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BASIS OF A GNOMONIC PARADIGM IN MESOAMERICA: THE CASE OF MAYAPAN

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ABSTRACT

In the last decade we have found several examples of the role of the gnomonic triangle (formed by the vertical gnomon, the shadow and the sunlight coming from the Sun) in the site selection and orientation of buildings in ancient cultures. We have discussed the cases of Stonehenge and Newgrange, where the gnomonic factor (*fg*) are equal to 3 and 4, respectively, and with the aid of platonic gnomonic factor (*fgp*), its presence in Greece and Egypt; we have begun the search of a gnomonic paradigm as a manifestation of Astronomy in antiquity. In fact, our search has given several possibilities, or better, several possible forms for the paradigm: Through the *fg* and through the *fgp*. Astronomy, undoubtedly, began with the observation of the Sun and the Moon; well before the appearance of Star Astronomy, the apparent motion of the Sun in the daily sky and at the horizon along the year was recognized. Prior to that, we can think about man looking his shadow and acquiring conscience of Space and Time as proposed by R. Calvino. Now, we turn our attention to Mesoamerica where orientations of buildings to events on the Horizon (sunrise, sunset, and zenith passages) are well recognized, in order to find a gnomonic paradigm. In particular we analyze the case of Mayapan's *El Castillo* and *Templo Circular*; paying attention to the main orientations of the latter, as reported by Aveni and Milbrath in 2004, and J. Galindo in 2007. We have found that they could have been fixed by the shadows of a gnomon: at Winter Solstice a shadow implying *fgp* = 0; at Winter-Summer Solstices a *fg* = 1; and, at the day of Zenith Passage a *fgp* = 1 1/3; and, the East rising day a *fgp*= 1/3. These results allow us to suggest the existence of a gnomonic paradigm for Maya Culture.

KEYWORDS: Templo Circular, gnomonic factor, Zenith Passage, gnomonic paradigm

1. INTRODUCTION

In the last decade, we have been identifying several ancient cultures that made use of the gnomon as a tool to orient its cities or monuments (Perez-Enriquez 2000, 2001, 2012); to locate the sites where these monuments or buildings must be placed (Perez-Enriquez, 2014); to define some of the architectural elements of calendrical meaning (Perez-Enriquez, 2007). Going from the north of Europe with places like Stonehenge and Newgrange to the Mediterranean region as is the case of Greek and Egyptian cultures; also, traversing the Mesopotamian region through an interpretation of the Plimpton Tablet as a table of earth markers (Perez-Enriquez, 2015); those findings have suggested the existence of some kind of gnomonic paradigm in ancient cultures.

In this article we make the analysis of a specific site in Mesoamerica (Mayapán) and a specific building there (the *Templo Circular*), in order to look for some aspects that allow us to propose a gnomonic paradigm for the Maya Culture. The selected building was studied few years ago by one of us (Galindo, 2007) and it is known as the Q152 structure of Mayapán.

The Q152 structure is located at 20,63° N Latitude and 89,46° W Longitude, in the Yucatán Peninsula, as it can be seen in Figure 1.

Figure 1 Location of Mayapan in Mesoamerica inside the Maya Civilization zone.

Due to this location, the *Templo Circular* is just about the region where the *gnomonic factor* (see section 3) has a value equal to one as it is the case for Chichen-Itzá, Teotihuacan and Xochicalco (Perez-Enriquez, 2010), only to make mention some of the most known cities of Mesoamerica. As such, Mayapán appears to have a special orientation according to that fact.

Mayapán has been studied by important researchers in the past. In particular, the orientation of *Templo Circular* and its neighbour, *El Castillo*, have been analysed by Ruiz *et al.* (Ruiz et al., 2001) and by J. Galindo in 2007 (Galindo, 2007), both studies take into account the mural paintings remains which show obvious solar as well as Venusian elements. On the other hand, A. Aveni and S. Milbarith (Aveni et al., 2004) and Peraza and his collaborators (Peraza et al., 2009), have considered that the relation with Venus seem highly unlikely. However, they leave out the fact that according to ethnohistorical sources the Prehispanic name of *El Castillo* was *Kukulcan*, feathered snake, and Venus as the morning star (Landa, 1994: 94-95). Moreover, in central Mexico, the round buildings are frequently associated to Venus (Špraj, 1996). There it can be read: "A personage coming from Central Mexico called *Kukulcan* founded Mayapán".

But our approach is new because we make use of the gnomon as a tool. And the proposed paradigm that must come out from this study opens new lines in the field.

In this paper, we discuss this site presenting, in Section 2, a brief description of the building Q152 and its surroundings. In it, we present some of the previously obtained data which allow to identify a calendrical alignment for the *El Castillo* and the *Templo Circular* mainly its orientation towards the sunset of the days dividing the year in 104 and 260 days.

The gnomonic factor (*fg*) and platonic gnomonic factor (*fgp*) are discussed in Section 3, but in this case, we work out their values for each of the four doorways of the building. We know that any comments have been presented before about the possible use of the gnomon by Maya people. However, there are many manifestations of elements pointing towards its use; Stelas, Staffs, Posts, are only few of the possibilities. Then, in Section 4, we present some evidences in the epigraphic and linguistic aspects. The Final Comments of Section 5 are oriented to present our considerations about the possible gnomonic paradigm coming from the results of our observations and their implications.

2. THE Q152 BUILDING OF MAYAPAN

The circular building located at the Central Plaza of Mayapán, which registration code is Q152 in the Carnegie Institute, represents a very important architectural reference of the site. The *Templo Circular* of Mayapan seems to have been built around 1350 AC, nearby the *El Castillo* which appears to be built 50 years before.

The *Templo Circular* of Mayapán is similar in shape to the Caracol at Chichén-Itzá. It is a 10.2 m diameter, four doorways, building situated in an almost squared platform (see Figure 2). Its reconstructed height is 7.5 m and it has a cylindrical central core of 4.5 m in diameter. The walls are very thick (1.15 m) in such a way that the doorways make, in conjunction with the vanes, significate points of

orientation (Galindo, 2007). As it can be seen in the diagram of the temple (Figure 3, in section 3, ahead), the four doorways are directed to specific orientations, not exactly in an East-West and North-South directions; the corresponding azimuths appear in Table I.

Figure 2 View from the North of the 'Templo Circular' and its platform.

The azimuth of the access with stairs to the platform, is considered as the general orientation of the building and was measured by J. Galindo as it were the doorways; the astronomical orientation of Q152 corresponds to the calendric division of the year in 104 and 260 days.

The Q152 building, the *Templo Circular*, when discovered, had some fragments of the ancient painting; the presence of the 'blue maya' color suggests that the building was a main feature of the city because this color was reserved for the Elite and sacrifices (Sanchez del Rio, 2011).

It is worth valued to mention that A. Aveni and S. Milbraith have suggested an alignment towards the equinox sunrise, directed to the center point of the upper sanctuary of El Castillo; however, this suggestion would change the alignment days due to the fact that the room lacks its higher section (Aveni et al., 2004).

3. THE GNOMONIC AND PLATONIC GNOMONIC FACTORS

Two main tools have been introduced for the analysis of orientations of buildings and temples of ancient cultures. Both are related with the observation of the shadows cast by a gnomon at noon time: i) the gnomonic factor (*fg*) was introduced by Perez-Enriquez while analyzing the UK's Stonehenge Monument (Perez-Enriquez, 2002); and, ii) the platonic gnomonic factor (*fgp*) was used to the study of Herodotus Oracles (Perez-Enriquez, 2014). They are defined as follows:

- *Fg* is the ratio of the difference between solstices' shadows of a gnomon (WSs, SSs) divided by the length of the gnomon (g)

$$fg = \frac{WSs - SSs}{g};$$

- *Fgp* is the winter solstice's shadow length divided by g (gnomon length) minus one

$$fgp = \frac{WSs}{g} - 1.$$

As just mentioned, the original definition was made at noon time at solstices; however, for the present study, the meaningful solar azimuths are taken at other important solar events for the Maya Culture as the Zenith Passage (ZP) or the East Rising Sun (ERS) and moments diverse from the noontime.

3.1 The gnomonic factor in Mayapán

Effectively, in the studies and calculations of gnomonic factors in different sites the orientation of the gnomon's shadows considered have been the noon ones. However, we have to point out that in some cases it has been necessary to consider otherwise as Perez-Enriquez has done for the *Zhou bi suanjing* shadows in Chinese Culture (Perez-Enriquez, to be published). Such is the case for this study.

In the *Templo Circular* we can identify an orientation specific for the noon observation: the South doorway. However, the measured alignment was 184,03° which implies a moment later than noon. Using a solar path simulator (*Stellarium*) (Chèreau, 2014) and consider the year of construction of the temple around 1235 AD, we calculated a value *fg* = 1 (one exactly). In this case both shadows, the Winter Solstice one (WSs) and the Summer Solstice one (SSs), were taken when the Sun had an azimuth equal to the 184.03° just mentioned (See Figure 3).

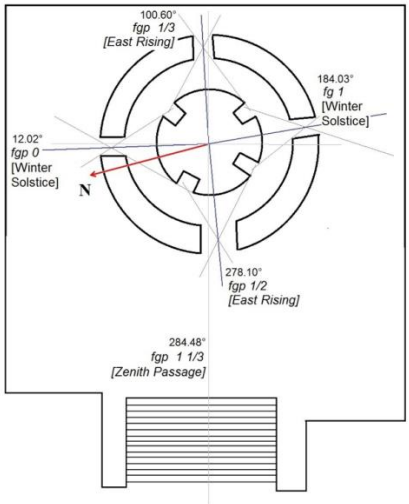

Figure 3 Diagram showing the Templo Circular's orientations and the gnomonic factors at the specified dates.

3.2 The platonic gnomonic factor in Mayapán

In the definition of the platonic gnomonic factor, again, the noon time has been considered in the previously studies made (Perez-Enriquez, 2014). In the study about the Egyptian sites along the Nile River, fgp considered the Winter Solstice shadow (WSs) and the shadow of the day when the Sun was at 45° instead at the Summer Solstice one.

For this study, we considered the Sun's positions such that its azimuth was considered the same as the alignment of the corresponding doorway.

This was done for the other three doorways of the *Templo Circular* and for the platform where it is located. Here are the results of the calculations made with the aid of the *Stellarium* solar simulator:

i) Access to the Platform. As was mentioned above, the main orientation of this building is towards the sunset for divition of the year in two periods: one of 104 and the other of 260 days. In this case, the corresponding alignment is 284.48°; i.e., the azimuth of the Sun projecting a shadow related with the fgp = 1 1/3 at the day of Zenith Passage (ZP);

ii) North Doorway. The measured alignment of this doorway was 12.02° corresponding to a shadow of a gnomon equal 1 when the Sun was observed at Winter Solstice day (*fgp* = 0);

iii) East Doorway. The day when the Sun rises at East and reaches the azimuth of the doorway (100.60°) the gnomon casts a shadow of 1,333 times the gnomon; then we calculated a fgp = 1/3 at that moment;

iv) West Doorway. In the same day of East Rising considered for the East doorway, at the time of sunset when the Sun had an azimuth of 278.10°, its altitude was 56.31° making a shadow of one and a half times the gnomon's length and consequently, a *fgp* = ½.

These results are shown in Table 1. under these spatial coordinates that we will make the determination of the corresponding *platonic gnomonic factor*.

3.3 The factors and its meaning

When we observe as a whole the results presented in Table 1, several things can be recognized: the dates correspond to special days along the year; the gnomonic factors have proper values; and, the azimuths coming from the alignments of the doorways are all different from the cardinal points.

Now, we will discuss briefly each one. The days of solstices were important for most of the ancient cultures as they were the days when the Sun rises and sets on its northern and southern positions on the horizon. In Mesoamerica, the day of Zenith Passage was a significant day because it was frequently correlated with the onset of heavy rains and as it was suggested by Malmström could be related with the origins of the Calendrical System (Malmström, 1997) . The fact that these days could have been selected to define the orientation of the doorways of a building such as the *Templo Circular*, suggests the presence of a gnomonic paradigm. Maybe the priest or the rulers gave attention to these matters. The integer values of the factors or fractional, has in their own an idea of measuring devices sucha as staffs, poles or rulers.

The alignments of the four doorways are different from the Cardinal Points and the constructors must have had a reason to do it. The East and West doorways are almost in the same line; also, day correspond according with our calculations, to observations made at the same day. That is not the case for the North and South ones, they are not on the same line but they correspond to an observation on Winter Solstice.

TABLE I. Of Gnomonic Factors (fg and fgp) for Templo Circular of Mayapán.

Doorway	Azimuth (°)	Gnomonic Factor	Day of Measurement
Access to Platform	284.48	*fgp=1 1/3*	Zenith Passage
North	12.02	*fgp=0*	Winter Solstice
East	100.60	*fgp=1/3*	East Rising Sun
South	184.03	*fg=1*	W-S Solstices
West	278.83	*fgp=1/2*	East Rising Sun

4. POSSIBLE EVIDENCES

Although we do not have all the elements to confirm that the alignments involved in the construction of this Mayan building were, in fact, obtained from observations of gnomon's shadow, we can try to find evidences pointing in that direction. In that sense, our investigations throw us two types of possible examples: some available on stelae and iconography; and, others in the ethnolinguistic of Mayan words.

Here we present two possible evidences of use of the gnomon. The first one refers to the presence of a 'decorated staff' that could have played the role of a gnomon; it appears on a engraving of the Stela 30 of Naranjo. In it, *Smoking Squirrel*, son of *Lady 6*, carries a staff with three knots and possible date's inscriptions (see Figure 4). The stela represents a ceremony that took place in 9.14.3.0.0. (date in the Long Count Maya Calendar equivalent to November 17, 717 AD) with the evocation of the Sun/Fire God (Closs, 1983).

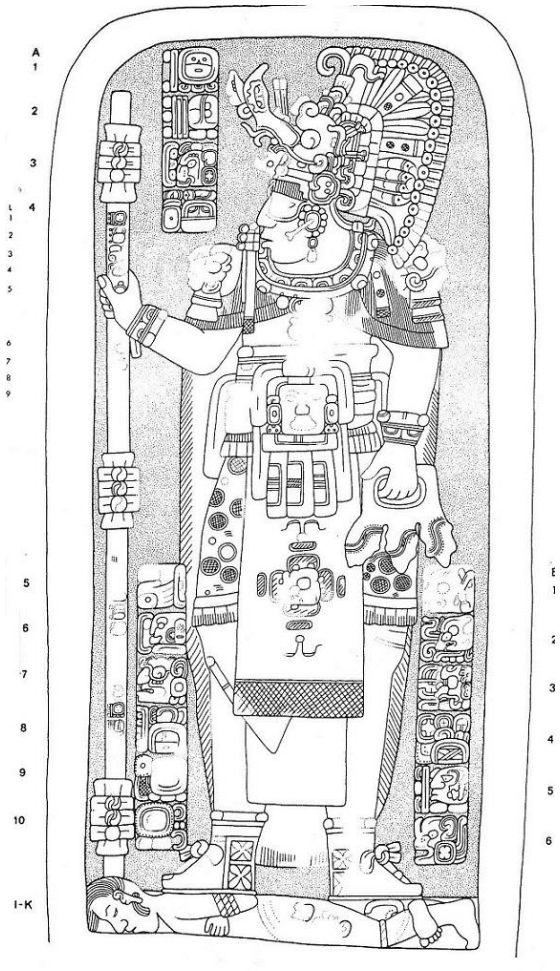

Figure 4 Maya Ruler Smoking Squirrel with a possible gnomon in his right hand with knots as markers (Stela 30, Naranjo) (Graham, 1978; Closs, 1983).

The second example comes from a linguistic analysis related to the identification of Noon Time and the possible instruments or tools used to that purpose. For example, noon time could be acknowledged by a shadow or through a Sun's position: *Chumuk bo'oy* /noon time/ Centre shadow; *Pochek' bo'oy* /exactly noon /when the Sun makes a straight shadow. Or with the expression: *kak chumuc kin* /at noon/ when the Sun is between two extremes (Alvarez, 1980).

For the instruments used as gnomons the Maya language gives the following examples: *Uaan nok* /measuring stick/ upright staff; *U ppizib nok* /vara para medir; *Tehché*/ upright pole/ bastón (Solis, 1949).

Finally, let us take some texts in the Zuyua language from the book *El Libro del Lenguaje Zuyua y su Significado*, where a mention about the Sun and the shadows it produces is presented. It is worth value reviewing a couple of these texts that are meaningful to what is proposed here. Remember that these texts were written, in the month of September, 1628, in order to make the Maya language understood by the people of that time. They give us to understand that these words are those "used by the Batabes –The Ones with Axe of the people" when they talk between them. The first text comes from Part II of the book:

> "Again he says: 'Well, my son, go get me the umbilical cord of heaven and bring me it here; you have to come by the East and you should bring it to your back.' The answer is: 'So it should be, oh father.', and he will go. Speaking is the Zuyua. [...] the umbilical cord of the sky that prompted is elaborated copal in thirteen different ways figures, and when it is told to bring it to their backs refers to his own shade when the Sun declines. This is understood in Zuyua" (Libro de los Libros del Chilam Balam, 1972: 135).

A Text even more representative is the fourth puzzle among the seven who must be guessed by the new rulers at the change of the Katun appearing in part I of the above mentioned book of the Zuyua language:

> "The fourth puzzle making them is to go to their homes saying: 'my children, when you come to see me, has to be precisely when the Sun is in the middle of the sky, you will be two and you have to come very close together, boys, and when you arrive here, your domestic dog is to come after you and it will bring in its teeth caught the soul of Cilich Colel, Sacred-Lady, when you come. Talking is Zuyua.' The two boys that refers that they have come together precisely at noon, is himself when he comes treading his shadow [...] This is the speech of Zuyua" (Libro de los Libros de Chilam Balam, 1972: 133).

5. FINAL COMMENTS

The azimuths implied by the doorways' alignments of the *Templo Circular* of Mayapán appear to be related to the existence, never suggested before, of a gnomonic paradigm. All of them (five directions) could have been defined in the early stages of the planning of the building; they could have been chosen due to the gnomonic triangles observed in significate dates of the year such as the Winter Solstice, the Summer Solstice and the days of Zenith Passage or East Rising of the Sun. We can suggest a paradigm through the following lines:

"The main orientations of the building could have been defined with the aid of a gnomon at azimuths where the length of the casted shadows of the Sun at identified special dates gave meaningful values."

Shadow lengths considered could have been of same as the gnomon as well as multiples or unitary fractions of it.

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