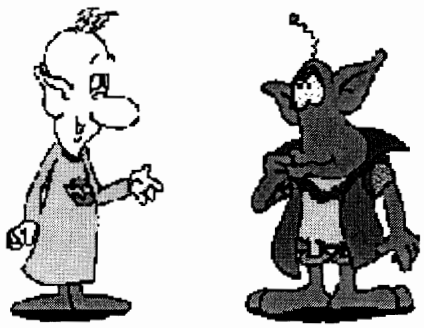


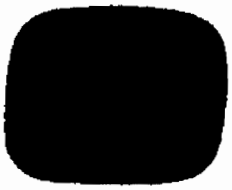
Project Ahau

I endure in order to equalize, Transcending opportunity.

I seal the store of death. With the cosmic tone of presence.

I am guided by the power of heart.

Chilam Balam and Tzacol asking themselves what Java is. They laugh when they understand Java is a program developed without cosmic synergy.



Electric Seed Logo

| Control | Developers | Logistics | Status | Files | Search | Briefings |

INTRODUCTION

Welcome to the Project Ahau. The mission of my work is to demonstrate the abilities of Mayan computers and implement the development of neurographics: architectural-oriented graphics created by neurological inputs. Thousands years ago, the Mayas occupied a unique domain called virtual space. In there, they created computer chips associated with pyramids in the real world to remind us of the harmony of the Universe. And then, they left their carcasses . . . so we may face them in cyberspace one more time.

Facing the uncertainties of nature and the extension of the mathematical science that the Mayas could have owned, opinions are divided. While some scholars reject "a prori" that the Mayas had something else than a pathetical obsession of counting, one by one, some investigators show the incredible accomplishments that represented the precise determination of astronomical cycles, the exact proportion of architectonic constructions and the imaginative achievements internalized in the discovery of zero, the invention of the numerical positions and the utilization of a vigesimal system.

Landa (1) says . . . "Their counting is 5 by 5 until 20 and 20 by 20 until 100, and 100 by 100 until 400, and 400 by 400 until 8,000, and this count was used for the cocoa trading. They have other large counts that are extended ad infinitum counting 8,000 twenty times that are 160,000, and turning to 20,

duplicating these 160,000 and after that duplication is made without end, THEY COUNT ON THE GROUND."

This afirmation is incongruent with Eligio Ancona (2) who comments ". . . They did not have notions of arithmetic, if we are to believe Landa who assure us that the Mayas did not known other operation that throwing beans on the ground or other flat surface to make their additions and subtractions. But this asertion can be disproved by the ingenious numerical combinations they used in their chronological system . . ."

The ancestral use of grains of corn to make their counts seem to be corroborated from diverse sources: Sánchez de Aguilar (3) said that the Mayas "throw their luck with a fistful of corn" and it is very suggestive to read in the Popol Vuh a paragraph where our cosmic grandfathers, Ixpiyacoc and Ixmucané before the formation of the human race, they make an augury based on mysterious calculations using corn grains and tzité. Recinos (4) identifies the tzité as the *Erythrina corallodendron* - Arbol de Pito, in Guatemala, and "colorín" in Mejico, and states that the fruit is a shell that encapsulates red grains similar to beans which the natives Mayas still use for magical spells.

From the examination of the mathematical aspects of Maya culture emerges the need to know how these corn grains and tzité were handled to calculate numerical operations. In further elaboration, not only they symbolized the unity with each grain or simulated bars and dots but they manipulated the grains as tokens or chips to add, subtract, multiply and divide.

It was until I had the opportunity to watch a Maya collaborator explain the way the H-Men (shaman) of one of our native groups calculated the distribution of a estate using corn grains and wooden sticks. I recognized the way that took me to the re-discovery of the techniques that undoubtedly were routine for the Mayan mathematicians. The inference that the red grains of tzité were used to represent the number 5 and equivalent to the bar of the Maya numeration was a fact that I was deducted logically. But the missing point was the fact that the H-Men while they placed the tokens on the ground, they placed the tokens in a square matrix of 9 squares (3 x 3), previously traced on the ground. The use of that board (similar to a chessboard) escaped to my attention and to many historians and scholars.

The archaeological evidence that has facilitated these board activities have not been discovered or acknowledge as such. However, it will be demonstrated in further sections that the calculations techniques are simple and it only needs a systematized rationale of the order of the numbers for an operator executes the most complex operations without mistakes. Consequently, the stelas and codexes do not have to reflect the sequence of numerical operations because they only perpetuated the final results of these calculations.

Curiously, it is not in the Maya area but the Peruvian where it reaches a full confirmation with similar results, if not identical. Before the Spaniard Conquest, these techniques included the utilization of grains with two different colors placed on a board similar to the checker board. Garcilaso de la Vega (5) says of the Incas . . . "From the arithmetic they know and in an admirable manner, the knots represented by threads of diverse colors give a method to count taxes and contributions in the Inca Empire by charge and discharge."

Acosta (6) says that in 1590 . . . "to make a difficult calculation for which an operator is required to use a pen and ink, the natives (of Perú) use their grains of corn. They place one here, three in other position and eight somewhere. They move the grains, one here, three there and the fact is they can complete the calculation without one mistake. In reality, they have better methods than us . . ."

Guamán Poma de Ayala (7) reiterates a similar finding. He affirmed they counted with boards and registered the calculations in "quipos" made with knotted threads of several colors. His illustration shows a drawing of the Mayor Controller and Treasurer Tauantinsuio Quipoc Curaca Cóndor Chava holding a quipu in his hands and to one side a board is drawn with twenty squares containing small circles, some blacks, some whites.

Another evidence is the Maya vocabulary. In the Diccionario de Motul (8) as is in the Pío Pérez (9) and the most modern one of Don Ermilo Solís Alcalá (10) confirm that the Maya language had words for the operations of addition, subtraction, multiplication and division.

Addition is BUC-XOC and to add is BUX-XOCIL or CUCH-XOCH; subtraction has varied phonetic forms and depends what is subtracted. To subtract in height is CABALTAL and to reduce is CHICHANCUNAH. Multiplication is DZAAC-XOC and division is HATZIL or HATZ-XOCH.

The dice game is named HAXBIL-BUL and is derived from HAXBIL (drill) and BUL (riddle game), however BUUL is also assigned to grains and we already know how the grains were related to fortunetelling and mathematical calculations that the Spaniards called superstitions.

The Mayan language, so rich in words, also has suffixes and prefixes highly differentiated that are attached to numerals to count distinct things. Lopez Otero (11) has researched this as explained in this table. Concepts such as "infinite" (BAKLIZ, MAXULUNTE); "cero" (MIXBAAL, ICH); "remnant" (U YALA); "equality" (CETIL), "identity" (LEILIL); "fraction" (XETT); and many others with a semantic vinculation with mathematics have survived in our times.

This section opens an avenue to rediscover new concepts that can be applied currently. From different cultures, from Chinese abacus to Keltic numerical inscriptions, all have basic elements of a archaic system of arithmetic that could be explained by convergence and linked to an impressive list of parallel cultural features, sometimes identical in conventional details, reinforce the theory of diffusionism notably. In other words, all of the Maya elements that have been compared with equivalents in the Old World could have been originated in America thousands of years before they appeared in Europe and Asia and that their diffusion was more widespread that originally suspected.

In this project, I don't pretend to have complete knowledge. I only expect to demonstrate that the Mayas using grains of two colors or little stones and sticks representing the numbers 1 and 5 and placing them on a board drawn on the ground, it is possible to create the fundamental algorithms of mathematics with a precision and order of magnitudes consonant with the chronological evidence, astronomy, engineering and architecture.

The visitor to this Web site can judge for himself if this purpose has been fulfilled. To this point, I not decided the best way to present it in the Web. Perhaps, a collaboration of the more professional programmers interested in developing a Maya Java computer to further present it to Sun, for example, is the most adequate way to present these novel concepts and then proceed with a copyright notice. Meantime, I will continue elaborating further sections of the Maya's computer concepts.

Rubén McDavid-Guevara, M.S., R.E.A.

References

1. Landa, Diego de. Relacion de las Cosas de Yucatán. Edición de Pebro Robedo. México. 1938. p. 112.

2. Ancona, Eligio. Historia de Yucatán. Imp. de M. Heredia Argüelles. Yuc. 1878. p. 141.

3. Sánchez de Aguilar, Informe contra Idolurum Cultores.

4. Recinos, Adrian. Popol Vuh. Fondo de Cultura Económica, México. 1949. p. 97.

5. Vega, Inca Garcilaso de La. Comentarios Reales de los Incas. Emecé Editores, S.A., Buenos Aires, 1945. p.119.

6. Acosta. Quotation made by Henry Wassen "The Ancient Peruvian Abacus," Göteborg, 1931.

7.Guamán Poma de Ayala, Felipe. Nueva Economica y Buen Gobierno. Université de París, 1936. p.361.

8. Ciudad Real, Fr. Antonio De. Diccionario de Motul (1578). Edición de Juan Martínez Hernández. Mérida. 1929.

9. Pío Pérez, Juan. Coordinación Alfabetica de las Voces del Idioma Maya. Imp. de la Ermita. Mérida. 1898.

10. Solís Alcalá, Dr. Ermilo, Diccionario Español - Maya. Ed. Yikal Maya Than. Mérida.1949.

The Numerals

" . . . Un punto indica un año; dos puntos, dos años; tres puntos, tres años; cuatro puntos, cuatro años. Una barra significa cinco años; dos barras, 10; un punto sobre una barra, seis . . ." (Chilam Balam de Maní.)

The characteristic principal of the Maya system of numeration consists of that the used symbols have an intrinsical value. In other words, the symbols themselves contain the multiplicity described. The idea is so elementary, from the semantic point of view, that is within reach to the children's mind: if one dot represents the unity, two dots represent the number 2, three dots, the number 3, and four dots, the number 4.

If we observe a traffic controller count the number of trucks that arrive at a construction area: he makes in his notepad one vertical line for each arrived truck until he reaches four vertical lines. Then, the fifth truck is counted with another line but this time he draws a line crossing the previous four vertical lines diagonally. Thus, he makes 1 set of 5 unities. After that, he counts all sets of 5 lines, multiplies by 5 and adds what is left. Well, the maya would do exactly the same thing only annotating dots and after four dots, he would cross the dots or link the dots to draw a bar. At the end, he would count the number of bars and dots left . The difference is that for the maya the dots and bars are already the numbers and not marks or signals only.

Many cultures on Earth seem to have used a similar ancient system of numeration. But, it happened that they encountered two serious problems: (1) a huge amount of space to represent a large number, e.g. 40, 100 or 2,000, and (2) the improbability of recognizing a total number, with a simple glance, without recurring to laborious additions in each one of the marks. This problem was resolved by all, with the exception of the Mayas and Indostanos, with conventional symbols for the sets of 10, 20, 100, 1000, etc. At that moment, the advantage that every numeral had an operative or intrinsical value was lost.

The Aztecs, as you may know, used a vigesimal system learned probably from the Toltecs whose culture was profoundly influenced by the Maya culture. From 1 to 19, points were used or small circles, and ocassionaly, images of fingers (as Mayans did.) For the number 20, however, they used an absolute conventional and arbitrary symbol, a flag. To reach to the count of 400 where they introduced another hieroglyph similar to the image of a tree to symbolize something that in their experience illustrated a big number (with branches and leaves.) Finally, the number 8,000 was represented with a handbag that would contain something very valuable equivalent to the high number of items.

The Babylonians, on the other hand, used cuneiform characters. Their system of numeration was hexagesimal (counting from 60 to 60). There are two theories of the origin this system grouped quantities. The first one forwards the hypothesis that it emerged as the fusion of two archaic systems: double-metric and the metric adopted by the Egyptians and the majority of Mediterranean cultures. The second emerged as a need for a calendar, so it resembles a vague babylonic year of 360 days, identical to the "tun" maya. In every case, the advantage was obvious. A system divisible by 2, 3, 4, 5, 6, 10, 12, 15, 30 and 60 which reduce the difficulties related to division, fractions and the use of irrational numbers. The babylonic system did not work very well in the development of algorithms, and for this reason, there was a vast activity of the mathematicians of that time to prepare tables, "magical" squares and progressions that would allow businesspeople and architects deduct quickly the results of the most common operations. Hogben (1) states that this abundant compilation only has a parallel with our actual technological era and to achieve this it was necessary for the Babylonians to resolve binomials and quadratic equations.

I would like to add that the metric and double-metric system have been confirmed in Europe, Asia Egypt historically. However, scholars have not explained yet the survival of the vigesimal system, of Maya origin, and still recognized in the French system ("quattre vingt"=80), the Basque and the Georgian. Isn't about time to investigate the Pre-hispanic interculturization between America and Europe?

Another example of numerical writing that started using the principle of accumulation and modified to represent quantities graphically is the Chinese numeration, and adopted by the Japanese in its modern style before the introduction of arabic numerals to that country. The Egyptians, with their admirable perfection of chronology and geometry, were not be able to originate another system to confront large quantities as they follow the same metric system with different signs to count 10, 100 and 1000. The Greeks and the Romans introduced more confusion by representing each numeral with a letter taken from the alphabet that probably contributed to the scientific decadence of the Medieval Age.

The two trascendental inventions of the Mayan system of numerations was first, the bar with a value of 5. Instead of placing in line ten small dots, it was enough to draw two bars achieving a considerable saving of space. The second invention consisted of the ordering of numerals by unities, twenties, twenties of twenties, twenties of twenties of twenties and so on. Each dot or bar is assigned a multiple value when taken in consideration the first, second, third, or fourth position in a column. Obviously, it resulted that the highest numerical ranges are associated with the top positions.

- One dot in the 6th position = 3,200,00
- One dot in the 5th position = 160,000
- One dot in the 4th position = 8,000
- One dot in the 3rd position = 400
- One dot in the 2nd position = 20
- One dot in the 1st position = 1

Simultaneously to this invention, it was discovered the need of creating a symbol that would fill the spaces in a column where no numeral was written. The Mayan symbol for the "number" zero is one of the most ancient concepts of abstract thinking. If the reader is asked to represent the nothingness you will understand how difficult is to imagine a figure without conventionalism but carries the essence of the idea implicitly. The arabic symbol for 0 will not probably resist a criticism or judgement as a self-explanatory sign. The most intelligent man on Earth will not figure out what it represents without a previous explanation!

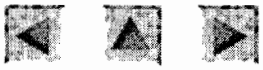
Palacios (2) affirms that the Mayan concept of zero implies the absence of everything - the empty void

is a physical improbability at least in the galaxy we inhabited - and, in reality, the Maya mathematician did not pretend to indicate absence or negation but a sense of completion. Say, to write 20, the zero indicates that twenty was completed and that nothing was lacking. This is an opposite assertion to the concept of absence or lacking. In support of that thesis, we could mention the opinion of Morley (3) who says that the symbol of zero found in the codexes represented a closed fist seen frontally. The closed fist would symbolize that the fingers (and, of course, the numerals because man started counting in this way) are retained within a closed space, integrated and completed. González y Obregón (4) also clarified the Aztecs counted with the fingers bent to complete a fist representing a complete count.

On the other hand, there is a defended point of view that the symbol of zero is a snail shell or sea shell for which there are solid rationale and documentary evidence. The shell is a frequent element in the Mesoamerican epigraphy and its vinculation with death, in my opinion, have been firmly established. It is easy to notice that the shell is the remant of a dead molusk. The Mayans must have understood that these empty carcasses were the fingerprint of vanished species.

Nevertheless, both concepts are reconciliated in one thought. The termination of Life is also the closure of a cycle, a measure that is completed . . . the final integration.

To summarize, one dot in the first position is 1, in the second position is 20, in the third position 400, in the fourth position 8,000 and 160,000 in the fifth position. The value of the bar is 5 in the first position, 100 in the second, 2,000 in the third, 40,000 in the fourth and 800,000 in the fifth.



References

1. Hogben, Lancelot. Mathematics in Antiquity. Londres. 1932.

2. Palacios, Enrique Juan. El Calendario y Los Jeroglificos Cronograficos Mayas. Ed. Cultura, México, 1933. p.36.

3. Morley, S.G. An Introduction to the Study of the Maya Hieroglyphs. Bureau of American Ethnology. Smithsonian Institution. Bull. 28, Washington, D.C. 1915.

4. González Obregón, Luis. Historia Patria. J. Ballescá y Cía, México, Tomo II, pp. 119-137.

The Mathematical Board

". . . entonces verán que era su sabiduría la que tenía poder sobre sus vasallos y solemnemente les será devuelta su estera, símbolo del poder . . ."

Chilam Balam de Chumayel.

Lost in the penumbra of times, the origin of the board, utilized in chess and checkers, is mysteriously mixed with the development of the mathematical science.

The diverse legends and myths about this invention are associated invariably to people or cultures which were acknowledged to have an advanced knowledge of numerals. Thus, the Romans received it from the Greeks, the Greeks from the Egyptians and the Babylonians learned it from the Indostans. While the Jews attributed the merit to Solomon - the most wise man among their kings - the Greeks assign it to Hermes, the Chinese to the Mandarin Hansing, the Hindus to Brahman Sissa and the Persians to the connotated astronomer Shatrencha. A major number of particulars, however, point to the fact that the board as well as chess and checkers games existed in India and there is mention of documents with previous dates. From there it seems to have migrated to Persia at the beginnings of the Christian Era and distributed through Europe from Constantinopla to the Spain occupied by the Moors.

If at the beginning the board had a mathematical function, later it was converted to a mysterious instrument of magic rituals and fortunespelling and end as a simple hobby. The science of one day becomes the magic of the next day and diversion in another time. Thus, there was a time when the hidden secret of the scientific character of the board was diluted by esoterism of the Kaballah and proliferation of magic squares where the numbers were combined in ingenious modes and symbolisms. The masonic ritual has preserved until our times a varied range of symbols inherited from an archaic cultural substratum. Examples are the floor with white and black mosaics, the numerals of the sacred stones, the masonic alphabet derived from a square box with dots.

Further, the board came to represent the mathematical plot of the universe on which the human knowledge is placed. For this reason, it appears on floors of masonic and rosicrucian temples as well as in the reticle that covers the internal walls of the Quadrangle of Las Monjas and the Governor's House in Uxmal. Also, it represents the crest of Mayan temples and observatories as an architectonic element

through several thousands years of civilization.

In the garments of the Inca dignataries, Guamán Poma de Ayala draws squares with inscribed numbers. The reader can compare his drawings with the post-hispanic "ponchos" to appreciate the reticulated design and discover some signs used by the Mayas with a mathematical meaning.

The stelas of Yaaxchilán, Piedras Negras, Copán y Quirigua show mantles and flaps of Maya priests with designs including squares and inscribed numbers. In Palenque exists several altarpieces dedicated to persons of high hierarchy where the most relevant feature is a shawl with squared designs and dots in the center of each square. This fact suggests the recognition of a title or rank where the mathematical knowledge is preponderant.

For the common calculations, it is probably that a board with nine squares was enough. An example is the magical table of Cornelio Agripa that was consecrated to the god Saturn or Chronos who is also associated with calendar calculations. It is useful to remember that Saturnian gatherings were events where the Greeks and Romans allow random or chance games and are tightly related with the mathematical techniques that I am investigating. A link is put into evidence: the probabilities are a branch of the mathematical knowledge.

In all symbolic boards columns and rows are very important as well as diagonals. As we see later, it obeys an important function contained in the three elements for the manipulation of tokens or chips.

It is not a surprise that the Mayas used boards to make their calculations, however, it arises the question of why these wooden or stone boards are not found in the Mayan zone as it happens in Perú. It exists in some mysterious squared designs on the floors of the Palace of Zacuala, in Teotihuacán, in the Chamber (closed) of the pyramid of Uxmal, in the castle of Chichén, and probably in other places but not in enough quantity to bring the attention of archaeologists. There are some explanations to the point. The floors have experienced an intense wear and tear by traffic and any painted square or line on them has the probability of have being raised. It could also be thought of the fact of poor durability of wood in a wet climate and did not have the advantage of being placed on doorways such as Tikal. We need to add that no one has been concerned in looking for boards on the floors, and probably now we will have more frequent reports of such findings.

Nonetheless, there is another reason that I wish to present as a hypothesis. One of the most solid antecedents in the use of boards is the placement of grains as tokens in a game known as "patolli," whose main players were the Aztecs. Says Mena and Jenkins (1) that ". . . Over a mat, e.g., rug made with hemp, a square is painted and it is crossed with two doubled diagonals, and in the point of intersection a square is centered and divided by for equal parts. Each one of the X-shaped cross is divided in twelve boxes. Near the extremities of each arm, within a wider box than the others a sign Nahui Ollin is painted . . ."

". . . The players are seated in small chairs, one in between every two arms as they throw drilled grains, shaken with their hands, before they are thrown. The grains must fall in the boxes. If they fall outside the boxes, the game is lost. As noticed, the number of total boxes is 52, 48 boxes in each arm and 4 boxes in the center, that are the years contained in the Mayan cycle. The number of plays must match the astronomical cycle calculation. The game is absolutely astronomical, in a literal sense."

More over, the same authors inform us that " . . . the players of patolli visited some Mayan festivals with a rolled mat under their arms and perforated grains linked by a thread . . ."

The codexes Durán and Magliabechi show explanatory drawings of the patolli game. Attention is called to the numerous coincidences with the Mayan techniques of calculations. Then, we get to the conclusion that the patolli game, chess and checkers were originated from the mathematical calculations as it could happen in the near future we develop intelligence games supported by pocket electronic brains.

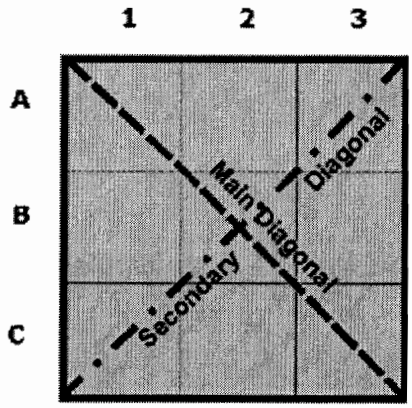
The Florentine Codex (2) shows a drawing where Cipactonal and Oxomoco, the couple of Aztecs cosmic progenitors who have been identified with Ixmucané and Ixpiyacoc of the Mayas-Quichés, invent the calendar. While Oxomoco appears manipulating some corn grains, Cipactonal has in his hands a bow with knots, that is a quipu. The significative detail is that Oxomoco is not throwing the grains on the ground but over a mat. It seems logical to assume that the mathematical boards of Mayas were mats. It has always been an intrigue that a mat, "póop" in maya, plays a role so prominent in their symbolism and considered as synonym of the throne. In fact, "to sit over the mat and in power," as expressed in the books of Chilam Balam, is the act of taking the command and government of Mayan people, and, in occassions, is given the rank of cosmic domain by suprahuman entities. The first month of the Maya civil year is called Poop. How do we compare a mat with such important functions?

It is evident that the mat contains a symbolism of great importance and it was believed to be found in the woven fabric that forms a repetition of crossed bands denominated "nahui ollín." This symbol, an admirable synthesis of the philosophical thinking of Mayas, occupies a preeminent place in the iconography of Tajín and in the Altiplano cultures. Therefore, it is not an speculation to think that the Mayan mats had a meaning directly related with the complex web of their society and dynamic of the Universe.

But now, another fact emerges: the possible use of the mat to paint over the surface squares with a function for mathematical calculations. Before this possibility, the content of this symbol integrates fully government and power. Not only to show the tight interrelation of the four elements or Universe appearances to form a microcosmic and macrocosmic weave but representing the intellectual power of Man, able to computing, anticipation and planning.

For these reasons, I forward the opinion that the mathematical boards were, to great extent, mats which are not existent due to the lack of discovered samples.

With the purpose of establishing clear references, I will use a Java programmed board similar to the illustration shown below.



MAYA MAT

The columns are identified by arabic numbers and the rows or horizontal lines by letters. The start point of the numbers and letters are in the top left corner. In reality we can arbitrarily choose any of the four

corners but it is logical to be inclined more toward that corner because all Mayan inscriptions coincide this point with the beginning.

We call the diagonal that starts from the top left corner and ends at the bottom right corner, the main diagonal. On the other hand, we designate the diagonal that begins at the top right corner and ends at the bottom left corner, the secondary diagonal. Each square is identified with a row number and column number (e.g. A for the row and 1 for the column) that belongs to.

The operations of calculus in the Maya system are manual. It results very difficult to describe them with words and diagrams because it requires an effort of imagination to assimilate them mentally. However, if they are executed with the help of graphical interfaces such as the one I am proposing in this Web site these operations are understood quickly. However, the reader can learn them with a paper sheet, beans and half toothpicks.

With these previous explanations, this project starts as we prepare to enter in a fascinating world of Mayan computers and the beauty of a Mayan universe never shown before. Enjoy it!

References

1. Mena, R. and Jenkins, A. Juan. Educación Intelectual y Física entre los Nahuas y Mayas Precolumbinos. México. pp. 37, 38, 44.

2. Códice Florentino. Fray Bernardino de Sahagún. Santa Fe. Nuevo México. 1950-52.

The Mathematical Concept of the Mayan Universe

". . . Sonó la Primera Palabra de Hunab-Ku, allí donde no había cielo ni tierra, y se desprendió de su Piedra y cayó al segundo tiempo y declaró su divinidad. Y se estremeció toda la immensidad de lo eterno . . . y su palabra fue una medida de Gracia . . ." (Chilam Balam de Chumayel).

"God made the integers, all the rest is the work of Man. (L. Kronecker)

I believe it has not escaped the readers' penetration the fact that the mathematical board on which the Mayas performed their operations is a two-dimensional array scheme: a matrix. In fact, the most simple definition of a mathematical matrix consists of a rectangular array of numbers that allows to perform mathematical operations.

Already in 1911, Roso de Luna (1) made an interesting mathematical analysis of the Cortes codex showing that the table of glyphs of the tzolkín on pages 13 to 18 of said Maya anahté constitutes deduced permutations of a fundamental determinant and those permutations present a cyclic-arithmetical progression by constant difference, in a series or closed cycle.

It is convenient to remember that the techniques of matrix calculus were recently developed in the past century while the Maya mathematicians used their boards several millennia ago. Moreover, the discovery of the mathematical matrices have created a revolution in the scientific methods of calculus incorporating a branch in Mathematics such as the Theory of Determinants, Vector Analysis and Tensor Analysis. All of these, in conjunction, is one of the most valuable instruments for Astronomy, Mechanics, Electricity, Fluid Mechanics, Elasticity, Plasticity and Rheology, Relativity, Nuclear Physics and other fields of modern science. It is in actuality, thanks to matrix and tensor calculus, possible to discover the parameters and variables of any phenomenon, not only in Euclidean space but also in Riemannian and Finsler spaces, and even others that we can not yet imagine.

Now, the starting point in the discovery of determinants, matrices and tensors was the confirmation that it is possible to place a set of numbers in columns and rows and perform diverse operations on them. For instance, adding and subtracting along diagonals to resolve equations with "n" unknown quantities or separating the isotropic and deviating components of deformation or radiation tensors. It is admirable to think that the Mayas had already discovered this method and performed operations of addition, subtraction, multiplication, division and calculations of square and cubic roots on a matrix array.

It is impossible to ignore the conclusion that in the current use of an archaic technique to execute the four basic operations we have not recognized that they are part of matrix calculus. We see, for example, the multiplication of two any numbers as:

$A = ka + ka + \ldots k_m a_m = k_p a_p$
$B = ka + ka + \ldots k_n b_n = k_q b_q$
Where $p = 1, 2, \ldots . m$
And $q = 1, 2, \ldots . n$

For these parameters A and B can be multiplied in a matrix, the condition is that the number of rows of the matrix A must be equal to the number of columns of the matrix B. In this case, both matrices are equal to 1:

$$A = | k_1 a_1 \quad k_2 a_2 \ldots \quad k_m a_m |$$

$$B = \left| \begin{array}{l} k_1 b_1 \\ k_2 b_2 \\ . \\ . \\ . \\ k_n b_n \end{array} \right|$$

The product will be:

$$AB = \sum k_{pr} k_{rq} a_{pr} b_{rq}$$

Developing this matrix, explicitly, it is obtained the following:

$$\begin{vmatrix} k_1 k_1 b_1 a_1 & k_1 k_2 b_1 a_2 \ldots & k_1 k_m b_1 a_m \\ k_1 k_2 b_2 a_1 & k_2 k_2 b_2 a_2 \ldots & k_2 k_m b_2 a_m \\ \cdot & \cdot \quad \cdot \cdot \cdot \cdot & \cdot \\ \cdot & \cdot \quad \cdot \cdot \cdot & \cdot \\ k_n k_1 b_n a_1 & k_n k_2 b_n a_2 & k_n k_m b_n a_m \end{vmatrix}$$

Suppose we have chosen a vigesimal system that limits the range to 5, $k_1 = 20^4$, $k_2 = 20^3$, $k_3 = 20^2$, $k_4 = 20$, and $k_5 = 1$.

It can easily be seen that the matrix which would form the values of k_{pr} and k_{rq} is the following:

$$\begin{vmatrix} k_1 k_1 & k_1 k_2 & k_1 k_3 & k_1 k_4 & k_1 k_5 \\ k_2 k_1 & k_2 k_2 & k_2 k_3 & k_2 k_4 & k_2 k_5 \\ k_3 k_1 & k_3 k_2 & k_3 k_3 & k_3 k_4 & k_3 k_5 \\ k_4 k_1 & k_4 k_2 & k_4 k_3 & k_4 k_4 & k_4 k_5 \\ k_5 k_1 & k_5 k_2 & k_5 k_3 & k_5 k_4 & k_5 k_5 \end{vmatrix}$$

In explicit form, this matrix would have the following numerical values:

$$\begin{vmatrix} 20^8 & 20^7 & 20^6 & 20^5 & 20^4 \\ 20^7 & 20^6 & 20^5 & 20^4 & 20^3 \\ 20^6 & 20^5 & 20^4 & 20^3 & 20^2 \\ 20^5 & 20^4 & 20^3 & 20^2 & 20^1 \\ 20^4 & 20^3 & 20^2 & 20^1 & 20^0 \end{vmatrix}$$

Therefore, if the addition of the subproducts $a_{pr}\, b_{rq}$ is made precisely along the diagonals parallel to the secondary diagonal, we will be grouping integers of the same scalar order.

The previous operation can be visualized also as the addition of two internal products of one linear matrix and a columnar matrix placed above and to the side of a unitary matrix:

$$AB = \begin{matrix} & k_p\ a_p \\ k_q\ b_q & \end{matrix} \begin{vmatrix} \\ 1_{pq} \end{vmatrix}$$

Use for example, a multiplication of 148 by 325. For better comprehension, we will do it in the decimal system, that is, for $k_1 = 100$, $k_2 = 10$ and $k_3 = 1$.

In this case,

$a_1 = 1$	$b_1 = 3$
$a_2 = 4$	$b_2 = 2$
$a_3 = 8$	$b_3 = 5$

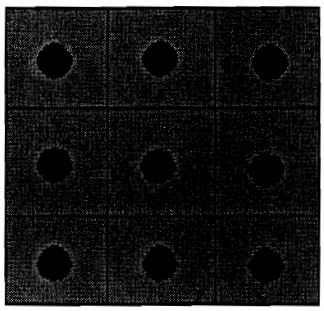
Substituting it in the general matrix, we obtain:

$$AB = \begin{vmatrix} 3 & 12 & 24 \\ 2 & 8 & 16 \\ 5 & 20 & 40 \end{vmatrix}$$

The addition along the diagonals parallel to the minor diagonal would be:

```
3        (By 10,000)
14       (By 1,000)
 37      (By 100)
  36     (By 10)
   40    (By 1)
```

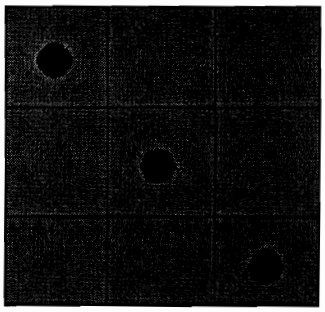
In the Mayan system, the unitary matrix would be represented with a dot in the center of every square of the board.

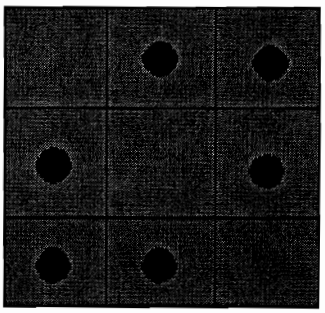


With such matrix we could make all the mathematical operations but yet we would obtain more versatility if we use other fundamental matrices of serialized numbers such as the ones seen in the garments of the Mayan priests on which empty squares are shown alternated with others having two or more dots in a regular order.

On the Inca garments it happens exactly the same, with such frequency that Guamán Poma de Ayala has marked the squares with Arabic numbers.

The most simple decomposition of the unitary matrix would give:





The first of Kronecker is necessary for calculation of the isotropic component of a tensor:

$$\partial_{rs} = \begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{vmatrix}$$

The second is the deviating component of the same tensor.

The Mayas represented these mathematical squares in their monuments, garments and paintings. It came to be something like a universal symbol of the Mathematics of the Universal web.

The stelae of Copán, Quiriguá, and the crests of Yaaxchilán and Palenque show in a uniform manner a grid design with squares on the clothing of the Maya high-ranked personalities. In the interior of these squares numerals appear or the geometrical symbols that I explained in the previous chapter. It would be redundant to mention the numerous examples that until now have been misunderstood. Archaeologists and other scholars have explained these patterns are a sophisticated design of a turtle shell. However, these explanations are highly incongruent with the appearance of the symbols in those areas of the facades that we know represent atmospheric space and of the sidereal cosmology or on the top of masks which these same archaeologists have identified as gods.

Notable examples of mathematical squares are on the internal facades of Quadrangle of Las Monjas, in Uxmal as well as in the House of the Governor, the masks of Xkichmook, the intercolumns of Kiuic, the arch of Labná, Las Monjas of Chichén Itzá and other buildings and stelae of the New Empire.

The universality of the abstract numbers, a concept expressed with such persistence for the Maya culture in their ornamental squares has came to be postulated recently in our century as the Dimensional Analysis and the Laws of Similarity. Science has recognized that there is in the internal mechanism of any event determined mathematical relations which are independent of space, time and mass. The discovery of this principle has made possible the deductive process of numerous fundamental equations in every order of the human knowledge. Thanks to this there are hydraulic models, structural models, analog computers and a rational compilation of statistical data.

But to speak of Dimensional Analysis it is necessary to enter into another aspect of the mathematical thinking of the Mayas. I mentioned in relation to the units of measure that the Mayas did not seem to have the same concept of time as ours. This would seem strange if we take into account an overwhelming majority of inscriptions which have relation with records of periods of time. However, in the Maya language there does not exist the word "time." The most common expression is "kinil" meaning in relation to the sun, or days. With a brief analysis of all Mayan words in relation to time, it is convincing enough that there is no implicit notion of what we actually experience as time. The applied words to the future mean only "from here to more" as in UCHMAL or simply a hopeful "may be" as in COCHOM. The expression for "ancient" (UCHBEN) does not involve a meaningful root of time. However, there is a specific word for "movement" in PEC and PECIL, which is such a highly significant fact that the other use of this word is to count circular things or recurrent cycles (turns, bows, etc.) There is a proper designation for "acceleration" (ZEBAL), "velocity" (ALCABIL), and deceleration (NICIL), and all of these show t hat the Mayas think fundamentally in terms of movement and not of time. The previous implications have an actual scientific transcendence.

If we reexamine our concept of time, we can convince ourselves that it may be an abstraction that does not exist. We talk about measuring the time with a clock and, in reality, we are comparing movements with the hands of the watch which are coupled with the apparent movement of the sun and the translation of Earth and its orbit. None of these measurements is strictly time; in fact, it may be as well an external general factor affecting equally all these movements - including those that control our organic and conscious processes - without being aware that time has been stretched or compressed. The total mechanism of the Universe may be suffering accelerations and isotropic pauses in group and we could never perceive them. When we want to know the mass of a body, we weigh it or measure its inertia. To determine its volume, we calibrate its dimensions. To know the contained thermal energy we use a thermometer. However, to describe its movement, we use an equation where space is involved and a conventional variable called "time", that is in fact,

movement. We can imagine units of valid universality for mass, space, energy, and movement (i.e. speed of light), but not for time.

It is possible that the mathematical thinking of the Mayas forces us to discuss the same bases of the dimensional analysis and we decide to abandon our temporal postulates and replace them with kinetic principles. The dimensional concept that the Mayas had about the Universe, which is based on four fundamentals units, is traduced in the representation of matter by a square, is an idea which has been confused with the affirmation that the Mayas believed Earth was flat and square. The four elements are: MATTER, MOVEMENT, SPACE AND ENERGY and correspond to known symbols of earth, water, air and fire. It represents, besides, the four states of matter: solid, liquid, gas and plasma transformation. But, I will not take this opportunity to conjecture that the Mayas had intuitively known atomic fusion and fission. I reserve this hypothesis for later confirmation of Project Ahau.

Finally, there is a third contribution of the Maya thinking that justifies our hopes for those who think that through the study of our great cultures of the past we can find solutions to our existential and philosophical problems. I refer to Synergetic Arithmetic. It is interesting when I was doing my Web research on matrix calculus, I came across Buckminster Fuller's F.A.Q. page maintained by Christopher J. Fernley. He directed me to Fuller's greatest publications to Mathematics, Synergetics and Synergetics 2. Notice the titles of Fuller's work!

It is not easy to explain something that yet has not appeared in our mathematical science and we can barely visualize. We attempt to understand and give expression to factors intervening in the constitution of a functional organism. Take a simple example: an automobile.

The pieces that constitute our vehicle need to satisfy certain requisites. They must be able to perform a specific function and to work well; they must be complimentary among themselves to be compatible. It is enough that if a spark plug does not work correctly the car motor will not be able to develop its full power. Moreover, we might have a good spark plug but the wrong one for the model of car or one that is incompatible with the rest of the components. All this would render impossible the harmonious working of the group.

None of the branches of Mathematics have introduced the scientific field of Synergetics. It is evident we can add in an algebraic form the components of an organism to obtain the functional vector of the set. A bunch of iron parts is not a car and a simple accumulation of organic tissues is not a human body. Not even the vector or tensor sum allows us to differentiate between an organism that functions and another that does not. There is a qualitative change that operates instantaneously in which all the integrating elements combine their efforts and perform harmoniously a new function, of superior hierarchy, with an entropic reduction that represents a higher degree of efficiency and transcends any individual possibilities of any of the components of the mechanism. When this happens we have obtained the synergetic sum, but for this to happen it is necessary to have a coordinating factor, a direction that the Mayas expressed in their numerical symbolism. When we understand Synergetic Arithmetic, and can express its precise formulas, additions, subtractions, multiplications, divisions, integrations, and derivatives of the factors and synergetic variables, we will be in a position to rationally plan our human robots, and production machines, and our governments might appreciate the magnificent synthesis of the Mayan philosophy relating the identity of Man with the Cosmos.

I have started this work with the description of simple - almost childish - techniques of calculus that the Mayas must have used. I can not conclude this chapter without externalizing the conviction that that simplicity, far from being a hint of our minuscule knowledge of a primitive

culture in the Third World, it represents a wisdom of knowledge we are far from reaching.

It disturbs me deeply to think that the great Mayan civilization disappeared mysteriously three centuries before the Spanish conquerors arrived leaving only their enigmatic stelae and deteriorated monuments. We ask as to the cause of their disappearance and we think in terms of ecological, psychological or historical determinants without finding a satisfactory answer. We ask to the mute inscriptions, hieroglyphs, and scrutinize the pages of the Chilam Balam's books and do not understand the mysterious reasons why the Maya culture perished, leaving a pathetical scream carved in the rocks of a Rainforest that could not devour everything.

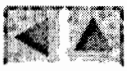
And, suddenly, from my Mayan intuition, from my memories of Maya DNA accumulated through long centuries, rises a light of comprehension reading the Chumayel Codex and explained to me by our race that the Itzaes magi did not disappear . . . they left!

And a hope crosses the Maya night when I hear the prophet saying in the 12 Ahau Katun the message will emerge from the white stones and there will be scientists who will understand the language of Zuyua. As that date approaches, I formulate an ardent desire that our Mayan wisdom nourish the roots of our historic personalities as a nation and as an awakened giant behind a galactic dream we extend to the rest of the world the formulas of our universal philosophy that were once upon a time the solid columns of millennial greatness.

Ruben A. McDavid-Guevara

Nexus Tzacol

NOTE: If you find this website interesting, but too mathematical for your taste, you can also visit my new website, The Search of Lord Pakal Ahau in the 21st Century. The content is aimed to my Mayan beliefs converted into modern philosophical thinking. Some visitors say it has a New Age flavor. Unfortunately, I disagree with them. These are ancient Maya concepts, passed from oral traditions. To go to the new website, please click here. The new website uses Flash presentations extensively. Thanks for visiting my personal pages.



(The author would like to express his appreciation to Bob Fritzius ***who kindly edited the chapter.)***

REFERENCES

Roso de Luna, Mario. La Ciencia Hierática de los Mayas. Librería de Pueyo. Madrid. 1911.

 Keywords: mathematics, universe, determinant, vector, tensor, rieman, finsler, matrix, calculus, euclidean, linear, unit, time, sidereal, acceleration, velocity, speed, movement, space, energy, matter, synergy, statistical, calendar, maya, adventure, count, number, square, root, cubic, chilam balam, chumayel, human, death, stone, stela, maya, glyph, infinite, equal, identity, fraction, addition, subtraction, multiplication, division, number, computer, language, chess, checkers,

code, mexico, south america, peru, quechua, one, five, abacus, cero, algorithm, epigraphy, astronomy, mayaquest, chiapas, data, java, guava, compiler, applet, class, subclass, library, public, private, protected, thread, void, null, extend, access, modifier, method, object, encapsulation, microsoft, sun, lucent, abstract, application, awt, api, exception, error, input, output, core, program, yucatan, burglin, mesoamerican, anahuac, fonts, belize, maya3, calendar, kerr, storniolo, precolumbian, codex, database, anthropology, programming, interface, array, index, ascii, assignment, binary, operator, bit, block, boolean, breakpoint, stack, cgi, hierarchy, variable, classpath, comment, constructor, run time, overload, control, flow, debugger, declaration, process, domain, escape, event, framework, function, garbage, collection, heap, hexadecimal, vigesimal, hyperlink, hypertext, identifier, import, inheritance, initialization, instance, integer, interpreter, virtual, machine, javac, javadoc, javah, javap, javascript, jdk, jit, keyword, label, logical, type, member, menu, signature, override, recursive, developer, multithreading, embedding, octal, ole, oop, package, pixel, polymorphism, precedence, primitive, workspace, random, reference, resource, rpc, runnable, notation, separator, source, static, string, text, throw, unicode, velikosky, url, uuid, gui, vrml, w3, wrapper.

The Symbolism of the Mayan Numbers

". . . Solamente habia immovilidad y silencio en la obscuridad, en la noche. Sólo Tzacol (el Creador), Butol (el Formador), Tepeu (el Gobernante), Gucumatz (la Serpiente Emplumada), Alom (la Madre) y Caholom (el Padre) estaban en el agua rodeados de claridad . . ." (Popol Vuh).

At early stages, the Maya perceived that the natural events recur in a cyclical manner and that are combined each other according to proportions and numerical parameters. The sequence of lunar cycles within a year, the conjunctions and eclipses, the periodicity of the solar flares and even the apparent repetition of major cataclysms registered in their history was a definitive urge to express that the Universe obeys the laws of the alpha and omega, that everything is measured and everything can be anticipated if the numbers are known for which are the cause of the manifestation. In the Kahlay of the Conquest, of Chilam Balam of Chumayel, there is a poetic fragment that I can not resist the temptation to translate because it describes eloquently that attitude toward Life although some historians have confused with the fatalist determinism of a culture situated in a prolonged descending slope. I judge it as a scientific positivism that anticipated our times recognizing the inevitable periodicity of the ecological cycles, the relativity of any temporal glory, and reflecting the anguish of knowing what the future is.

So, the fragment read like this: ". . . Every month, every year, every sun, every spirit, walk and pass when it has completed its just measure. Also, every blood and dynasty reaches the place of solitude as it takes the power and the throne. Measured was the time when the Itzáes praise the magnificence of the Three; measured was the time they could find the goodness of the Sun; measured was the time they could look over them the knitting of the stars; and from there, looking at them, the gods contemplated. The gods that were jailed in the stars. Then, everything was good and then, they were abated . . ."

A culture highly mathematical as the Maya had to incorporate teogonic concepts with the numerals, using them as symbolic elements to express their ideas about the Universe.

The hipostasis, perceptible manifestations of Hunab-Ku, the abstract deity, unknownable and without possible representation of the Mayas, are clearly expressed in the Popol Vuh under the symbolic names of Tzacol, Bitol, Alom, Cajalom, Tepeu and Gucumatz. Each one of these designations has a clear and simple ethymology that has been elucidated by several authors with congruent results.

Tzacol means "Creator", Bitol is the "Former", Alom is the cosmic female progenitor, Cajalom is the cosmic male progenitor, Tepeu means the "Governor", and Gucumatz (Kukulcan, in maya) is the "Plumed Serpent": the Quetzalcoatl of the Toltecs and Mexicas.

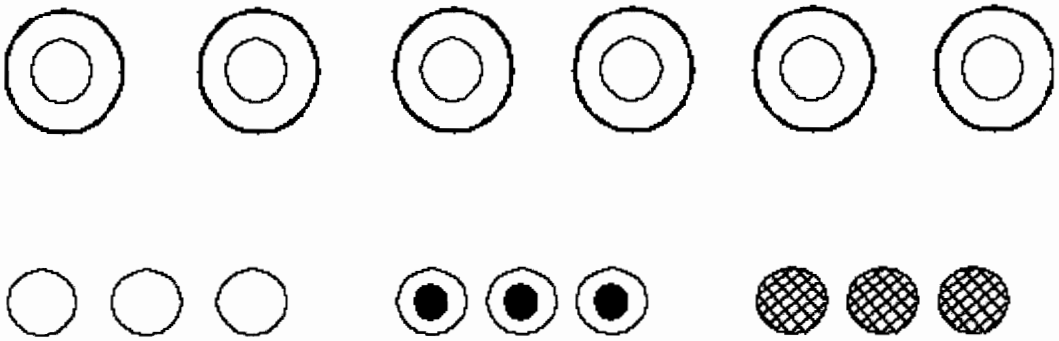
It is not required a big effort to reconstruct the essential thinking of the Mayan philosophers that reunited in these six teogonic personalities the visible and comprehensible attributes of an abstract deity revealing its presence. To return with imagination of what the Cosmos would have been, descending through the evolutive scale of beings and things, we reach a hypothetical starting point of all Creation where the postulates compel us to accept the supernatural intervention of a Creator. It is evident that the creation represents a foreign act to the natural order of the Universe because from there the Law of the Conservation of Energy is manifested invariably and nothing can be created or destroyed but only modified in appearance or manifestation. In other words, since energy acquired its expression it has remained unaltered in total magnitude: neither the transformation of matter into energy, neither the confirmed existence of anti-matter, neither the phenomena related with the possible displacement of some molecules in a fourth geometrical dimension modify or invalidate this conservative principle. However, the theoretical movement that for the first time manifested the energy of the Universe, in any of its primitive expressions, establishes the problem of the Creation. This event implies the birth of energy from nothing without antecedents of any previous form. This origin is not explained within the the natural order. It is of supernatural order and required from the Maya thinking, the intervention and willingness of an entity: God with the personality of Tzacol, the Creator.

The number ONE represents Tzacol, " . . . In the One, Chuén, says Chilam Balam of Chumayel took itself his divinity and made the sky and earth. . ." In the so called Book of the Spirits, the document states: " . . . From the abyss matter was born and the Power carved the Great Stone of Grace; there there was no sky. And seven sacred stones were born, seven warriors suspended in the spirit . . . seven chosen flames . . . and they moved! And seven were their graces also and seven were their qualities. And it happened in the immensity of the nights; there where there was no God because they have not received their own God who was within the Grace, within the darkness . . . there where there was no space or matter . . ."

This passage reflects the energetic concept of the Maya Universe, in spite of the Spanish version contaminated with other concepts covering the symbol of the "stone" (concrete nature), "grace" (substance or essence), "flames" (manifested energy) and "darkness" (space).

Tzacol is, therefore, the first hipostasis or sensible manifestation of God. He is the Huehuetéotl, the creator of Fire. A fire that Heraclitus postulated as the constitutive energy of all Universe in constant return. Tzacol is the red sun born from the darkness in the Eastern horizon during the Winter solstice. The glyph of the numeral One is a dot or point: a small circle that reminds us the shape of an spore, or an ovule and a germinated egg of the Indostan cosmogenesis. It is seen in the fretwork of the Mayan facades that are eloquent pictograms of the ideas this culture had about the Universe.

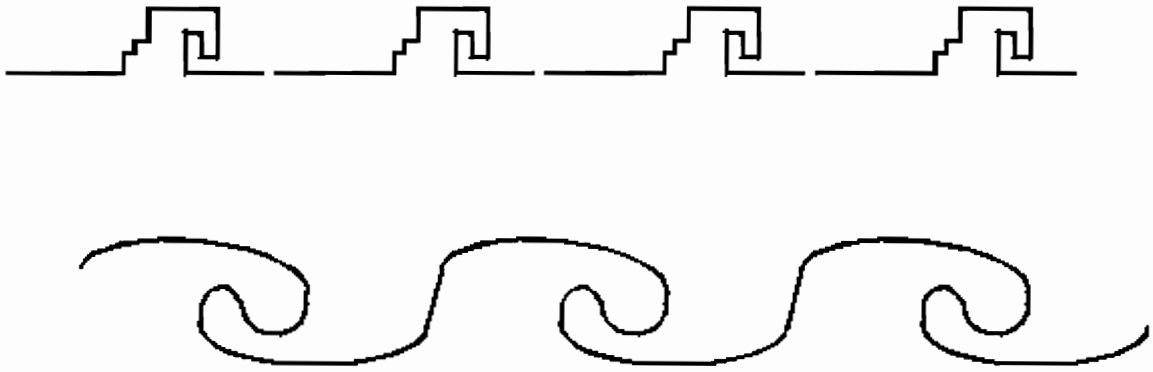
TZACOL SYMBOLISM



Put into movement the cosmic mechanism the existing matter begun its ascending evolution toward more complex forms of organization allowing to reduce the entropy and taking advantage of the obtained energy. From the infinite number of transformations that ocurred some of them persisted representing a better functional perfection. Attempting to understand this admirable concatenation of factors, the Mayas touched again the supernatural frontier and required of the intervention of an abstract God invested in a new personality. The "Former." This is Bitol, similar to a crafter, modeling the clay of the Creation in the evolutionary process toward their mysterious designs.

The warm and tranquile waters of the Precambrian sea incubated the first cultures of living cells. The first fermentations of the animated existence. In these waters, says the Popol Vuh and modern science, evolution operated toward living beings until one day these living organisms emerged from the sea and invaded the beaches and spread over the land. This wave breaking near the beach is the ideogram of Bitol, the "Former" of the Universe. Wave and backflow, evolution and involution, constitute the geometrical design of the series of fretwork extensively used in the Maya architecture.

BITOL SYMBOLISM

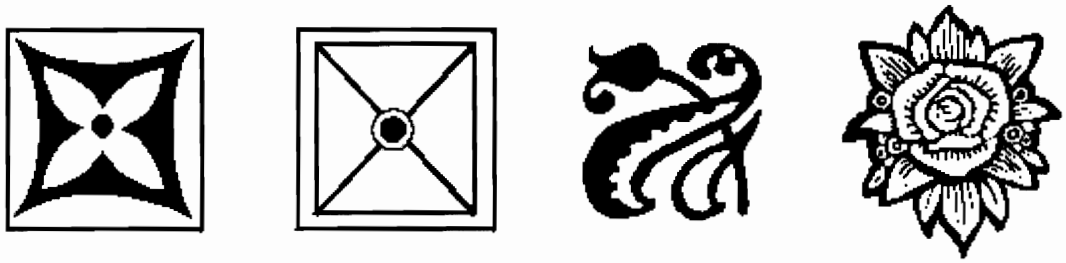


The polarity is the motor principle of the Cosmos. From the atraction and repulsion that establishes the movement of the atoms and molecules. The equilibrium of the bodies at rest, of the bodies in movement, of the activities of beings, polarity rules all of them. By virtue of this principle, a portion of the Universe participates of a polarity that can be qualified as "femenine", "negative" or "passive" (please ignore the political correctness) and the other half as "masculine", "positive" or "active." To use these tems "negative" or "positive" I am not implying a relative importance of one over the other. They are qualities of identical magnitude, complimentary and essential in the cosmic scheme. Can we conceive the existence of an atom without electrons? Of an electric current without positive and

negative poles? Of a generation without polarity in the sexual creation? It is necessary that the capacity of giving exist to have the capacity of receiving, it is precise to have the container to hold the content.

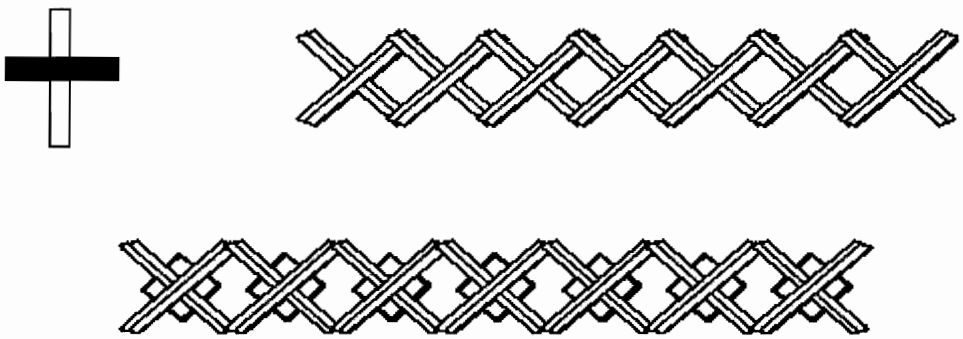
Alom and Cajalom, " . . . the mother and father of Life, of everything created, the ones that give the breath and the thinking, the ones that give the children. . ." These are the words of the Popol Vuh. In Alom it is represented the essence of all that is conceived, all that has the capacity to give and to receive. She is the electron, the Mother Earth, the Moon. She is the conscience and the flower. Beautiful is the symbol chosen by the Mayas: the flower. Like her, the flower is the femenine condiment by excellence. Alom is Mother Earth. She receives the golden seed of corn, able to germinate and nourish the womb like mother to child. Alom is the conscience, the lotus receiving the vibrations of the surrounded Universe and translated concrete images. She receives the inspiration to produce the ideas. The flower appears in the Mayan fretwork with an intimate and simple design different from other geometrical forms to give the master touch of beauty and humanization of the scientific coolness of the abstract designs. The numeral FOUR and the SQUARE are symbolically equivalent.

ALOM SYMBOLISM



Cajalom, on the other hand, is the father of Life and his functions as progenitor are evidently set when the sun is placed in the zenith. It is from that position energy is sent with more power. From there, at the intersection of the six cosmic roads (the points of orientation of the Sun), in the center of the in the heart of the sky, the Maya ideogram of Cajalom is designed: The Maya Cross. The symbol of Cajalom is the cosmic cross formed by the vertical coming from the zenith to the center of Earth and the horizontal that is the way of the Sun (from East to West). In the center of the cross is the Sun. The numeral symbol is FIVE, but as we see later it is transformed into SEVEN by the adition of the sun at the center, also of the cross of the six arms formed by the horizontal plane. Girard (1) has explained this on the numeral SEVEN called the God 7 or "the maintenance God."

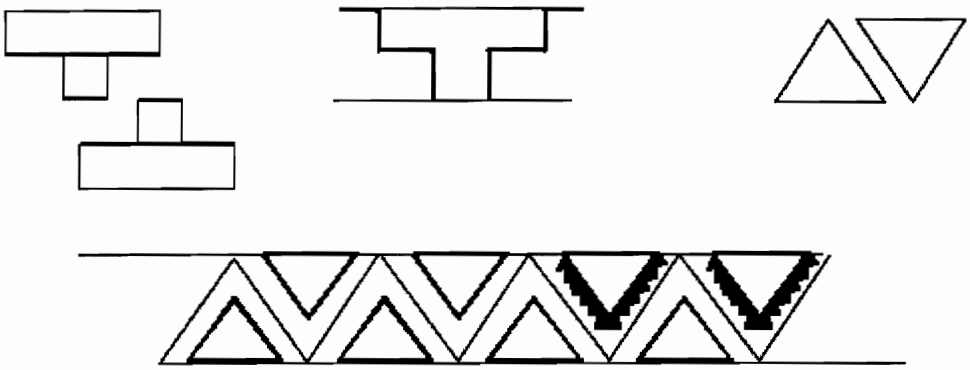
CAJALOM SYMBOLOGY



Tepeu is the Governor. He is a God with an ordering personality extending to the most remote corner

of the Universe the invariable law of causality, of the proportion and similarity. His ideogram is IK that appears in the Mayan fretwork in two positions: upward and downward. It exemplifies the hermetic concept "as above, so below, what has been, will be again." Its numeral is SIX and it is related with the causal trinity: thesis, antithesis and synthesis, acting upward and downward.

TEPEU SYMBOLISM



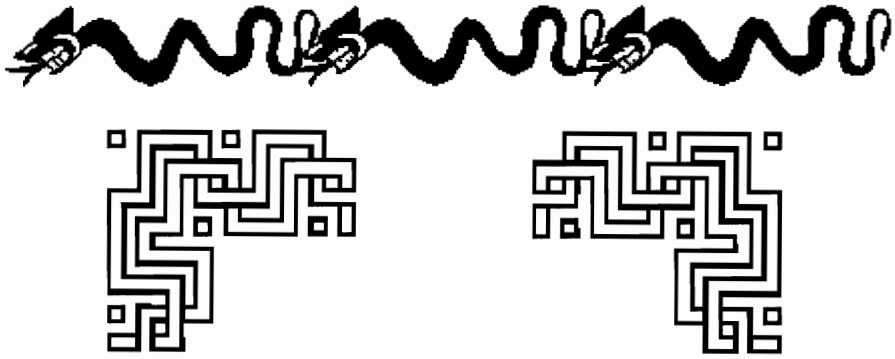
Gucumatz, that is Kukulcán-Quetzalcoatl, is the Plumed Serpent. Omnipresent theme in the Toltecs, Zapotecs and Mayan representations. It hides a teaching and symbolism of great depth.

The senses of man are limited in number as well as in sensibility. From there, all things that are presented have a dual aspect. One part of nature is available to our senses and another escape to us. The first is concrete and the second is abstract. In representing this fact the Maya symbolism makes a tool of its imaginative resources.

If we try to find in the physical world a synonim or parallel to describe a set of intangible things, it is difficult to find a better example than the air surrounding us. This untouchable environment is practically unreachable to our senses but we know it exists because its presence is manifested in the movement of the leaves of trees, the dust and other light bodies. The symbol of air, and in consequence the symbol of the abstract or spiritual (that is conventionally assigned) is the bird because air is its natural media. The element where the bird lives and interacts.

On the other hand, the material, the tangible and earthly is represented with the serpent. The simbolic representation is evident if we recall that everything that is perceived by our senses comes from Earth. It the serpent the animal that lives and drag over the ground. The plastic beauty of the serpent exemplifies the Mayan concept of the cyclical recurrence of phenomena, the poison that represents the danger in the appearance of all material forms. Its total symbolism has reserved a sacred place in the Egyptian, Hebrew, Caldean, Babylonic, Hindu cultures.

GUCUMATZ-KUKULCAN-QUETZALCOATL SYMBOLISM



Here you have the Maya genius and simple naturality of the fusion of two symbols: the bird and the serpent expressing the duality of the Universe. By logic, the mathematical symbol is TWO. Matter and spirit forming a unique being undivided in the tangible and untangible Universe, indivisible and ruled by the same laws.

Now, what does it remain for the Mayas could define the concept of God? As we have seen, it resulted in six the perceptible manifestations of nature by which they inferred the existence of an abstract God and in consequence, the number 6 could represent God in a suggestive manner. But if the Mayas could have assigned it, they would pretend that this infinite God was not such thing because our human mind is able to contain the totality of these qualities.

It is now when the Mayan genius discovers the adequate symbolism: the perfect simile because in spite of the six representations, the set is not any more 6 but 7. It has been added something else that remains unnamed and contains all the rest that escape our understanding and experience. It constitutes the synergic principle that functions harmonically in all the manifestations as a group. The definition of God, consequently and similar to the Pitagoreans, rest incomplete and it is one of the most perfect formulas the human mind can formulate.

Besides the admiration that awaken us from the deep teogonic Maya thinking, we noticed we are touching the frontiers of the mathematical knowledge that the Mayas had reached in relation to the organizing principle of the Universe. Already, some investigators, among them Rafael Girard, have presented the way some numerals are transformed symbolically in others, the binomial mother-father is transformed in the numeral 3 when the child is added and linking them genetically as a functional triad: origin of the family, the tribe and of the nation. This principle is extended to other numerical representations: the four solstitial points of the horizon only can have life when the sun is placed on them, and thus, the numeral 4 is converted into 5. The four solstitial points and the two corresponding to the East and West only have meaning when the seventh element is associated, again the sun in its zenith position converting the number 6 in 7. As we see later this elemental Synergic Arithmetic (from the Greek, work in conjunction) is one of the most important contributions of the Maya thinking that we may as well understand and apply to our lives.

Continuing with the symbolism of the numerals, we can point the ambivalent character of the numbers 3 and 9, explained also by Girard. The numeral 9 links the law of cause and effect with gestation. It is the proper numeral of the Moon and her eight nightly companions (the planets?), therefore, it has a clear association with the night, the underworld, the occult and the nine lunar months of the human gestation. The numeral 9 is formed by multiplying 3 x 3 but also adding 4 + 5, 7 + 2, and 8

+ 1. Each one of these symbolic operations represent something distinct. 4 + 5 is conception, 7 + 2 is incarnation, 8 + 1 is birth, and 3 x 3 is proliferation, succesive stages of procreation. The relations are extended to the nocturnal, the occult, the rituals toward the mystic birth (e.g. the Order of Balam and its nine grades). It is not my intention to enter into this fascinant theme but only to illustrate the way the Mayas utilized the numerals as symbols.

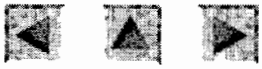
The numeral 13 is another example of which my mentor have baptized as Synergic Arithmetic. There are reasons to think that the Oxlahuntikú (13 stellar gods) were constituted by the twelve constellations of the Maya zodiac and the sun passes them in its ecliptical travel creating a functional set where the sun and the stars assume an astrological personality. This concept is illustrated in the Chilam Balam of Chumayel in two figures. The first represents the sun in its ortho zenith accompanied in each side by twelve stars while the second figure shows the twelve kings or masters of the sky and it is completed by the sun in its zenith position. From there, the number 12 is transformed in 13 by the addition of the ruling element and coordinator of the set as an organic unity necessary for the recognition of the event.

Finally, the number 20 represented the totality for the Maya: the complete and integrated. Its representation creates a new element because in the vigesimal system is expressed as a dot in the second position and zero in the first position.

Within the unit of superior range the numerical and symbolic elements are contained in the contribution for the addition operation. In there, all of them exist and each one previously explained are fused in a dot that is at the same time a small circle: an infinitesimal microcosmos withint the unlimited. Below the dot or point, is the zero. This symbolic element represents the existence when everything is completed. It indicates that perfection is reached when all the numerals concurs harmonically and are added to complete twenty. When this happens, it transcends to another functional hierarchy, leaving the shell back and the memories. Zero is therefore not a negation but the categorical affirmation of fulfillness. It is not death but total realization.

Until now, the reader has participated in the Maya thinking with its positive philosophy and creation. I hope I have lit the internal spark of the spectacular greatness of the Maya symbolism which is only a pale reflection of the most acute observers of nature and thinkers of incredible depth of the Mesoamerican era.

From the discussion of these principles I have also initiated concepts of my work in Synergic Arithmetic. In further sections of this Web site I will continue elaborating on graphical aspects that I call Neurographics: numerical graphics created by neurological inputs. Thanks to the Maya thinking, the reader will see complex equations representing matrices, tensors, etc. where the Maya fretwork takes place again in a time of chaos. It is my hope that these new concepts bring an ordered style to the Mathematics of our times and also serve as arquitectonic designs as the Mayans did.



References

1. Girard, Rafael. Los Mayas. Libromex Editores. Mexico. 1966.

Units of Measure

". . . Y empezó a venir Ah Ppisté, el Agrimensor, y entonces llegó Chacté Abán a preparar las parcelas de tierra para ser cultivadas. Y vino Uac Habnal a marcar los linderos con señales de hierbas, en tanto que Miscit Ahau limpiaba las tierras deslindadas. Todo esto mientras Ah Ppisul trazaba sus amplias medidas . . ." (Chilam Balam de Chumayel).

Until now, it is ignored which system of weights and measures the Mayas used. To clear this issue, this section has compiled an statistic of the measures of length obtained from several investigators in the archaeological zones of southeast of Mexico, as well as Guatemala and Honduras. The main sources include Morley (1), Rupert and Denison (2), Ricketson (3), Ruppert (4), Thomson and Proskouriakoff (5), Pollock (6), Ruz Lhuillier (7) and many others. The procedure used in this section consisted of creating a list of the dimensions of structures, architectonic elements and stelas, as it has been reported by numerous archaeologists who have measured them. This list required a careful selection. For instance, in several occasions it happens that stelas are fragmented and the informant reported as its height the piece he discovered. In other circumstances, the measured height is understood as the part of the stela serving as the foundation, and with a high chance of probability, it did not enter in the proportions that the artist designed. Another observation is that the thickness of the stela can not help us to describe the scale used by the Mayas to measure lengths for the simple explanation that that thickness was usually the one acquired from the original stone. I can not imagine that the Maya artist engaged in the reduction of the natural thickness of the stone with the purpose of matching a round number of units. Therefore, if we wish to discover a unit of length that could relate statistically with the Maya linear units we need to look for in the width of the stone. The width has more probabilities of having being chosen by the artist.

From the description of the measures of the buildings we need to carefully select our data. Frequently, the reports informed us of widths that had a consolidation and do not have the original dimensions. The sinking of buildings are translated in collapses and unevenness that also do not reveal the Mayan scales of lengths. Besides, there is an unfortunate trend of archaeologists to report approximate measures. Few of them carry out their calculations to the centimeter and none reported to the milimeter. Thus, a length of 1.092 cm it is reported as 1.10 cm and another of 68.5 cm as 70 cm. Example of these innacuracies are in the reports of Smith and Kidder on Nebaj and in the Mexican Instituto Nacional de Antropologia e Historia in which the dimension are asigned in multiples of 5. Obviously, this data can not be taken into

consideration for the statistics.

It was compiled a total of 1.128 measures of monuments of the Old Empire, covering the most important sites : Uaxactun, Tikal, Bonampak, Piedras Negras, Yaaxchilán, Quiriguá, Copán, Lubaantin, Xultun, Balakbal, Uolantun, Chichantun, Yaxha, Laguna Perdida, Itzimte, Polol, Motul de San José, Tayasal, Ixlu, Naachtun y Palenque. All data was processed independently and convergent tendencies were reunited in one statistical group to attempt to find out a periodicity in the design or otherwise an arbitrary proportion or different systems in the Maya provinces. The result of the statistical analysis was definite and revealing. (Figure 1 in construction.)

It was discovered, using minimization of differences between the statistical crests and several modules, that exist a periodicity with an interval of 4.56 cm and its multiples. Also, there is no existing variation in the area covered by the Old Empire. In fact, from Quiriguá to Palenque, and from the most ancient structures corresponding to the beginning of Baktun 8 (41 D.C.) to the last ones of the end of the Great Classic Period (950 D.C.), the module remains invariable.

From these results, it emerges the curiosity to investigate if the new unit of measures of lengths was continued in the New Empire. Fortunately, we have the magnificent work of Ruppert about Chichén Itzá from which 973 useful dimensions used to create an identical statistic of the one compiled for the Old Empire. I consider, of great transcendence, to have obtained a module of 4.55 cm that for practical means can be considered identical to the Old Empire. The revealed uniformity is an eloquent example of the great Unity and cultural continuity that the Maya civilization had through several millenniums. (Figure 2 in construction.)

Landa (pp. 111) tells us that the Mayas used to ". . . crop with a measure of 400 feet named *hun uinic* measured with a stick of 20 feet, 20 in width and 20 in length." The Diccionario de Motul (pp.905) confirms that the "uinic" was ". . . a measure of soil to till or cultivation of 20 Kanes. . .," and in another page (pp. 494) the Kaan is defined as ". . . a measure of a rope that the natives use to measure their "milpas" called "mecate" among the Spaniards... they have a measure of three sticks or ropes of three "brazas" each rope that make 36 (4 x 9) "brazas." Don Juan Martínez Hernández who edited the Diccionario de Motul explains ". . . kaan: mecate (from the nahuatl mecatl): measure of 24 varas of Burgos of 838 milimeters; each "mecate" is subdivided in 12 "brazas" of 2 varas of Burgos, that is, 20.112 linear meters.

Now, "braza" was the designation that the Spaniards gave to the unit of length that the Mayas coincided approximately with the European unit. This measure was the "zap" but consulting to the Diccionario de Motul, Pio Perez, Otero and Beltran de Santa Rosa, I don't see anything different except the "zap" is a "braza" equivalent to 2 varas.

Two hypothesis can be formulated. Based in the vigesimal character of the Maya arithmetic and in the high incidence of measures of 91 cm in the monuments of the Old Empire as well as the 45.4 cm in Chichén Itzá a conclusion is that the Maya meter had exactly 91.2 cm and divided in 20 parts. In this case, the zap had 1.82 m and a kaan would be equivalent to 12 zaps or 24 Mayan meters. The total length of the archaic kaan would be 21.84 m which is equivalent to one "braza."

The other theory would consist of assuming that the Kaan originally had only 20 Mayan meters and its length is equivalent to 18.20 m modified after the Spaniards introduced the unit "vara" in Yucatán. If we reread the citation taken from the Diccionario of Motul we noticed there are two measures and both designated with the name Kaan. One has 9 varas, that is 15.084 m while the other contains 24 varas reaching a length of 20.112 m. The hypothesis that the kaan has 18.20 m would place this fact in an

intermediate position of both versions.

To clear this point, a second statistic is made but this time we select only the distances of one kaan of order of magnitude or greater under the assumption that the Maya planner worked with kaanes instead of minor units in the design of terraces, courtyards, and sidewalks. The research concluded that the kaan has 24 Maya meters of 91 cm each one and with the introduction of the Spanish "vara", this unit was shortened to 1.73 m.

Morley says ". . . in reality, these ropes of measure are, in the north of Yucatán, of 21.50 m of length." The Mayans say these ropes are somewhat longer because "of the length taken by the birds." Ignoring this fine Yucatanian irony I conclude that the true reason lies on the fact that the "mecate" of 21.50 m is closer in length to the ancient Maya kaan. Moreover, I dare to say that the length of the "mecates" in the north of Yucatán, cited by Morley, is not precisely 21.50 m because it is illogical to think that if the "mecate" was redefined in the Colonial era as 24 varas, the Yucatanians of that time would have anticipated the invention of the meter and had added exactly one meter and a half to the rope. It is more reasonable to think that they added a vara (1.67 m) and in this case, the "mecate" has a length of 21.78 m differing by 6 cm only from the old kaan of 21.84 whose existence is postulated.

None of these explanations make us assume that the Mayas knew the mile or Spanish "legua." Instead, about the "sacbé" (white road) from Cobá to Yaxuná - that, incidentally measures half kaan of width - Alfonso Villa confirmed the presence of monuments placed approximately within an 8 kilometers of distance between each other. I suggest this is a good opportunity to verify or modify the two hypotheses presented in this section. If the Mayas extended the vigesimal system to large measures of length it is probably that the units of major length than the kaan are the "kaalkan" (20 x 21.84 = 436.8 m.) and the "bakaan" (400 x 21.84 = 8.736 m.) In this case, the trails of the road Cobá to Yaxuná correspond to bakaanes.

I return now to the Maya vara of 91 cm, base of the investigation. Beltrán y Pío Pérez concide in the measure of the vara called BETAN in Maya. This name is highly significative because it is composed of two roots BE (road) and TAN (a mean to produce something.) In consequence, the word BETAN expresses the functional relation existing between the unit of measure and the road construction. In the names KAAN and BETAN are hidden a fascinant semantic concept: while the kaan, agricultural measure by excellence, is associated with KAN (mature, crop, corn, gold, etc.), BETAN establishes a conexion with engineering and communications where the primary measure (the step) is a unit of length and at the same time the act itself of transfer and communication. Same as the "milla" originated from the distance of 1,000 steps of five Romans feet and the vara of Burgos of 83.8 cm as the average length of the step, it is probably that the Maya betan recognizes the same genesis.

In a descending order of magnitude, half of a betán is 45.5 cm of length. Our statistical data allow to know that in the constructions of the Old Empire the dimensions are in the order of a betán predominantly and in the New Empire dominates the half betán. This fact is explained logically that the Old Empire' s geographical domains are near the mountains where is easier to obtain stones of larger sizes. Probably, the half betán mentioned in the Diccionario de Motul is the kaan composed of 36 "brazas" of box. The word "box" is a label that the Mayas gave to the black people of Campeche, imported by the Spaniards, and is the despective name that the white Europeans gave to the brown Yucatanians. In consequence, the "braza" of box may be a designation given by the Spaniards to the original measure corresponding to half betán.

The module of 4.55 cm identified previously is exactly the 20th part of a betán. We don't know the assigned names to the vigesimal fractions judging from the microdimensions recognized in the codexes and ornaments so I baptize them with the name of AZAB (middle) equivalent to 4.55 cm and CHAN

(small) to the 2.275 cm subunit, hoping one day we discover the real names.

As a summary, I offer the following hypothetical metric scale.

MAYA METRIC SCALE		
1 bakaan	20 kalkaanes	8.738 m
1 kalkaan	20 kaanes	436.8 m
1 kaan	24 betanes	21.84 m
1 betán	20 azabes	91 cm
1 azab	20 chanes	4.55 cm
1 chan	2.275 cm	

The braza, codo, cuarta and geme are Spaniard units that seem to have no relation with the Maya equivalents.

Now, our curiosity takes us up to the geographical extension that the betán could have had. Of course, I believe to have demonstrated the uniform application in the Mayan zone of this unit. But, was it known outside the geographical and cultural contour? Was it extended to the Altiplano? Did it reach South America? These are questions of great transcedence and I put ahead some data for others with the means to investigate them.

From the work of Javier Romero (8) on the burials of the pyramid of Cholula we extract 11 measures from a total of 19 samples that are exact multiples of 4.55 cm. Pollock cites Cummings who inform that the pyramid of Cuicuilco measures at the base 387 feet (118 m) that is exactly 130 betanes. The top platform has a diameter of 291 feet (88.7 m) that is 97.5 betanes. The height is 74 feet (22.56 m) that concides with 25 betanes and the ramp has a width of 70 feet (21.34 m) that is 23.5 betanes, which is almost a kaan.

From Xochicalco we have compiled 86 measures from a total of 94 samples that are exact multiples of 4.55 cm. The pyramid of Tajín measures at the base 36.63 m, that is, 40 betanes. The prints of the seven main steps are 2.74 m that correspond to 3 betanes. Finally, the height is 22.80 m or 25 betanes.

In Quemada, Zacatecas, where Mohedano confirmed Mayan features and a narrow parallelism with Xochicalco, 22 measures were obtained matching the Mayan scale. It seems there are many coincidences that I do not want to make premature conclusions until more data is available to clear this issue.

In regard to a geometric vocabulary, the Mayan language has precise names and different for height (CAANALIL), width (COCH), thickness (PIM, only for tabular forms), thickness (POLOC, for columnar bodies), thickness (NUCUCH, for three dimensions), length (CHAUAC), depth (TAM), inclined (CHINAN), flat (CHUEN), curved (PEPET), concave (LOP), convex (BOZAN), vertical (UAOM), horizontal (TAX), etc. which confirm the wide knowledge of geometry applied to buildings.

The unit of volume, for architectonic purposes, must have been the cubic betán, but we know of an agricultural measure, the MUCUB, containing half load of corn. The agricultural unit, as I explained previously, is the "uinic" that consisted of 400 squared kaanes, that is, 0.954 hectareas.

For weighing, it was used the CUCH or "load" that must have contained 43.4 kg. The scale was known to the Mayas using stones as units of weights.

In regard to time, we know of two equivalents of the hour. The LUB that means "day's work" and KIN TZIL, that literally is translated as "sun breaks." It is probably that the day was divided in 24 hours. Besides the obvious relations with the 12 constellations of the Mayan Zodiac of 12 signs the number 24 has desirable characteristics for the use of the Mayan people. It is easy to appreciate that 24 can be divided by half, by thirds, by fourths, by sixths, by eighths, by twelveths and by twenty-fourths parts given entire numbers.

Few scholars have investigated about the way the Mayas measured the hours of the day, in spite of being sure they used solar clocks. The important units of time in one day (KIN) are well-known. In ascending order, they are:

Mayan Units of Time	
KIN	One day
UINAL	20 kines
TZOLKIN	13 uinales = 260 kines
HAAB	18 uinales + 5 kines = 365 kines
TUN	18 uinales = 360 kines
KATUN	20 tunes (some authors comment the katunes are 24 in the New Empire.)
BAKTUN	20 katunes
GREAT CYCLE	13 baktunes

It is inferred that other larger cycles are the PIKTUN, KINCHILTUN and ALAUTUN, elevating the number of cycles to 3,200,000 years each one. However, I have found a base to sustain that the cycle of 13 baktunes, made evident in inscriptions, and when added is equal to 5,200 years as the main cycle. Five of these cycles complete 26,000 years that the terrestrial axis needs to describe a precesional circle that makes the astronomical North shifts in the sky. If the Mayas observed this precesion and calculated the period it is probably they chose it as the Great Cycle. On the other hand, there is evidence that two catastrophes occurred separately within a period of 13 baktunes.

To finalize this section, I must comment that the concept of time the Mayas had was distinct from ours. These ideas will be included in the section 9, the Mathematical Concept of the Mayan Universe.

References

1. Morley, S.G. The Inscriptions of Peten. Carnegie Institution. Publ. No. 437. Washington, D.C. 1938.

2. Ruppert, K. and Denison, J.H. Archaeological Reconnaisance in Campeche, Quintana Roo & Peten. Carnegie Institution. Publ. No. 543. Washington, D. C. 1943.

3. Ricketson, E.B. Uaxactun, Guatemala. Carnegie Institution. Publ. No. 477. Washington, D.C. 1937.

4. Ruppert, K. Chichen Itza. Carnegie Institution. Publ. No. 595. Washington, D.C. 1952.

5. Ruppert, K., Thompson, E., and Proskouriakoff, T. Bonampak Chiapas, Mexico. Carnegie Institution. Publ. No. 602. Washington, D.C. 1955.

6. Pollock, H.E.D. Round Structures of Aboriginal Middle America. Carnegie Institution. Publ. No. 471. Washington, D.C. 1936.

7. Ruz Lhuiller. Exploraciones Arqueologicas en Palenque. Anales del Instituto Nacional de Antropologia e Historia. S.E.P. Tomo X, No. 39. pp. 69-299. Mexico. 1958.

8. Romero, Javier. Estudio de los Entierros de la Pirámide de Cholula. Anales del Museo Nacional de Arqueología, Historia y Etnografía. Tomo II. Mexico. 1935.