares that there is no conflict of interest.

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