Air-Spring Flutes of Mayan Culture

Vanessa Rodens

As the Mexican ethnomusicologist Samuel Martí already clarified in his publications on various Mesoamerican musical instruments, we are still astounded by the highly refined findings of the sound artifacts from the pre-Hispanic period, especially wind instruments (aerophones). Among other types of musical artifacts left to us by the Mayans, aerophones particularly demonstrate both the high level of musical development and their creators' acoustic knowledge and craftsmanship (Martí 1970:126). The artifacts under study were collected during past archaeological excavations in the area once occupied by the ancient Mayan culture during the pre-Hispanic period.

Due to their non-perishable manufacturing materials, these or other sound artifacts have endured in their contexts over many centuries and, in many cases, remain in good condition.

The family of true aerophones is not small; rather, on the contrary, based on the archaeomusicological finds collected to date, it represents the largest and most multifaceted family of all Mayan sound artifacts, composed of several groups and subgroups of objects, such as straight-tube flutes and globular flutes with finger holes (ocarinas), straight-tube and globular flutes without finger holes (whistles), conch shell and ceramic trumpets, whistling vessels, etc.

A particularly interesting group of whistles is referred to in organological terms as *air-spring whistles or noise whistles* (air-spring flutes in English, according to Franco in Martí 1970:126), which have already captivated the scientific attention of several ethno- and archaeomusicologists as well as musicians in the past for four main reasons: first, due to their internal morphology; second, due to the sounds they produce, which cannot be compared to the sounds emitted by an ocarina, a straight-tube flute with finger holes, or a regular whistle. Third, this whistle belongs to a subgroup of wind instruments that is very rare and still little studied, and fourth, as noted by Velázquez Cabrera (2006:256), they are still not included in the established taxonomy of musical instruments or archaeological typologies of Mayan artifacts.

This paper is a general introduction to this type of sound artifact from Mayan culture. It will describe its external and internal morphological characteristics, manufacturing and performance techniques, and acoustic features and mechanisms. A description of the archaeological contexts, iconography, and symbolism will then be presented. Lastly, the function and meaning, as well as the earlier and later forms of noise whistles, will be elucidated briefly.

Research Background

The first researcher to direct his scientific attention to the study of air-spring whistles was the Mexican engineer Juan Luis Franco (1962, 1971). In his contribution, he not only introduced the term "air-spring flutes," which remains valid with certain limitations to this day, since from an archaeo-organological perspective they are not flutes, even though they have finger holes and a mouthpiece because the sound does not originate from an airflow hitting a bevel (Both 2005:48). He also proposed that the physical principle of the pneumatic pad could apply to these wind instruments, a principle that relies on the aerodynamic production of compressed air. In addition, he published various illustrations and a highly detailed description of the morphology and mode of action of a small number of aerophones dated to the Olmec period (Franco, in Martí 1970:126; Both 2005:48; Velázquez Cabrera 2006:255).

The Mexican ethnomusicologist Samuel Martí, to whom we owe many contributions on Mesoamerican sound instruments, also dedicated himself to studying these same whistles. He was the first researcher to publish objects from the Mayan culture, which were excavated on the necropolis island of Jaina, Campeche. Most of the pieces he presented are currently exhibited in the Mayan Hall of the National Museum of Anthropology of Mexico or the Mayan Archaeology Museum in Campeche.

It is worth noting that apart from the two pioneers mentioned, several researchers have dedicated themselves to the extremely interesting issue of air-spring whistles, including Schöndube Baumbach (1986), Contreras Arias (1988), Rawcliffe (1992), Velázquez Cabrera (2006), and Both (2005, 2006).

Contreras and Schöndube, for example, documented a small number of *gamitaderas*, that is, wind instruments that can imitate an animal's call to attract it, which, according to them, are located in the Regional Museum of Guadalajara (Schöndube 1986:91-93; Contreras Arias 1988:182; Velázquez Cabrera 2006:255). Furthermore, Contreras introduced the term "double-diaphragm aerophones" and pointed out that one of these instruments may have been illustrated in the Florentine Codex (Sahagún 1979, Book 8, Folio 30, Paragraph 7; Contreras 1988:54, 61-72; Velázquez Cabrera 2006:255). If he was correct in his assumption, we have pictorial evidence that these sound artifacts were used by the Aztecs up until the 16th century and were considered musical instruments.

We owe many new insights to Both, Rawcliffe, and Velázquez Cabrera, which have contributed significantly to the advancement of organological studies of noise whistles.

Thanks to Rawcliffe and the acoustic experiments conducted with exact replicas of air-spring whistles, we now have a clearer idea of the acoustic characteristics and sounds produced by these whistles. Additionally, he introduced the term "chamber duct flutes" for these whistles (1992:52).

However, through the exemplary research of Both, who analyzed a small sample of Aztec noise whistles currently housed in the Ethnological Museum of Berlin, Germany, significant progress was made in studying these specific instruments. Thanks to his contributions, we know that Rawcliffe was not mistaken in her observations. Additionally, Both pointed out that the acoustic behavior of these instruments does not operate based on a pneumatic pad, as Franco proposed, but rather corresponds to the Venturi effect, discovered by the Italian physicist Giovanni Battista Venturi (Both 2005:51). He also archaeologically confirmed that noise whistles were used until the 16th century.

Like Rawcliffe and Both, we owe much to the Mexican researcher Velázquez Cabrera, who conducted a highly interesting study on ancient noise generators made from different types of stone (ilmenite, serpentine, marble, and calcite). These pieces were collected from the surface and/or excavated by archaeologists at various archaeological sites in Mexico, which were occupied by the Olmecs during the Early Preclassic period (1200-900 BC) and by other pre-Hispanic cultures throughout the Classic (200-900 A.D.) and Postclassic periods (900-1521 A.D.). Velázquez Cabrera crafted several exact replicas of the original pieces, recorded the different sounds produced by these noise generators, and analyzed them.

General Information about Air-Spring Flutes

Currently, the sample of pre-Hispanic air-spring whistles comprises 22 pieces, which are in various states of preservation (Figs. 1-4).

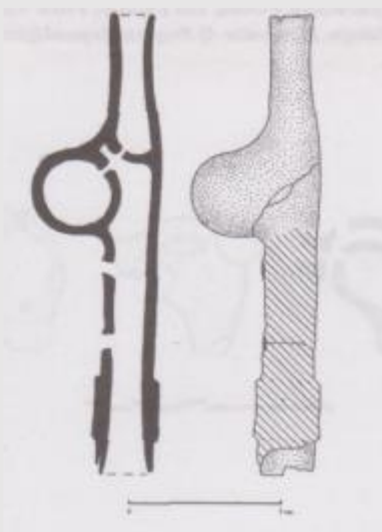


Fig. 1: One of five air-spring whistles found at BU2-1, Structure 2, Pacbitun, Belize, Late Classic period. (Drawing: P. Healy, R. Dichau, and L. Wright. Pacbitun Archaeological Project)

Fig. 2: Archaeological drawings of an air-spring whistle of the second variant (Fragmented). Room 39, Structure 2A8-2, Danta Complex, El Mirador. Late Classic period. (Drawing: S. Belkin. FARES, Mirador Basin Archaeological Project).

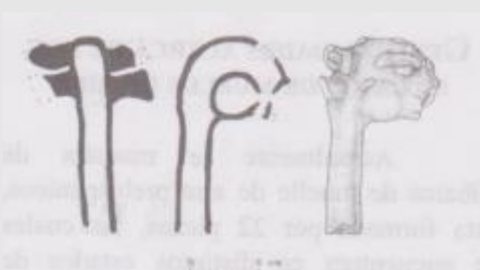


Fig. 3: Archaeological drawing of a whistle of the second variant. Structure 4-West, Las Pacayas, Petén. Late Classic period. (Castellanos 2003, Appendix IV, Fig. 31. Drawing: R. Morales. Las Pacayas Archaeological Project).

Fig. 4: Archaeological drawing of a whistle of the second variant. North Room, Structure M8-10, Aguateca, Petén. Late Classic period. (Inomata 1995-716, Fig. 8.16b. Aguateca Archaeological Project)

Most of the pieces were found during controlled excavations over the last few decades at archaeological sites in the Northern Lowlands, especially at the necropolis on the island of Jaina (Martí 1970:127, Fig. 105; Rawcliffe 1992:57, Fig. 17) along the coast of Campeche, Mexico, as well as in the settlements of Aguateca (Inomata 1995:734, Fig. 8.16b), Altar de Sacrificios (Willey 1972:68; Fig. 57o., q), El Mirador (López 2007:156; Morales – Aguilar 2007, personal communication), Las Pacayas (Castellanos 2003, Appendix IV, Fig. 31), Motul de San José (Deter-Wolf 2000:93, Fig. 77), Pacbitun (Healy 1988:30; Healy et al., in press, Figs. 6-12), Piedras Negras (Monterroso 1999:103), La Trinidad de Nosotros (Moriaty et al., in press), and Xunantunich (Pendergast and Graham 1981:19) in the Central and Southern Lowlands of Guatemala and Belize, respectively. They were associated with various archaeological contexts, which will be described in more detail in their dedicated chapter.

Except for one noise whistle, dated by Pendergast and Graham (1981:17, 19) to the Early Postclassic period (1050 A.D.), all date to the Late Classic period (600-900 A.D.).

Morphology

Upon close examination, it becomes evident that the external morphology of pre-Hispanic air-spring whistles shares many characteristics with other wind artifacts, such as a straight tube or vessel flutes with finger holes and simple whistles. All these sound-producing objects feature an airstream duct (insufflation channel) and a resonance chamber perforated with at least one finger hole, which allows modification of the sound produced by the instrument.

However, the distinguishing features of air-spring whistles, which are crucial for their archaeological organological classification, are not found on the surface of the body but within it.

To date, two types of noise whistles have been documented in the Maya region: first, straight tube-shaped air-spring whistles, and second, vessel-shaped ones.

Examples of the first type (Fig. 5, see also Fig. 1) have an upper section with a straight tubular airstream duct, ending in a narrower passage (the Venturi effect) at the end of the duct. This airstream duct directs the airflow first into a collision chamber and then through another hole into a depressurization chamber, which is wider and globular or oval-shaped (Both 2005:51). Connected to the collision chamber is a tubular resonance box that may be perforated with one or two finger holes, as shown in most recovered pieces.

The second type of whistles (Fig. 6, see also Fig. 2) also features a straight tubular airstream duct with a Venturi, a collision chamber, a depressurization chamber, and a resonance box. However, this type differs in three aspects from the first: first, its general shape is vessel-like; second, it is smaller in size; and third, the depressurization chamber is not on the outside of the sound-producing instrument but hidden within the body. In most of the present cases, the depressurization chamber is situated in the head of a zoomorphic figure, such as a deer or a coatimundi.

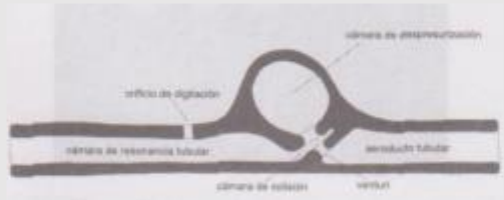


Fig. 5: Technical drawing of a whistle of the first type with definitions of the various organological elements. (Drawing modified by A.A. Both and V. Rodens).

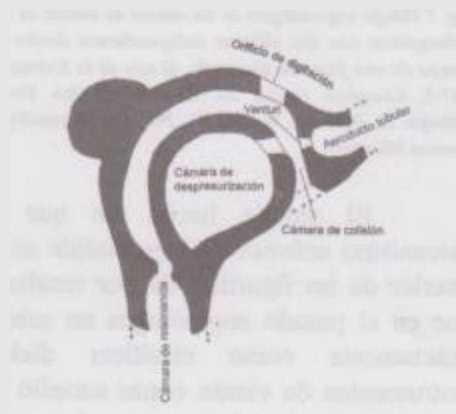


Fig. 6: Technical drawing of a whistle of the second type with definitions of the various organological elements (Inomata 1995:716, Fig. 816b modified by V. Rodens).

The only known exception to date was discovered in 2004 by Morales Aguilar, east of Structure 2A7-3 on the second platform of the Danta Complex, El Mirador (Fig. 7). This piece is unique. First, the inflation channel is located not in the animal's mouth but in the tail; second, it has only one hole, which likely serves as a finger hole or rather as an exit, and third, it lacks a straight tubular resonance box as found in the other whistles. However, the most remarkable feature of this piece, which makes it unique, is that inside the figurine there are two whistles: a simple whistle (in the head) and the air-spring whistle. From an archaeological organological perspective, this is considered a polyorganic instrument.

Fig. 7: Archaeological drawing of a polyorganic air-spring whistle with two independent whistles inside the body of a zoomorphic figurine. East of Structure 2A7-3, Danta Complex, El Mirador. Late Classic period. (Drawing: H. Iwamoto. FARES, Mirador Basin Archaeological Project).

The fact that the acoustic mechanism is hidden inside the figurines has historically led to difficulty in classifying these wind instruments accurately, as seen with two excavated pieces from the archaeological site of Altar de Sacrificios, Petén (Willey 1972).

Manufacturing And Performance Techniques

Due to the complex manufacturing process involved in creating noise whistles—specifically, their intricate internal morphology—artisans likely specialized in crafting sound-producing artifacts, requiring advanced knowledge of acoustics. These whistles could not be fully manufactured with a mold.

Research on both variants of these whistles indicates that they are composed of several clay elements, each modeled separately with distinct tools and then assembled to form the complete wind instrument. This is evidenced by two observations: first, remnants of clay slightly protrude from the external and internal walls; and second, the variations in size, shape, and decorative elements applied on the surfaces (Fig. 8, see also Willey 1972:69, Figs. 57o, q).

Fig. 8: Photos of two whistle examples. Mound 38 and Structure A-III, Altar de Sacrificios, Petén. Late Classic period. (Photos: V. Rodens. National Museum of Archaeology and Ethnology, Ministry of Culture and Sports, Guatemala).

With these findings, we can reconstruct a hypothetical sequence that illustrates how potters or artisans proceeded during the manufacturing process.

First, they independently modeled various elements of the whistles: a straight or slightly curved tube with a narrower end (the Venturi) that served as the inflation channel; a hollow, globular, or oval body with a circular hole, which acted as the depressurization chamber; and another straight tube that served as the tubular resonance chamber.

The tubes were made by wrapping a thin wooden stick with wet clay. To create the Venturi effect, the opposite end of the inflation channel was sealed with clay, and a circular hole was cut with a sharp, pointed object—a specialized wooden tool or an obsidian knife—resulting in a smaller diameter than the tube. The whistle's tubular resonance chambers were formed with a thin stick, with at least one finger hole cut or pierced into the tube. Straight tube-shaped examples typically have one or two holes, with the first hole located immediately below the depressurization chamber.

For the depressurization chamber, artisans likely started with a ball of wet clay, cut it into two equal parts, and hollowed it out evenly with their fingers to create a uniform cavity with walls of even thickness. Once both halves were hollowed, they cut a circular opening in the chamber wall, which served as the entrance to the depressurization chamber. In most whistles, this opening is the same diameter at both the entrance and exit.

However, some whistles, like the one from Room 39 in Structure 2A8-2, Danta Complex, El Mirador (López 2007:156, see Fig. 2), have entrance and exit diameters of different sizes in the depressurization chamber.

After modeling all the tubes and the depressurization chamber, the assembly of all the elements began one after another. It is worth mentioning in this context that the assembly of the straight-tube air dock whistle components seems to have been easier. The tubular resonance chamber was first assembled with the depressurization chamber, and the opening of the depressurization chamber was precisely adjusted to the venturi, which was located at the end of the air duct before the elements were brought together. Next, the open spaces, or the intersection points on the surface, were filled with wet clay. This was done for several reasons: primarily, to reinforce these points and ensure they would last a long time, especially during the firing process; secondly, to hide the connection points between the various composite elements, and to smooth the surface of the whistle.

As mentioned earlier, the assembly of the characteristic elements of the vascular-shaped noise whistles, which mostly represent animal heads, was more labor-intensive. Based on the evidence of smoothed clay remnants both on the exterior and interior of the objects, it is possible to determine that the globular or oval depressurization chamber was joined with the tubular resonance chamber and perhaps in the same work step or shortly after, the insufflation tube was attached. An important aspect during the assembly process was that the venturi was precisely adjusted to the opening of the second chamber. After assembling the mentioned elements, the construction of the lateral parts and the top of the animal's head began. Because the two finger holes were cut very carefully and no clay remnants were found inside the instrument, it can be assumed that they were made before finishing the body of the whistle.

At the end of the assembly of the parts that characterize the whistles, relief decorations were added, such as animal heads, which were molded or shaped, along with smaller pastillage elements like arms, ears, eyebrows, and eyes. Additionally, a slip was applied to the surface in various colors, as was the case in Pacbitun, Campeche, and Las Pacayas.

The options to play a whistle like the ones presented are truly limited. The instruments are played along their length, and the performer can blow air over the upper edge or directly into the air duct. The flutist can modify the sound in various ways: by covering the finger holes with their fingers, as well as opening and closing them as they wish. Another option is to manipulate the airflow, meaning changing the air pressure while blowing into it. The sound produced by the instrument with low, normal, and high pressure is different. According to Both, there is another way to manipulate the sound while the performer moves their hand in various ways when the air exits the resonance chamber (2007, personal communication).

General Observations Regarding the Sound and Acoustic Mechanism

Engineer Franco (1962, in Martí 1970) and other scientists (Rawcliffe 1992; Both 2005, 2006; Velázquez Cabrera 2006), who have studied air spring flutes, emphasize that the sound produced by the objects of study cannot be compared to the sound of any other type of simple whistle, which has been reported in large quantities in Maya settlements by archaeologists over the past few decades. When playing the instruments and carefully listening to the sounds they produce, the difference between the clear, linear sounds, for example, of a simple whistle and an air spring flute becomes immediately noticeable.

Both points out in his contribution on Aztec noise whistles that whistles like those discussed produce a distorted sound, which is non-linear, and that makes us think of the atmospheric noise produced by the wind (Both 2005:43). Additionally, he mentions that the sound varies depending on the air pressure with which the performer blows into the instrument so that they can produce sounds that imitate the wind or noises that can be compared to aggressive howling sounds. According to his studies, some whistles whisper, meaning they emit very weak sounds (Ibíd.:43-44).

The fact that these whistles imitate natural phenomena with their sounds highlights that the acoustic effect of different air currents colliding against each other was intensely studied by the manufacturers before it was possible to reproduce such sounds in instruments of such small sizes (Both 2005:43). Logically, manufacturers did not learn to manipulate these sounds overnight, but rather as the result of a long developmental process, which, as archaeological evidence from western Mexico suggests, may have already been initiated by hunter-gatherer groups and perfected over the centuries.

But we should ask ourselves: how is it possible that instruments of such small size produce sounds with which a performer can imitate the atmospheric noise of the wind or create an aggressive howling sound?

The source of these sounds is the acoustic mechanism, or more precisely, the interaction between the narrow passage at the end of the air duct (venturi) and the depressurization chamber. According to Franco, the hole at the end of the insufflation channel serves to direct the air stream into the entrance of the oscillation chamber, where the air is compressed until the pressure inside the chamber matches the pressurization of the insufflated air. After that, no more air enters the oscillation chamber; instead, according to Franco's hypothesis, the air stream passes through the hole in the oscillation chamber and pulls air from within the chamber. The result is the creation of a depression in the oscillation area. Then air enters the chamber again until the pressure is balanced when the instrument is blown (Franco, in Martí 1970:126).

An important factor that also influences the sound of noise whistles is the diameter of the opposite holes and their distance from each other (Rawcliffe 1992:52-58).

The results of studies on Aztec air spring flutes conducted by Both largely confirmed Rawcliffe's observations and showed that Franco was partially mistaken in his assumptions (Both 2005:51). However, according to Both's results, the acoustic mechanism of the whistles does not operate based on the pneumatic cushion, as Franco proposed, but rather corresponds to the Venturi effect discovered by the Italian physicist Giovanni Battista Venturi (*1746-1822). Furthermore, both emphasize in their contribution that to truly understand this physical effect, all attention must be directed to the Venturi tube, which in the present cases corresponds to the tubular air duct with the narrowest passage at the end of the channel (Ibíd.:50-51).

Venturi's observations, based on the feeding of both liquids and air, suggest that the pressure proportions are more limited in the place where the diameter of the tube is narrower, resulting in a very high current speed because the same amount always exits as enters. Based on this observation, Both propose that this physical principle likely serves as the engine for the acoustic system of the instruments, as immediately behind the narrowest passage at the end of the air duct, depressurization relationships arise, which partly correspond to a vacuum. This results in air being periodically drawn from the globular or ovaloid chamber and immediately colliding with the next air stream, which exits through the circular hole of the air duct. In this way, the characteristic wind-like sound is created (Ibíd.:51).

It should be noted that Both highlight that the term "oscillation chamber" was not very appropriate, as it suggests a resonating body (Ibíd.:51). However if the sound produced by the instrument is a noise, a constant wave that would allow for a clear sound, such as a linear sine oscillation, cannot be generated inside the chamber. In summary, it can be stated that, according to the Venturi principle, the depressurization chamber is more of an aspiration chamber, from which air is periodically drawn and then follows through in a mass once again. At the same time, counterpressure arises within the same chamber.

Archaeological Contexts

Thanks to the detailed documentation by archaeologists who have found air spring flutes at the Mayan settlements of Jaina, Pacbitun, Xunantunich, El Mirador, Motul de San José, La Trinidad de Nosotros, Piedras Negras, Aguateca, Las Pacayas, and Altar de Sacrificios, we have a wealth of information about the archaeological context and its social implications.

It is worth mentioning in this context that a total of six pieces with straight tubes from the sites of Pacbitun and Xunantunich, Belize, were associated with burials.

The five air spring flutes from Pacbitun (Fig. 9, also see Fig. 1), for example, were excavated from burial BU 2-1, located in Structure 2, which represents the second largest structure at the site, to the west of Structure 1. According to the excavation analysis conducted in 1986 by Paul Healy and his colleagues from Trent University, Canada, it was the burial of a woman dating to the Late Classic period (Healy 1988:24-31; Healy et al., In press).

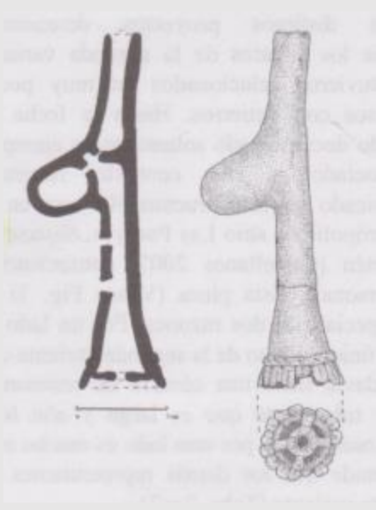


***Fig. 9** Another air spring flute of the first variant found in BU2-1, Structure 2, Pacbitun, Belize. Late Classic. (Drawing: P. Healy, R. Dickau, and L. Wright. Pacbitun Archaeological Project).*

Based on the quantity and high quality of the items buried with the woman and the location of the burial, it is suggested that a person of very high social rank, from the elite of the site, was buried. Surrounding her head and feet were 20 high-quality painted vessels, jade jewelry, a magnificent obsidian knife, and a total of 14 different sound instruments. Among the sound objects are the five noise whistles, each with two finger holes, eight simple whistles of anthropomorphic and zoomorphic figures, as well as a poliorganic instrument consisting of a vascular rattle whose body is connected to a flute (ocarina) with four finger holes and an inflation tube protruding from the closed resonance body. According to Healy, this is the largest find of sound artifacts, particularly air spring flutes, that are still in very good condition (Healy 1988:24-31; Healy et al., In press).

It should be emphasized that aside from the Pacbitun whistles, the specimen from Xunantunich, dated to the Early Postclassic period, was associated with the burial of a woman. Based on the archaeological evidence, or rather dental mutilations (inlays and wear), the excavating archaeologists Graham and Pendergast interpret that this was also a person of high rank (1981:17). However, unlike the Pacbitun BU 2-1 burial, this burial was not located in one of the site's larger structures, but rather in a platform near Structure B-5, only 20 to 30 centimeters below the surface. Of particular importance is that in the burial of the woman, only the straight-tube air spring flute was found, with no other artifacts (Ibíd.: 17-19).

Given that Jaina Island, located about 60 meters off the coast of the state of Campeche, Mexico, is known for the high number of burials, with about 20,000 tombs believed to have been made on the island, it is highly probable that the six straight-tube whistles also formed part of the burials of several people from the peninsula (Figs. 10-11). However, unfortunately, more detailed statements about the archaeological context and social implications cannot be made, as it should be considered that most of the whistles were published in the 1960s, and it is not exactly known who found them or, most importantly, their context on the island.

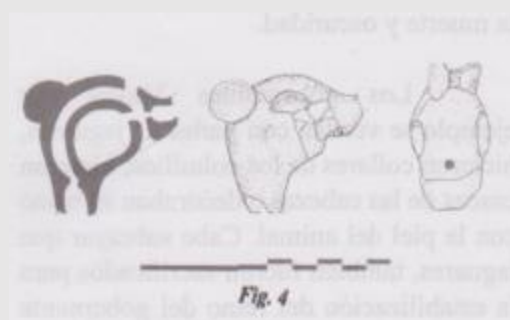
Fig. 10 Air spring flute with applied jaguar head. Jaina, Mexico. Late Classic. (Photo in Martí 1970:127, Fig. 105. National Museum of Anthropology, Mexico City).

Fig. 11 Air spring flute decorated with the head of a vulture. Jaina, Mexico. Late Classic. (Photo in Martí 1970: 127, Fig. 106. Martí Collection, Mexico).

The archaeological data from various projects show that whistles of the second variant were rarely associated with burials. To date, only one example has been documented, associated with a funerary context located in Structure 4-West on the acropolis of the Las Pacayas site in Sayaxché, Petén (Castellanos 2007, personal communication). This piece (see Fig. 3) is special for two reasons: on one hand, it is the only air spring flute of the second variant that still has a long, well-preserved straight tube resonance chamber, and on the other hand, it is much larger than the other representatives of this variant.

It should also be emphasized that the other representatives of the second variant were found in residential buildings and plazas near the main structures that were occupied and used by members of the elite at the sites.

The two whistles (see Figs. 4 and 12) from Aguateca, Sayaxché, and Petén, were found on the floor in the north room of Structure M8-10, along with other sound artifacts and finds distributed throughout the main rooms and the platform (Inomata 1995:216). Excavations in this building revealed not only that it was a residential-type building located south of the palace group and east of the causeway, but also that Structure M8-10 was inhabited by members of the elite. Based on the various archaeological finds made by Inomata, he interprets this building as a place where scribes also produced inscriptions (Ibíd.:216).



In addition to the noise whistles, a very large number of sound objects made from various materials were documented, including drums of different sizes, chin whistles, ocarinas, simple whistles, fragments of straight-tube flutes, a vascular rattle (Ibíd.:595), and several belts and/or necklaces made of smaller marine shells (Ibíd.:549, 584, 595, 726, Fig. 8.8, 753, Fig. 8.35e, and 754, Fig. 8.36a). There is no doubt that the occupants of M8-10 used these sound artifacts, perhaps for domestic tasks, while creating inscriptions on the surface of vessels or paper, blessing their works, or venerating their gods through special rituals.

It should be noted that the two air spring flutes from the El Mirador site were also found in residential areas and plazas that were occupied by the elite members of the site.

During the 2004 field season, a poliorganic whistle, the only documented example to date, was collected and documented by Morales Aguilar. This piece is characterized by having two independent whistles of different types inside a zoomorphic figurine (see Fig. 7). Morales commented that the piece was found east of Structure 2A7-3, on the second platform of the Danta Complex, which was investigated by Howell in the early 1980s (1983). This piece was removed from its original context because it was excavated and left near the surface by a rodent that had made its nest near the structure. Therefore, a more exact description of the location and its probable function cannot be provided (Morales Aguilar 2007, personal communication).

The second piece was found within limestone and ash on the occupation floor in Room 39 of Structure 2A8-2 on the third platform of the same architectural complex during the 2006 field season (see Fig. 2). According to López, this room is one of more than 50 rooms of various dimensions, which are interpreted as Classic modifications made around and on top of the structure, which peaked during the Late Preclassic period. However, based on the ceramics and other objects collected, the whistle should be dated to the Terminal Late Classic (López 2007:156).

Iconography and Symbolism

A crucial aspect of an archaeological musicological study is the detailed observation and interpretation of the iconography, that is, whether the pieces are decorated or not, as the study of these elements can provide many clues about the symbolism and meaning of each object.

As one can observe, all the whistles are decorated with various elements. To date, three main groups dominate according to the categories of zoomorphic, phytomorphic, and abstract decorations.

Within the group of represented animals, there are three monkeys, three vultures, three deer, a jaguar, a coati, and a toad. This group also includes two additional whistles. However, due to their poor state of preservation, the surface of the poliorganic example from El Mirador is highly eroded, and the second piece from the same site is broken and eroded, making it impossible to identify or classify exactly what type of animal it represents (see Figs. 2 and 7).

The various species of animals mentioned above do not represent domesticated creatures but rather animals from the natural world, which, according to archaeological and iconographic evidence, apparently played an important role in the everyday and ritual life of the Maya. As emphasized by Paredes (Paredes et al., in Valdés et al. 2001:765), they were associated with cosmic and natural forces.

Iconographic studies and archaeological findings undoubtedly show that the jaguar (Panthera onca) represented courage, valor, and strength (see Fig. 10). In Maya society, it was interpreted as the ancestor of royal lineages, so the ruler's family was automatically deified (Schlesinger 1999:163-165). As a symbol of the sun, it represents life, and as the nocturnal sun, it is linked to the underworld (Xibalba), death, and darkness.

For example, Maya rulers would dress in jaguar pelts, make necklaces from the animal's teeth, create headdresses from its head, or decorate their thrones with their skin. This was crucial for the stabilization of the ruler's reign, as was the case in Copán (Miller and Taube 1993:102).

The jaguar's skin was so sacred that it was also used as a drumhead for large straight resonance box drums or to decorate trumpets (see Kerr K3332 and K4412), which automatically deified the sound instrument. The jaguar was also considered a companion of destiny (way or nagual) and granted special powers to those who venerated it (Miller and Taube 1993:102).

It is also worth mentioning that representations of vulture heads (*Coragyps atratus*) applied atop the decompression chambers on three air-spring whistles from Jaina (see Fig. 11) evoke the impression that they were associated with both the underworld and death as well as the sun and life. It was considered a symbol of kings, the primary bird deity (Schlesinger 1999:187), which in Maya writing often replaced the glyphs of Kinich Ahau T.747a (Thompson 1963).

The symbolism held by spider monkeys, deer, toads, and coatimundis is also multifaceted, as it always depends on the social context. One aspect they all share is that they were considered naguales, which, according to Maya belief, bestowed strength and special powers to those who worshiped them.

Three whistles display applications of spider monkeys (*Ateles geoffroyi*), which are quite realistic. They feature a molded monkey face, long and slender arms, and a prominent abdomen. According to the iconographic illustrations (Kerr n.d.) and the tales of the Popol Vuh, the spider monkey was closely linked with the arts and writing, especially painting and codex production (Miller and Taube 1993:135-136; Tedlock 1996). Additionally, one can observe that these animals were associated with dancing and the production of sounds using various sound objects (See K1208). On the other hand, the spider monkey is commonly connected with sexuality, lust, fertility, procreation, and spring, as it is also the patron of the day Chuen in the Maya calendar. The monkey's prominent abdomen most likely references the pregnancy of a woman, possibly representing the moon goddess (Paredes et al., in Valdés et al. 2001:765-766).

Just as with monkeys, deer (*Odocoileus virginianus*, see Figs. 3 and 8), which primarily appear with second variant whistles, are interconnected with fertility, femininity, renewal of life, and sexuality (Miller and Taube 1993:75), especially when depicted in representations illustrating nude women, as seen in examples K1182, K1559, and K2794 (Kerr n.d.; Miller and Taube 1993:74-75; Schlesinger 1999:178-183). As a nagual, it was linked with the underworld. An especially interesting detail is that deer can anticipate weather changes, as they sense air pressure drop before it begins to rain and announce rain with their calls (Schlesinger 1999:181).

Toads (*Bufo valliceps*) are attributed with various functions and meanings (Fig. 12). On the one hand, they are symbols of fertility, procreation, life, and birth, as is undoubtedly indicated by the birth glyph *Sih* (see Thompson 1963, T.740) in Maya writing, while on the other hand, they are inhabitants of the underworld, living in ponds or inside caves, which were considered entrances to the underworld.

Fig. 12 Photo of a specimen (variant II) depicting a toad. Trinidad de Nosotros, Petén. Late Classic. (Photo: V. Rodens. Motul de San José Archaeological Project).

In general, the coatimundi (Nasua narica), which belongs to the raccoon family, is a playful, curious, friendly, and tame animal (see Fig. 4). These characteristics were very likely the reasons why coatimundis in Maya life were regarded as sacred clowns (Schlesinger 1999:178). The coati also appears alongside other animals, such as the jaguar, armadillo, and deer, in various illustrations on the surfaces of painted vessels, which are associated with dancing, processions, and music. These characters are usually interpreted as naguales. Another interesting aspect is that this animal is associated with agriculture (Ibid.:178).

As previously mentioned, there are two additional categories of decorations: four pieces with phytomorphic symbols, and three with abstract decorations.

Four air-spring flutes from the Pacbitun site are decorated with phytomorphic elements located at the opening of the conical resonance chamber (see Fig. 9). However, it is not possible to interpret which type of plant they represent or what significance they held for the Maya (Healy 1988:30; Healy et al., In press).

The group of abstract decorations includes objects incised with circles, such as a whistle from Jaina (del Río, in Rawcliffe 1992:57, Fig. 7), or instruments with flat surface decorations, such as multi-colored paintings (Healy et al., In press).

To date, no whistles have been documented that are decorated with features of human beings, gods, or hybrid beings. Another interesting detail is that, so far, illustrations of such instruments have not been identified in the iconography.

Upstream and Downstream Forms

There is no doubt that the air-spring whistles of the Maya culture are unique representatives of this group of wind instruments from the Classic period, showcasing a high degree of acoustic knowledge and the ability to mimic atmospheric noise—specifically, the sound of a natural phenomenon through the manipulation of an acoustic mechanism.

The oldest documented archaeo-musicological findings, which may mark the beginning of the development of air-spring whistles, date back to the Paleo-Indian period (15,000 – 9,000 B.C.). These bone whistles were documented by Schöndube at the Guadalajara Museum (1986:91, Fig. 1,2).

According to Mexican researcher Roberto Velázquez Cabrera, who identified an extremely interesting sound generator made of ilmenite among the personal materials of the late Mexican anthropologist Beverido, an extensive study was conducted on this and various other whistles crafted from lithic materials (e.g., serpentine, marble, calcite). Over the last few decades, a significant quantity of these sound artifacts has been documented at pre-Hispanic settlements in the state of Veracruz, Mexico, which were occupied by the Olmec culture (2006:258-260).

One of these whistles, unfortunately, documented without precise archaeological context, was collected by Beverido during a time when he was supposedly working with Michael Coe in San Lorenzo, Veracruz. This piece (Fig. 13) was found near Monumental Head No. 17, dated to the Early Preclassic (1200-800 A.C.).

Fig. 13 Noise generator from Olmec culture made of ilmenite. Near Monument No. 17, San Lorenzo, Veracruz, Mexico, Preclassic. (Photo: R. Velázquez Cabrera).

It should be noted that Velázquez Cabrera mentions in his work many other whistles of the same type that were excavated about 4 km from San Lorenzo. According to archaeologists Cyphers and Di Castro (1996:3-13), around 10,000 ilmenite stones with identical perforations and approximately the same dimensions were recovered. In addition, similar whistles were reported in other Olmec settlements in Chiapas (Agrinier 1987:19-36). Ilmenite stones are believed to have been imported from the state of Chiapas, where there are several mines, as no mines from which the materials for instrument production could have been extracted were found in the central Olmec habitation areas (Ibid.; Velázquez Cabrera 2006:258).

Velázquez Cabrera also documented and analyzed noise generators made from other types of lithic materials from the Olmec/Popoloca zone, specifically from the archaeological site of San Juan Raya near Zapotitlán Salinas in the state of Puebla. Another marble example was collected from the surface of Terrazas de Paso del Coyote (site Z56) between the Campanario Ometepec and De la Hierba hills near San Juan Raya. However, this whistle dates to the Epiclassic or Early Postclassic period (Velázquez Cabrera 2006:259).

In addition to lithic noise whistles, a ceramic example was documented that, according to information from Rawcliffe (1992:57, Fig. 17), supposedly dates to the Preclassic period, like most of the other sound instruments mentioned above. It was collected at Tzoteapan.

The Aztec culture also used air-spring whistles, which should be interpreted as the latest representatives of a long developmental sequence (Both 2005:48). These sound artifacts differ from Maya examples in several aspects: first, in their dimensions, second, in their external and internal morphology (Fig. 14), and third, in the contexts in which they were found. Interestingly, the Aztecs preferred two variants. The first group is represented by vascular-shaped examples, characterized by a relatively long air duct with a narrower passage at the end of the channel, a semi-spherical decompression chamber (Fig. 15)—most likely a Postclassic feature (Both 2007, personal communication)—and a resonance chamber with a curved or irregular inner wall. Two examples of this type were excavated in Tlatelolco, Mexico City. Pieces of the second variant differ slightly from the first, having a smaller resonance chamber. Another very interesting detail is that these are not standalone sound objects but form part of the handles of polychrome incense burners, which were found in 1900 by Leopoldo Batres in the temple area of Tenochtitlan, Mexico (Both 2005:47).

Conclusions and Future Work

Fig. 14 Fragment of an Aztec air-spring whistle decorated with a skull, currently housed at the Ethnological Museum of Berlin, Germany. Inventory number IV Ca 2621m. Mexico, Postclassic period. (Photo: C. Obrocki. Staatliche Museen zu Berlin, Preussischer Kulturbesitz, Ethnologisches Museum, Berlin).

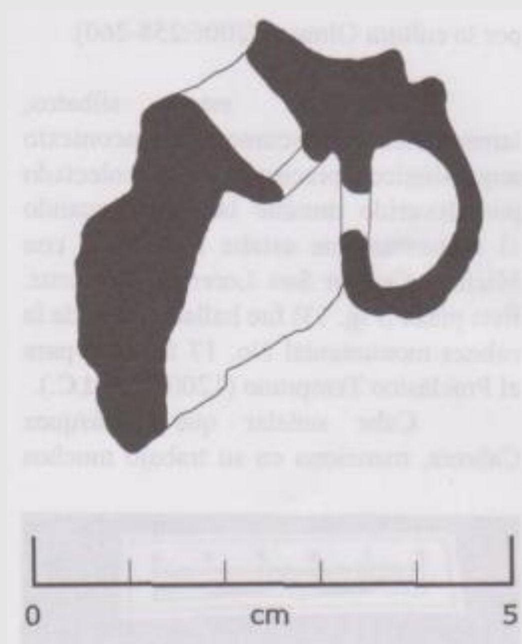


Fig. 15 Technical drawing of an Aztec whistle showing its different internal sections. (Drawing: A. A. Both).

The air-spring whistles presented in this contribution are undoubtedly incomparable to any other type of whistle collected thus far in Maya-area settlements. Their unique exterior and interior morphology, advanced acoustic mechanism, and the sounds they produce underscore their high level of acoustic sophistication.

The morphology of these pieces, especially their distribution across the Maya area, shows that the whistles were not confined to a single region and likely followed a general construction pattern that originated in one zone and spread to others. The whistles also indicate a definite exchange of musical or acoustic knowledge between various Maya settlements.

Moreover, the archaeological context and social implications confirm that sound instruments played an extremely important role, as many whistles were associated with the burials of individuals of very high social rank or were found in residential structures and main plazas occupied by royal family members.

Considering the iconography, we can also assume that the whistles held significant importance, as the surfaces of these aerophones are decorated with representations of various animals—beings from the natural realm with symbolic meanings and regarded as manifestations of sacred forces due to their distinctive qualities (De la Garza, in Valdés et al. 2001:765).

Although we have already gathered much information about these whistles, our fascinating and rigorous research is far from complete. We are only beginning systematic documentation and study of the various types of air-spring whistles of the Maya culture. To achieve a true understanding of the whistles, particularly their acoustic mechanism, function, and meaning, many more detailed studies will need to be conducted shortly.

- Conduct a systematic search for more archaeo-musicological findings among the Maya and other Mesoamerican cultures to expand the current database and close the gap in transitional phases, allowing for the reconstruction of a developmental sequence.
- Carefully review recent and older publications and reports from various archaeological projects to identify additional pieces.
- Analyze different iconographic sources, such as scenes depicted on the surfaces of painted vessels, to determine if there are pictographic references to performance techniques and context.
- Arrange for X-rays of the whistles from different angles and create precise technical drawings, as well as replicas of the pieces, to understand the manufacturing process. These replicas could also be used for acoustic experiments and recordings, provided the original primary findings are not in a good state of preservation.
- Document finger positions to associate each sound with its corresponding fingering hole, compare and evaluate the sounds and intervals of Maya noise whistles, and compare them with other similar whistle types. This would help identify differences in the sounds and define them as precisely as possible.

Acknowledgments

This work was made possible through the assistance of numerous individuals and would never have been completed without their support and guidance. First, I wish to express my gratitude to the Director General of Cultural and Natural Heritage, Lic. Salvador López, and to the Head of the Department of Monuments, Dra. Vilma Fialko, Deputy Head, Lic. Jorge Mario Ortiz, and Supervisor Hugo Barrera—members of the Guatemalan Institute of Anthropology and History (IDAEH – Instituto de Antropología e Historia de Guatemala)—for facilitating the permits and allowing the initiation of the archaeo-musicological research on pre-Hispanic Maya sound artifacts in the Department of Petén, Guatemala. I would also like to thank the Director of the National Museum of Archaeology

and Ethnology (MUNAE – Museo Nacional de Arqueología y Etnología), Licda. Claudia Monzón, and her skilled collaborators for their assistance and supervision during the study of the sound instruments presented in this work and others.

I also extend my sincere thanks to the directors, assistant directors, and collaborators of the following archaeological projects who provided their scientific support by allowing the analysis of sound objects featured in this work:

- Aguateca Archaeological Project: Dr. Takeshi Inomata and Dra. Daniela Triadan.
- Mirador Basin Archaeological Project: Dr. Richard D. Hansen, Lic. Edgar Suyuc Ley, Francisco López, Carlos Morales Aguilar, Hiroshi Iwamoto, and Sharon Belkin.
- Las Pacayas Archaeological Project: Dr. Jim Brady, Dr. Héctor Escobedo, Licda. Jeanette Castellanos.
- Motul de San José Archaeological Project: Dra. Antonia Foias, Licda. Jeanette Castellanos, Mtro. Aaron Deter-Wolf, Mtra. Christina Halperin, and Mtro. Mathew Moriarty.
- Piedras Negras Archaeological Project: Prof. Dr. Stephen Houston and Dr. Héctor Escobedo.

Also deeply grateful for the collaboration and support of Dr. Paul Healy, Director of the Pacbitun Archaeological Project, Belize, as well as Drs. Pamela Downe, Ruth Dickau, and Lori Wright, excavated and documented the air-spring whistles at the same site.

Finally, I wish to extend my thanks to my dear friends and colleagues dedicated to the study of Mesoamerican sound artifacts for their advice and academic assistance: Dr. Arnd Adje Both (International Group of Archaeo-Musicological Studies, German Archaeological Institute), Mtro. Alfonso Arrivillaga Cortés (Head of the Ethnomusicology Area, Center for Folklore Studies, Universidad de San Carlos), and Mtro. Roberto Velázquez Cabrera.

Bibliography

Agriener, Pierre

1989 Mirador-Plumajillo, Chiapas, y sus relaciones con cuatro sitios del horizonte Olmeca en Veracruz, Chiapas y la costa de Guatemala. *Arqueología 2:19-36. México.*

Both, Arnd Adje

2005 Totenkopfpfeifen der Azteken. *Baessler-Archiv* 53: 43-54, Berlín.

2006 On the Context of Imitative and Associative Processes in Prehispanic Music. En: *Studien zur Musikarchäologie V, Orient-Archäologie 20* (editado por E. Hickmann, A. A. Both y R. Eichmann), pp. 319-334, VML, Rahden/Westfahlen.

Castellanos, Jeannette

2003 *La afiliación socio-política y función del sitio arqueológico Las Pacayas, Sayaxché, Petén, durante el Clásico Tardío.* Tesis de Licenciatura, Área de Arqueología, Escuela de Historia, USAC, Guatemala.

Contreras Arias, Juan Guillermo

1983 *Atlas Cultural de México.* Instituto Nacional de Antropología e Historia, México.

Cyphers, Guillén Ann y Anna Di Castro

1996 Los artefactos multiperforados de ilmenita en San Lorenzo. *Arqueología* 16: 3-14. México.

del Río, Marcela

1962 Instrumentos musicales prehispánicos. *Excélsior* (14 de octubre): 34. México.

Deter-Wolf, Aaron

2000 *Whistle Figurines from Motul de San José, Guatemala*. Master's thesis, Centre of Latin American Studies, Tulane University, New Orleans.

Franco, Juan Luis

1971 Musical Instruments from Central Veracruz in Classic Times. En *Ancient Art of Veracruz, Exhibition Catalogue of the Los Angeles County Museum of Natural History*, pp. 18-24, Ethnic Arts Council of Los Angeles, Los Angeles.

Healy, Paul F.

1988 Music of the Maya. *Archaeology* 41 (1): 24-31. New York.

Healy, Paul F., Vanessa Rodens y Pamela A. Downe

En prensa *Ancient Sound Producing Artifacts of Pacbitun*, Belize.

Hornbostel, Erich M. von y Curt Sachs

1914 Systematik der Musik instrumente: Ein Versuch. *Zeitschrift fr Ethnologie* 64: 553-590. Berlin.

Howell, Wayne

1983 *Excavations in the Danta Complex, El Mirador, Petén, Guatemala*. Master's thesis; Department of Anthropology, Brigham Young University, Provo.

Inomata, Takeshi

1995 *Archaeological Investigations at the fortified centre of Aguateca, El Petén, Guatemala: Implications for the Study of the Classic Maya Collapse*, Vol. I & II. Doctoral Dissertation, Department of Anthropology, Vanderbilt University, Nashville, Tennessee.

Kerr, Justin

s.f. Maya Vase Database: An archive of Rollout. <http:research.famsi.org/kerrmaya.html>

López, Francisco

2007 La Danta: Excavaciones en la estructura 2A8-2, Operación 400K, N, E-E, F-F, Q, L, D-D. Base de la fachada principal, lados Norte y Sur. En *Investigación y Conservación en los sitios arqueológicos El Mirador, La Muerta, Tintal, La Tortuga, Tazumal, La Llorona, Camarón, El Desencanto, Lechugal, Icotea, Los Chuntos y El Laurel, Informe Final de la Temporada 2006* (editado por N. M. López), pp. 152-177. Instituto de Antropología e Historia (IDAEH). Dirección General del Patrimonio Cultural y Natural. Ministerio de Cultura y Deportes, Guatemala C.A.

Martí, Samuel

1968 Instrumentos musicales precortesianos. Instituto Nacional de Arqueología e Historia, México.

1970 Alt-Amerika: Musik der Indianer in präkolumbischer Zeit. En *Musikgeschichte in Bildern 2, Musik des Altertums, Lieferung 7* (editado por H. Bessler y W. Bachmamnm). VEB Deutscher Verlag für Musik, Leipzig.

Miller, Mary Ellen y Karl Taube

1997 *An Illustrated Dictionary of the Gods and the Symbols of Ancient Mexico and the Maya.* Thames and Hudson, London.

Monterroso, Nancy

1999 PN23: Excavaciones en la Plaza R-20. En *Proyecto Arqueológico Piedras Negras, Informe Preliminar No. 2, Segunda Temporada, 1998* (editado por H. Escobedo y S. D. Houston), pp. 103-122. Instituto de Arqueología e Historia de Guatemala (IDAEH). Dirección General del Patrimonio Cultural y Natural. Ministerio de Cultura y Deportes, Guatemala.

Moriarty, Matthew D., Ellen Spensley, Ingrid Seyb, Crorey Lawton, y Jorge Cazali Guzman

En prensa Excavaciones de Sondeo, Continuación del Mapeo y la Prospección de Basureros en la Trinidad de Nosotros en el 2005. En Proyecto Arqueológico Motul de San José, Informe #7, Temporada de Campo 2005 (editado por E. Spensley, M. D. Moriarty y C. Lawton). Informe que será entregado al Instituto de Arqueología e Historia de Guatemala (IDAEH). Dirección General del Patrimonio Cultural y Natural. Ministerio de Cultura y Deportes, Guatemala.

Pendergast, David M. y Elizabeth Graham

1981 Fighting a Looting Battle: Xunantunich, Belize. Archaeology 34 (4):12-19. New York.

Rawecliffe, Susan

1992 Complex Acoustics in PreColumbian Flute Systems. En *Musical Repercussions of 1492, Encounters in Text and Performance. Part 1: Music of the Ancient Americas* (editado por C. E. Robertson), pp. 35- 63. Smithonian Institute Press, Washington.

Sahagún, Fray Bernadino de

1950- 1982 *The Florentine Codex: General History of the Things of New*

Spain (12 Vols.). University of Utah Press, Santa Fe.

Schóndube Baumbach, Otto

1986 Instrumentos musicales del Occidente de México: Las tumbas de Tiro y Otras Evidencias. *Relaciones* 7: 91-93. México.

Tedlock, Dennis

1996 *Popol Vuh: The Maya Book of the Dawn of Life and the Glories of Gods and Kings.*

(Rev. ed.). Simon and Schuster, New York.

Thompson, Eric S.

1962 A catalogue of Maya glyphs. University of Oklahoma Press, Oklahoma.

Valdés, Juan Antonio, Mónica Urquizú, Horacio Martínez, Carolina Díaz Samayoa

2001 Lo que expresan las figurillas de Aguateca acerca del hombre y los animales. En *XIV Simposio de Investigaciones Arqueológicas en Guatemala, 2000* (editado por J. P. Laporte y H. Escobedo), pp. 761-787. Museo Nacional de Arqueología y Etnología, Guatemala.

Velázquez Cabrera, Roberto

2006 Ancient Noise Generators. *En Studien zur Musikarchäologie V, Orient-Archäologie* 20 (editado por E. Hickmann, A. A. Both y R. Eichmann), pp. 255-272. VML, Rahden/Westfahlen.

Willey, Gordon R.

1972 *The Artifacts of Altar de Sacrificios.* Papers of the Peabody Museum of Archaeology and Ethnology 64 (1). Peabody Museum, Cambridge.