

COSMOGONY AND DIRECT USES OF GEOTHERMAL ENERGY IN MESOAMERICA

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ABSTRACT

An imposing series of recent volcanic apparatus, the Volcanic Mexican Axis, formed the region's hearth where the Mesoamerican cultures developed. During thousands of years, this area was a place particularly rich in active geothermal manifestations. Intense contacts between man and geothermics influenced deeply the material development and cosmogony of the mesoamericans. Geothermal energy played an important role on basic human activities such as occupancy of the territory. The volcanic explosions expelled the populations and afterwards they returned, due to the renewal of volcanic ground fertility, lake formation and natural hearth presence. Vapour baths, cooking by steam at fumaroles or on naturally hot rocks, irrigation of gardens and therapeutic applications, were some original utilizations of the natural Earth's heat in Mesoamerica. The mythical religious interpretations of geothermal phenomena occurred very early, reflecting a profound respect toward terrestrial heat. Man's relationship with geothermal energy had a dual ethical interpretation: beneficial / harmful, constructive / destructive. This undemanding influenced deeply the mesoamerican cosmic view.

INTRODUCTION

When opening any book on the history of science, one rarely finds any chapter or paragraph dealing with science in pre-Hispanic America. However, the mesoamerican cultures created in an independent and absolutely original way: art, hydraulics, architecture and mathematics. They developed autonomously the concept of zero, an advanced numeric system and they knew how to carry out astronomical calculations with astonishing precision. Today we know that wisdom and scientific knowledge were a daily reality in Mesoamerica. Less known is the general conception they possessed about the world. The context wherein their beliefs and knowledge originated came from their peculiar idea about the Cosmos. Cosmogony is the science of the creation and evolution of the Universe. Their Cosmogony arose, at least partially, from intense experiences with geothermal phenomena. To comprehend this vision one must look into the natural environment, religion and Mesoamerican mysticism.

The cultural area that today we call Mesoamerica extended from the state of Sinaloa, in northern Mexico, and included the entire region extending to a portion of modern-day Nicaragua (Fig. 1). At times the southernmost border expanded to the isthmus of Panama. In the north, it was desert, an impossible place for sedentary life. Thus America developed, separated from Europe by the Atlantic and from Asia by the Pacific; it remained isolated for thousands of years from the discoveries and cultural mixtures of the Old World. Because of that isolation, the civilization that was created here held unique attributes. Mesoamerica was a region of the world predominantly volcanic; it included earthquakes, thermal waters, fumaroles, boiling muds, steaming grounds, eruptions. The superficial geothermal manifestations and the energy of the earth were daily phenomena for the remote Americans. Since prehistoric times, covering millenniums, its inhabitants kept extremely close contact with the energy of the earth. Because of it, geothermics in the widest sense of the word deeply influenced the material, spiritual and cosmogonic developments of the Mesoamerican people.

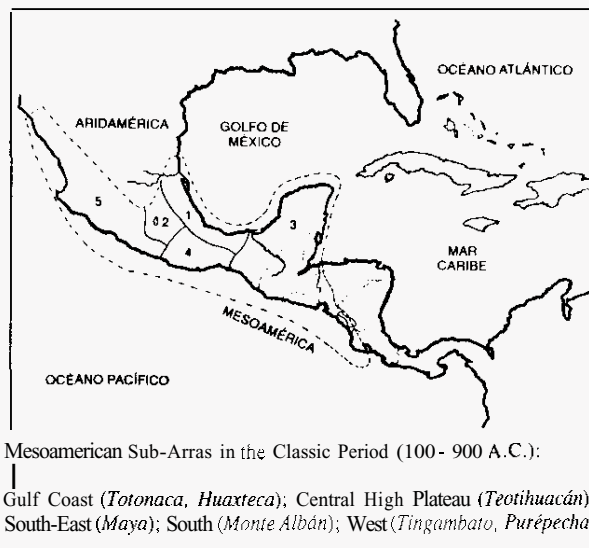


Fig. 1.- Limits of Mesoamerica in the XVI Century [González, 1991].

This work is a preliminary outline, not an exhaustive treatment of the subject. Our survey has a double objective: i) To explore the influence exercised by geothermal energy on the material and spiritual development of Mesoamerica and on the relationship between man and territory and, ii) to emphasize the historic antiquity of the cognitive process of geothermal phenomena. The history of geothermics in America still needs to be written; this brief document sketches that possibility for the first time. The proposal of this theme is left open for new studies, in hopes of a better understanding of the ancient history of Mesoamerica.

BRIEF SURVEY OF PREHISTORY IN AMERICA

Man's origin in America doesn't introduce, apparently, any epistemological problem. On this continent, nobody has ever found human remains from predecessors of the 'Homo Sapiens' as in Africa, Asia and Europe. Today it is accepted that the proto-Americans came from Asia, some 50,000 years ago and that they passed through the Bering Straits in the northwest. The first immigrations could be the so-called 'Amurians' [Ruiz, 1987], or inhabitants of the shore at the river Amur in Siberia. Sodi [1992] thinks that they also could have come from southern zones of Central Russia. The indigenous *Cahuilla* from California, the *Sioux*, the *Redskin*, the *Tolteca* and the *Teotihuacano*, have the facial features of the 'Amurians'. That first passage could have been carried out during the Wisconsin glaciation that lasted from 70 thousand until 30 thousand years B.C. This agrees with the oldest ages of human fossils in America [Carmona, 1993]. The Mongoloid immigration, with the probable 'Olmecas' and 'Mayan' ancestors, should have occurred subsequent to the second glacial period, around the year 12,500 B.C., at the end of the Woodfordense interglacial period.

The first contacts of the proto-American 'Homo Sapiens' with geothermics probably happened soon thereafter when the nomads were passing through the northern portion of the Ring of Fire between the North American and Pacific plates, in southwestern Alaska. Then, when the new populations, advancing progressively toward the south, reached the northerly sector of the Cascade Range, they met numerous active volcanoes and other geothermal manifestations. Subsequently in their slow expansion, they should have met the imposing manifestations of Yellowstone Park and The Geysers Geothermal Field. After somehow crossing the enormous deserts in Arizona, New Mexico and Texas, some ancestral nomads were able to arrive to the great morphotectonic depression between the Imperial and Mexicali valleys, at the present-day Mexico-USA border. Now, the familiarity with geothermics should have been very high.

Those archaic groups should have spread slowly towards the centre and south of Mexico, in search of better soils and climates. Yarzúa de la Torre [Burgassi et al., 1992], points out that the volcanic activity in Mexico's present territory was general in the Tertiary Era. It decreased first in the Western Sierra Madre and lasted longer in the zone situated between 18° and 22° latitude. At the south-central sector of Mexico, the Volcanic Mexican Axis is characterized by an imposing series of three thousand volcanic apparatus, from which ten are still in activity. The sector is particularly rich in geothermal manifestations, active and fossil; thermal springs, fumaroles, gas exhalations, mud lakes and volcanoes, hydrothermal deposits such as kaolin, sulphur, iron oxide, etc. It is at an altitude of 1500 to 3000 meters, in temperate lands. It formed some ten thousand years ago [Ruir, 1987], a privileged region to be occupied by man. With the passing of centuries different human groups evolved in that area attaining high cultural levels. In this sector, the heart of Mesoamerica, a profound relationship was articulated between man and geothermal phenomena.

GENERAL CHARACTERISTICS OF MESOAMERICA

Extraordinary civilizations have often emerged at the shores of big rivers: the Nile, Euphrates, Tigris, Danube, Tiber, Seine, etc. In America that didn't happen either at the Amazon River or at the Mississippi River. In Mexico some twelve thousand archaeological sites have been detected (Bernal, 1979), the majority near to volcanic areas. Why were the Mesoamerican cultures born in those places and not in others? Why in America did some people develop a lot and others little? Archaeological statistics suggest that geothermics exercised some singular attraction on the human settlements in this region of the world.

Historically Mesoamerica is divided into four parts [Sodi, 1992]:

- Prehistoric horizon, from 10,000 years B.C., to 2000 years B.C.
- Formative period or Preclassic, from 2000 B.C. to 100 B.C.
- Classic Period, from the year 100 to the 900 of our era.
- Postclassic or Historic Period from the year 900 to 1521.

The Mesoamerican people became sedentary upon cultivating corn. They were not navigators. They knew the wheel but, because of the irregular topography of their territory, they didn't need to develop the cart, or the use of animal labor. Perhaps their technology was similar to the Bronze Age in Europe. They were outstanding artists in almost every area: painting, sculpture, gold and copper work, architecture, poetry, feather embroidering and the manufacture of codices. They possessed great scientific achievements in astronomy, mathematics, medicine, hydraulic engineering. Their architecture, in intimate communion with Nature, was deeply religious and mythical. The new specialty of archaeo-astronomy shows one singular feature of their architectural conception. When studying the heavens, the Mesoamerican sages used to record not only the observation itself, but also time and space were coordinated into landscape by means of the orientation of buildings and ceremonial Sites [Broda, 1990]. This means that there was a sense of cosmic orientation in the construction of cities, which were planned to include a system of codes immersed in the scenery [ibid].

There were many different cultures that, in different times, developed in Mesoamerica. However, simplifying, one could speak of a Mesoamerican Civilization because there was a certain uniformity, a shared cultural inheritance. All the Mesoamerican people had a common mental horizon: religious beliefs, theocratic-military organization and a general concept of the Cosmos. The Mesoamerican people revered the same gods, although with distinct names. Their cult objects had something very peculiar: they represented only things captured by the senses: the volcano, the sun, the moon, the wind, fire, water, corn, death, etc. At different times, Mesoamerica knew peak periods and decadence, ascent and destruction without ever breaking the global continuity of that civilization. A universe deeply religious, recurrent, circular, where all returns to its origin and everything begins again. According to Octavio Paz [1992], this walk in circles is due to the fact that the Mesoamerican cultures didn't receive influence from the exterior.

THE FIRST USES OF TERRESTRIAL HEAT

From his remotest and darkest past, prehistoric man used volcanic rock, silex, obsidian, flint and basalt to manufacture weapons and tools. Tales and legends exist, coming from pre-Hispanic sources, which tell of the use of waters and thermal muds in the hygiene of the body, in the curing of wounds and in tempering arrows and lances used for hunting and for war [Suárez & Cataldi, 1993]. Some 3000 to 3500 years ago, with the beginning of stable settlements that began to devote themselves to the cultivation of soil, the first experiences of the utilization of natural heat arose. The placing of food among very hot stones to toast or to steam began at this time. Such items as ears of corn, potatoes, and the meat of certain animals were cooked in this fashion.

In the following epoch, starting from probably the 'Late Formative Period' from 800 to 100 B.C., with the development and diffusion of pottery, cooking or heating with pots in steam first started. The pots were placed upon the boiling water or on the spouts of vapor of certain manifestations. In the second case, they cooked the food by indirect contact with the heat of the earth, as the natives still do today in the geothermal zone of Ixtlán de los Hornos in Mexico.

EVIDENCE OF HUMAN SETTLEMENTS IN THE VICINITY OF MESOAMERICAN VOLCANOES

It is probable that the relationship between man and geothermics was establishing itself in America in an autonomous but slower way in relation to other zones of the European-Asiatic and African continents [Cataldi et al., 1992a & 1992b]. The presence, 3000 years ago, of resident communities in many zones with geothermal manifestations and at the feet of all the volcanic apparatus of Mesoamerica, is verified by investigations and archaeological discoveries. The presence of such settlements would be enough to infer that from very remote times man established a relationship of conviviality with the volcanoes, the surficial manifestations and, generally, with the phenomena that characterized the energy of the Earth.

Payson, at the volcano Arenal, and Hurtado de Mendoza-Alvarado Induni at Miravalles, both in Costa Rica [Burgassi et al., 1992], showed in their investigations that the economical, social, agricultural and craftsmanship development in the original population sites were influenced by volcanic eruptions. Important volcanic events determined processes of an 'expulsive' kind on the populations and inverse processes of an 'attractive' type, some years after the occurrence of the events. The last type would be due to the periodic renewal of the fertility of the volcanic soil, the existence of water and good climatic conditions.

Therefore, the volcanic activity should have determined alternate emigration-immigration fluctuations over the old population in the zone. Ceramic residues discovered at the volcano Miravalles indicate the presence of an agricultural population beginning in the year 800 B.C. L. Norr [ibid.], mentions the use of sepulchral badges shaped as very thin plaques, extracted from lava laminar formations and used by pre-Hispanic populations between 800 and 500 B.C.

The geothermal zone of La Primavera, Mexico, is in a volcanic caldera with multiple domes, hot springs and fumaroles. In one of these domes, named *Colli*, there were found obsidian arrowheads and, according to Gutierre Tibón [1967], the hill is consecrated to the god of fire. A piece was also found that characterizes *Iztlacoliuhqui*, 'the twisted of obsidian, the God of Punishment'.

The indirect references about the contact between the population of Mesoamerica and geothermics are quite varied. The majority consist of names of places, **gods** and narrations about religious myths [Suárez & Cataldi, 1993, Hernández et al, 1995]. There also exist traditions and legends always transmitted orally, and some transcribed by Spanish monks. Many others, like most of the codices, were hopelessly **lost**. As an example, the indigenous informants of Spanish historian Sahagún [1956] narrated an **arrival** of travelers from remote regions, through the coasts of the Gulf of Mexico, who came to settle down in a mythical place named Tamoanchán, where the nahuatl culture flourished for the first time.

'Here is the story that the old men used to tell: 'In a certain time that no one can any longer recount, and which now nobody can remember... Over the water, in their boats they came, in many groups, and arrived at the edge of the water, on the nonh coast, and where their boats were left, is called Panutla... As they went immediately following the water's edge, searching for the white and smoking mountains ...'

We are not acquainted with the reasons that impelled those legendary nomads to seek and settle down near volcanoes. Sahagún's informants were not very explicit. This story suggests a willful consciousness in the relationship between man and geothermal phenomena in America.

GEOHERMAL ENERGY IN THE POSTCLASSIC PERIOD

Cooking food with steam has been one type of traditional use of natural heat in the Mexican geothermal areas. The diffusion of the nahuatl term *Atotonilco*, which in this language means 'the boiling waters' {*atl*=water, *totonil*=hot, *co*=place} is a word highly diffused in Mexico. The ancient inhabitants of the **25** villages possessing this name, attributed to the thermal waters healing, divine and magical properties. This allows us to infer that many human settlements in those locations were determined by the presence of geothermal manifestations at least one millennium before the Christian era. The use of geothermics to cook and to cure was certainly not limited only to Mexico. Such **use** also spread to the whole of Central America [Suárez & Cataldi, 1993].

During the same period, the hot springs and thermal muds of the several *Atotonilcos*, and those of other geothermal locations in the Mexican Volcanic Belt, were used with healing purposes in mind. From time immemorial, many American tribes took vapor baths, throwing cold water on rocks gathered from the mouth of hydrothermal manifestations at high temperatures, around which they socialized.

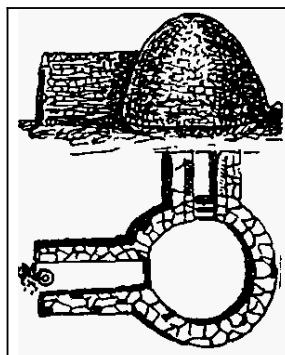


Fig. 2.- A *temazcal* in Puebla (from Krickeberg, 1956).

Subsequently, in some Mexican towns they were accustomed to using the *temazcal* (Fig. 2) for

therapeutic and religious **purposes** [González, 1991]. This vapor bath was obtained by showering piled rocks, heated by fire, with cold water. The *remazcal* was constructed in a dome shape, made of volcanic stones and morlar and was heated from the outside. The narrow corridor at the entrance was adorned with an image of *Teteo Inan*, the great goddess of the **earth** and of childbirth. The *temazcal* was **used** collectively by the pregnant women and babies too.

In fact, the vapor bath as the hot water bath, usual in many other locations, had the appearance of a ritual practice, delineating therefore a diffused attitude of the hot waters' culturization, comparable to that established in the Mediterranean area in pre-Christian times [Cataldi et al., 1992b].

In this period, the usage of the thermal bath was very common in Mesoamerica. There were hundreds and all of them had assigned medicinal and divine properties. The temperature of those thermal waters is between 20 °C and 40 °C. South of Mexico City in the Valley of Cuautla, is the bath of Oaxtepec with sulphurous waters at 25 °C. It was used by the Aztec kings for recreation and had the foremost botanical garden in the continent. There also, the thermal waters were employed to heal Moctezuma's soldiers and for immigration.

In architecture, the Aztecs knew how to continuously use the abundant extrusions of lava rocks around the region. The upper classes of Aztec society made their homes with tezontle, a hard volcanic rock extracted from stony ground situated in southern Mexico City. The minerals in Mesoamerica not only served to manufacture weapons and tools, they were charged also with a mythical religious meaning. For example cinnabar, a red colored mineral, was **used** to paint the holies of important personages. It was believed that the mineral would provide him heat in the Afterlife.

Principal corpses were decorated with wooden masks incrustated with various shades of turquoise or jade. Both rocks were related to the heat and to the humidity of the Earth [Ruiz G., 1992]. Tezcatlipoca, one of the more important divinities, was characterized by a sculpture in obsidian and to him was given the name of "smoky mirror". Flint and the obsidian were related to death, magic, war and fertility.

THE MESOAMERICAN COSMOGONY

For the 'nahuas', the original supreme being was *Cipactli*, a feminine monster that inhabited the sea. Two **gods** converted into serpents cut *Cipactli* in two portions. From the first half they made the underground world, from the second, heaven. For the Mayan the cosmos consisted of a structure formed by horizontal planes in which sacred powers lived. They decided the destinies of each person. For both cultures, those divine energies were land, corn, volcanoes, wind, rain, lightning, the sun, the stars.

Two stable visible bodies in the heavens are the Sun during the day and the Milky Way during the night. Among the Aztecs, *Huitzilopochtli* god of war born on the Earth, represented the Sun. His dismembered sister, the goddess *Coyolxauhqui*, characterized the Milky Way [Aguilera, 1979]. The Sun, dying at every sunset, undertook a daily trip through the underground to charge himself with the energy from the womb of his mother *Coatlicue*, goddess of the Earth. Only in this way could he be born again, in each sunrise.

Water was always related to the Mesoamerican people's origin [León-Portilla, 1992]. Water was the basic element in one of the first epochs of their existence. At the horizon the waters of the Earth joined the water of Heaven enveloping the world. That world was called *Cemanahuac*, ('that which is surrounded by water'). The cosmic meaning of water was **so** important that in the nahuatl language *arl* (water) came **to** represent precisely the phoneme "a". Because of such importance *Tláloc*, the god of rain, was adored in all Mesoamerica. The Mayan called him *Chac*; the Mixtecas, *Cocijo*; the Totonacas, *Tajln*. In náhuatl, city is translated as '*in atl in tepetl*', literally: 'water-mountain' [ibid.]. Pilgrimages were made to the volcanoes in several festivities marked in the solar calendar. The existence of lakes in **various** craters of old volcanoes reinforced the belief in the relationship volcano-water. This equivalence implicitly contains the idea that the mountains are big water reservoirs, preserved as reserves by the gods of rain. **As** is referred to by the Florentine Codex:

"ANrhe high *mourns*, where *the* cloudsjoin *to* make rain, are *gods*. To each *om* *of* them *an image is made* ... Like rhe image *of* the volcano *Popocatepetl* (smoky *mountain*) or *of* her whose *name is* *Izaccihuatl* (while *woman*), or *the image of* the mourn *Poyauhtecatl* (*that which is from the region of the fog*). .."

Existence for the ancient Mesoamericans found its reason of being in the notion that man and woman are the **necessary** collaborators of the living universe. Both depend on nature the Same way **as** nature depends on them. Heat was the force that sustained life. Heat was equal to life; cold was equal to death. Cosmic ideas of beings living with Nature.

The Five Aztec Suns.- In many chronicles and oral traditions, in indigenous manuscripts and on the reliefs of several pre-Hispanic monuments, the idea is found that our time was preceded by four

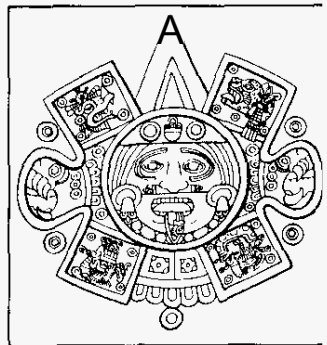


Fig. 3.- The five Suns or Eras in the center of the Aztec Calendar.

Eras named Suns by the Aztecs (Fig. 3). Each one of these epochs finished with the destruction of the world by different and terrible cataclysms generated by the energy of the Earth. Those missing worlds were in cosmological order: *atl* (water), *ocelotl* (tiger), *quiahuitl* (rain) and *ehecatl* (wind) [León-P., 1961]. Our present world is designated **on** the Aztec Calendar by the date *nahui ollin* (4-Movement), which mean, earthquake.

Each age had great mythical imparlance; the meaning and the end of each of them are the following:

Atl-Tonatiuh (water Sun). The first men had been made from ashes. In this first catastrophe humanity was destroyed by water in the form of floods, the inhabited land invaded, converting the men into fish.

Ocelotl-Tonatiuh (Tiger Sun). In this second age the sun stopped at noon, interrupting its path. Suddenly night appeared and heaven was oppressed. At this time giants lived, who in spite of their great corpulence, were in fact weak beings; when they fell because of an accident, they fell forever.

Quiahuitl-Tonatiuh (Rain of Fire Sun). In this third age, the rock boiled, burning the people; it was a rain of fire coming down from volcanic eruptions (*Tlaequiahuitl*), which destroyed the world. Man who existed there had a tragic end: he remained transformed into turkey. The date 4-*Quiauitl*, which records the end of this time, is placed under the protection of *Tlaloc*, god of rain. He also was the god of fire, falling from the sky in the form of lightning rays and volcanic eruptions [Leon-P., 1983].

Ehecatl-Tonatiuh (Wind Sun). During this epoch, everything was destroyed by the wind in the form of terrible hurricanes, snow storms and glaciation. Human beings were converted into monkeys and were scattered to the mountains. At the termination of this fourth Era, the gods met in Teotihuacán in order to once again create the world [ibid]. By means of the sacrifice of one of them, who flung himself into the tire of an active volcano, the Fifth Sun emerged.

Ollin-Tonatiuh (Movement Sun). This was the last of the cosmogonical Eras, the Fifth Sun in which the *nahuas* lived. We are living in the midst of this Era, which will be devastated by earthquakes. Its divinity is *Xiuhrecurli*, god of tire who joins the heat of the Earth with that of heaven.

For the Aztec cosmogony, in four attempts the world is **born** and dies, destroyed by gigantic catastrophes. Similar beliefs, where the numeral 4 prevails in the cosmogony, are found among the Mayan-Quiche in the south of Mexico and among the Tarahumaras in the nonh [Soustelle, 1940].

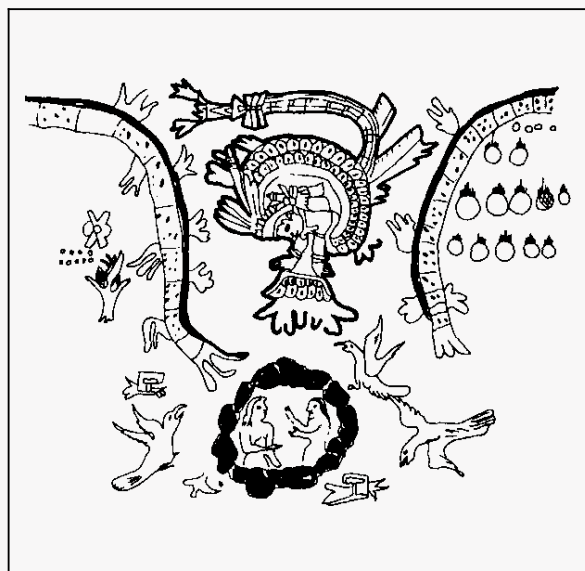


Fig. 4.- In the figure, up at the Center, the pod of the volcanic fire descends, leaving from a Crater and throwing lava and fire.

During the course of the aforementioned Eras, a spiral evolution took place: men appeared in upgraded forms, as did food and plants [León, 1961]. The end of each age was governed by one of the 4 primal forces in nature: water, earth, fire and wind.

In the myth of suns a strange depth is observed, apart from its religious implications and geological coincidences. The original text emphasizes a penetrating consciousness concerning the relativity of the world and of existence. In this legend, an implicit and resigned acceptance that everything passes, everything finishes, even the gods, is observed. This legend, by itself, makes up an extraordinary synthesis of the group of cosmogonical certainties which the latest heirs of Mesoamerica confronted.

In Mesoamerica, the origin, existence and development of the universe were the effects of divine beings and energies in action. Therefore, the understanding of the reality was of a religious nature. For the Aztecs, religion was the axis around which all their existence turned. This was accomplished even in art [Tibon, 1967].

Gods, world and men formed a cosmos in equilibrium, interacting in a dynamic reality. Such continuous motion occurred in an orderly way [De la Garza, 1990], giving stability to their existence. This was usually governed by the ethical duality of good/evil, inseparable from the intrinsic nature of all beings, even among the gods.

The Mesoamerican concept of geothermal manifestations war impregnated also by a fervent religious meaning, pregnant with duality into a positive/negative, beneficent/harmful, constructive/destructive relationship. The characteristics of three geothermal divinities point out this paradox:

HUEHUETÉOTL.

One of the principal gods, the oldest one, father of the other gods. He was the divinity that controlled fire, living in the 'navel of the world', that is to say, in the center of the earth. At the same time he was the nearest to men, *Tloque Nahuaque* 'Sir of the Neighbouring Vicinity', of the immediate present. thus he lived directly with man, in the residence of each man.

For the Aztecs, *Huehuetéotl*, (Fig. 5) was the fire itself, coming from the volcanoes, the heat from terrestrial origin and the oldest principle generator of life that resides in the center of the Earth [Vaillant, 1941].

The representati of *Huehuetéotl* as an old man suggests the oldness of the mountains and volcanoes. The antiquity of this *god*, characterized in a different way at *Teotihuacán*, underlines the importance given by the Mesoamericans to geothermal heat. His cult, continued during many centuries, converts him into the oldest god.

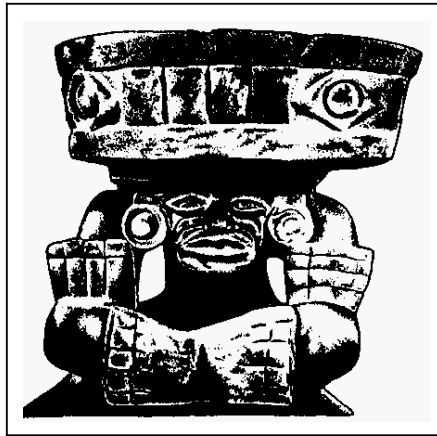


Fig. 5.-*Huehuetéotl*, God of terrestrial fire.

TLÁLOC.

Aztec God of the rain, was at the Same time malevolent and beneficent; he fecundated the soil with water and at the same time could bring floods and disasters provoking hail, thunder, lightning or volcanic eruptions. He was consequently a dual god who could mean rain of water or rain of fire. *Cholchihurlicue*, was his feminine part, the goddess of running waters.

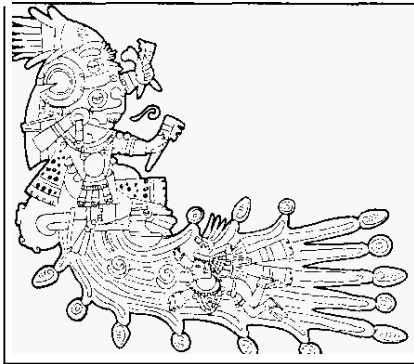


Fig. 6.- *Tláloc* god of rain and of volcanic eruptions

part, the goddess of running waters.

TLAZOLTÉOTL

The Aztec goddess of carnal love and natality, but also of the vapor bath and of the confession of wicked sexual relationships. She was the devouring goddess of garbage, of the lewdness and of the spiritual impurities; she also was named *Cihuaacóatl* (woman-serpent), one of the forms of the goddess of the Earth, which presided over part of the underground world, the world of the dead, the sower and childbirth.

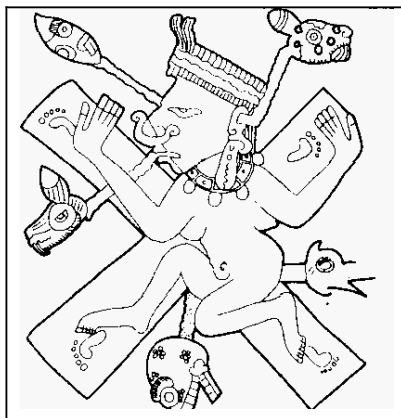


Fig. 7.- *Tlazoltéotl*, goddess of the Steam bath.

THE CALENDAR AND THE CONCEPT OF TIME

One fundamental feature in the Mesoamerican civilization was the obsession about the flow of time. According to Marcus [1979], the oldest known writings, Zapoteca and Maya (600-400 b.C.), are closely related to the calendar. The mesoamerican calendar exists since the year 700 B.C., structured as a complex measuring system based on the idea of time as a material flow. The Aztecs conceived

the time *Cáhuil* under the concept of "that which is leaving us" [León, 1961]. In a flow, time must come from a divine source. It was another time, outside of the human scope, which originated man's time. At the beginning of the universe, the vital activities of the gods created this world. The order in which the mythical actions happened gave birth to the calendar. Every new engendered being will take for its name the name of the day in which he was created [López, 1990]

A current conception of Cosmology defines it as the study of philosophy of the universe as an ordered whole. Given the terrestrial nature of the oldest gods and the worldly origin of *Sun* and *Earth*, the symbols that formed part of the calendar to represent days, months, years and centuries, deeply reflected the influence of geothermal phenomena in the Aztec Calendar's final structure. This calendar is the best known and has been the most studied of all. The calendar had tremendous importance in the daily life of Mesoamericans. We give a brief description here.

The calendar held cycles of distinct dimension and significance. One of 260 days surged from the calculation between two cosmic fundamental numbers 13 and 20; which governed the order of the destinies of mundane beings. It also was the cycle of 360 days divided into 18 months of 20 days each. The year of 365 days existed as well, with 5 'useless' days, that guided the labour and ritual activities. Also there was the cycle of 9 days pertaining to the divinities named 'Sirs of the Night'. There was also a major cycle of 52 years, attached to the Constellation of the Pleiades, at whose completion was celebrated the festivity of New Fire, related to terrestrial heat and representing, probably, periodical eruptions or earthquakes. This half century was divided into 4 groups of 13 years each. The ritual activities corresponded to the agricultural cycles and, given that the basis of the calendar was the solar year, the principal function of the religious cult was to regulate and control the social and economic life.

Each one of the cycles expressed the eternal return of things and the recurrent regularity of natural phenomena. It was considered that the complex reality of the world originated from the intersections and simultaneous influences of cycles of different time. The historic repetition was inevitable but only at the end of a gigantic cycle that includes all the possible combinations of the previous cycles:

"... again it will be like this, again so will be the things, in some rime, in some place." [Florentine Codex].

The premier ring holding the 20 days of the Aztec Calendar (Fig.8) shows again the importance the ancient Mexicans gave to the concepts related to geothermal processes: rain (water, fire or eruption), flint (production of knives and fire), movement (earthquake), serpent (related to the ground and to things underground). The most surprising concept is the one related to water (*atl*) essential in all its forms, whose patron saint was precisely the god of fire *Xiuhrecurli* [González, 1991]. The aztecs used the special name *atl tlachinolli* to say 'water in fire'; the geothermal relation is immediately evident. On the central disk there is found a series of elements that, combined, provide the planetary cycle, the lunar phases, the period of comets and the occurrence of eclipses.

RECAPITULATION AND CONCLUSIONS

In America, volcanic eruptions and other geothermal manifestations were well known and used since Prehistoric times. Some 3500 years ago, established settlements were begun in Mesoamerica devoted to the cultivation of soil, as well as the common direct and indirect utilization of natural geothermal heat for cooking food, therapeutic applications and steam baths. In this place, geothermal energy was the principal background for human development, ever since the obscure and extensive dawn of prehistoric times.

The first magical religious interpretations of geothermal processes occurred soon thereafter. This is evinced by the antiquity of the god representing terrestrial fire, considered as the father of all the other gods

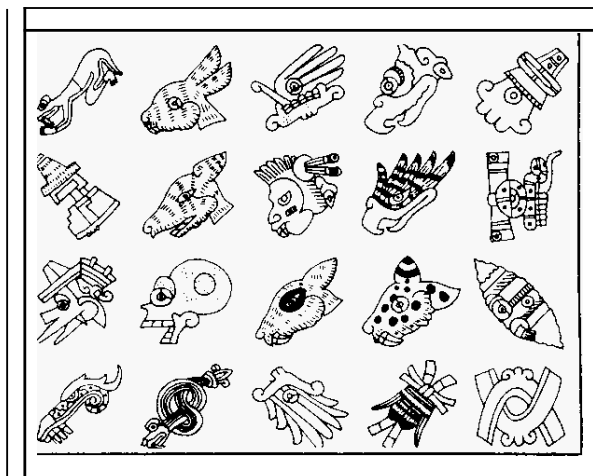


Fig. 8.- Symbols of the 20 aztec days, from left to right: lizard, rabbit, grass, eagle, flower, home, stag, ape, eagle, rain, wind, death, dog, jaguar, knife, Cipactli, serpent, water, sugar-cane and movement.

It is plausible that the dual ethical concept of good and evil, that was thought to be intrinsic to the nature of all living beings, it had been inspired partially by the existing relationship between Mesoamerican man and geothermal energy. This relationship was forever pregnant with duality: beneficial heat from thermal springs, fertility of volcanic ground, hard rock to manufacture weapons, tools and homes; *remazcal* for cleaning the flesh and the spirit; evil heat from lava expelled with violence, diaspora forced by continuous earthquakes and volcanic eruptions and missing worlds as a result of terrible cataclysms. *Tlaloc*, god of rain, lightning and volcanic eruptions, is the other form of *Tiequauil*, the rain of fire.

With the annihilation of Tenochtitlan, the latest great Mesoamerican culture concluded. For the Aztecs, in 4 Eras or Suns the world was destroyed by gigantic catastrophes generated by the energy of the Earth. The present world, the fifth, will know the same destiny. *Nahui Ollin*, 4 Movement is its sign: that of the earthquakes. *Xiuhrecurl*, divinity of the Fifth Age and patron saint of water, is the god of fire that joins the terrestrial fire, in the center of the earth, with the fire in heaven. This was the Aztec cosmogony intimately attached to geothermal energy.

The millenniums of experience and wisdom accumulated by the Mesoamericans led them to a balanced existence between their societies and nature. Because of that, they revered water, corn, the volcano, the serpent and the hummingbird. The majority of the conquistadors never exhibited great mental amplitude. Their narrow zeal to quick enrichment prevented them from perceiving the grandness of the mesoamerican cosmological vision in its respect for natural resources. For the ancient Mesoamericans, the manipulation or exploitation of nature was irrelevant to their cosmological concept. The relationship man-geothermics in Mesoamerica was the will for life and respect for the creative work of the gods. Not will for power over the geothermal phenomena.

The systematic and repeated observation of natural phenomena led the Mesoamericans to make scientific predictions and guided their social behaviour in accordance with their knowledge. They constructed a structured cosmic outlook, integrated in a coherent system of thought. This allowed them to explain the universe while satisfying their ideological, moral and political needs.

Geothermal phenomena and astronomy formed the conceptual base for the Mesoamerican calendar. The calendar represented not only a scientific achievement but, even more important, it reflected a social, historic and religious system by its ideological content; economic importance by its prediction of the agricultural cycles; and political importance by the sacredness of the Stone of the Sun, which legitimated the divine political power of the ruling classes. The knowledge developed on geothermics, astronomy, the calendar, mathematics and writing, reflects the emergence of a refined scientific consciousness in the mesoamerican cultures.

In particular, the use of natural heat and its by-products, as well as the daily Observation of geothermal phenomena played an important role on the cultural, ethical and religious formation and on the social development of the people in many places of Mesoamerica

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