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The Study of Shell Object Manufacturing Techniques from the Perspective of Experimental Archaeology and Work Traces

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1. Introduction

The techniques employed to manufacture mollusk shell objects in pre-Hispanic Mexico have been little studied to date. This may in part be attributed to the fact that, as in the case of the majority of precious materials, these pieces are found as already finished pieces in funerary or votive offerings in construction; the discovery of evidence of their production—such as rejected pieces, workshop waste, or discarded tools—is rare; only occasionally is such material found in trash deposits, construction fill, or sometimes where the shell objects were actually produced. Given this general scarcity of information, two research projects devoted to shell object manufacturing techniques have been conducted at the Templo Mayor Museum in Mexico City. To overcome the lack of information stemming from the paucity of direct indicators of production, researchers have turned to experimental archaeology and the characterization and comparison of manufacturing traces. The present article describes the theoretical-methodological foundations of these projects and presents the principal results obtained to date concerning shell pieces found in offerings in the sacred precinct of Tenochtitlan.

2. Background

A review of research on shell object production techniques for societies that did not use metal tools in different parts of the world (Oceania, Asia, Europe, South America, the Caribbean, North America, and more specifically Northern Mexico and Mesoamerica)¹ has made it clear that the identification of instruments utilized in making shell objects has been based on their association with production evidence in the archaeological contexts of the respective discoveries. The result of this method has been the reconstruction of different steps in the production sequence, which are occasionally based on historical or ethnographic information. Rarely is any attempt made to corroborate the inferences arising from contextual relationships, which is a problematical approach because often the deposits where the objects were found were not production zones, but rather trash heaps that might

¹ See Allen et al., 1997; Dacal, 1978; Dales & Kenoyer, 1977; Di Peso, 1974; Fash, 1991; Feinman, 1999; Feinman & Nicholas, 1995; Flannery & Winter, 1976; Gómez, 2000; Hartzell, 1991; Haury, 1976; Hocquenghem & Peña, 1994; Hohmann, 2002; Kenoyer, 1989; Mayer, 1997; Miller, 1996; Suárez, 1977; Turner, 1987; Vargas et al., 1993; Villalpando & Pastrana, 2003; Woodford, 1908; Yerkes, 1983.

contain waste material from many different types of activities. In exceptional cases, experiments have been conducted to test hypotheses concerning production processes, which although they might increase the probability that these were indeed carried out, they in no way conclusively confirm these processes. Seldom are work traces present on the pieces examined, even though they might in fact constitute the best evidence to propose or reject the use of specific manufacturing techniques.

Given these reservations, several general conclusions can be reached concerning the processes and tools reported for working shell in societies based on a lithic technology. In many of the cases reviewed, reference is made to percussion—understood as the action of striking one material with another, generally of greater hardness—as the first step in the manufacturing process, which, according to different authors was carried out with hammers and stone anvils. This same technique was sometimes employed to produce preforms. Different forms of abrasion were then used to shape irregular pieces of shell, to correct irregular edges, to smooth and polish surfaces, to cut, perforate, and even work decorations. The tools used for these purposes were passive surfaces for abrasion (stone slabs, rounded rocks, grinding stones) and active stone instruments; and lithic implements made of flint, obsidian, or slate, such as flakes, blades, knives, and points. Occasionally the use of sand as an abrasive and water is mentioned, together with the above-mentioned utensils, as well as cords for cutting and incising, reed perforators, and cactus spines. Noteworthy is the research conducted at the Inca site of Tumbes, Peru, where evidence suggests that surface abrasion of the valves was the first step in the manufacturing process and apparently no type of percussion was used to produce the objects (Hocquenghem & Peña, 1994). Information on other specific techniques includes heating shells of the *Olivella* genus in Davies, California, a treatment used to turn them uniformly white and to facilitate cutting, abrasion, and perforation in bead production (Hartzell, 1991); and decoration engraved with acid that was practiced in Snake Town, Arizona (Haury, 1976).

3. Experimental archaeology projects

Experimental archaeology, together with ethno-archaeology, form part of so-called middle range theories, which make it possible to infer the social dynamics of the past from archaeological contexts, which are static moments of the present and that have undergone changes resulting from diverse factors, from their formation to the moment of their excavation (Binford, 1977:6; Gándara, 1990:74). Experimental archaeology is based on replicating past events, which can range from producing a tool to the simulation of a way of life, under controlled conditions (Callender, 1976:174). To design experiments, numerous factors should be considered, such as the utilization of the materials and tools characteristic of the society and the historical moment that is being studied. Particular importance should be given to “uniformitarian suppositions”, which makes it possible to infer that what is happening in the present was what occurred in the past (Binford, 1991:22).

3.1 The conchological material experimental archaeology project

In 1997 the first experimental archaeology project on shell materials was begun at the Templo Mayor Museum; its principal objective was to augment knowledge of the manufacturing techniques employed in the production of almost 2,300 conchological objects found in the offerings excavated by the Templo Mayor Project in the central religious building in

Tenochtitlan, the capital of the Aztec Empire, and its nearby structures. The basic assumption was that the use of a specific tool, made from the same material as used in ancient times, employed in a specific way should project characteristic and differentiable features (Ascher, 1961). In this way, determining the traces produced by the different techniques and implements tested could be identified in archaeological materials. Therefore, the analysis and comparison of manufacturing traces was defined as the principal uniformitarian criterion.

The materials for experimentation were the same shell species that were used to make the objects from the Aztec offerings. The tools used were those that were typical in the Basin of Mexico at the time of the Mexicas (i.e., Aztecs), based on archaeological finds and information from documentary sources. The entire range of modifications (abrasion, cutting, perforation, incision, and openwork) based on typological analysis and known to have been used to transform the raw material into the objects studied were performed.

The project began with a phase of exploratory experimentation (Gibaja Bao, 1993:12), which permitted determining the diverse factors that had to be systematically taken into account in all of the experiments, which resulted in the creation of a format. It consisted of a progressive number for each experiment, its name, its objective, the materials utilized, their initial and final measurements, the time it took and the processes carried out, in addition to observations. Furthermore, photos were taken of the materials prior to the start of the experiments, the work phase(s), and the final result (figure 1).

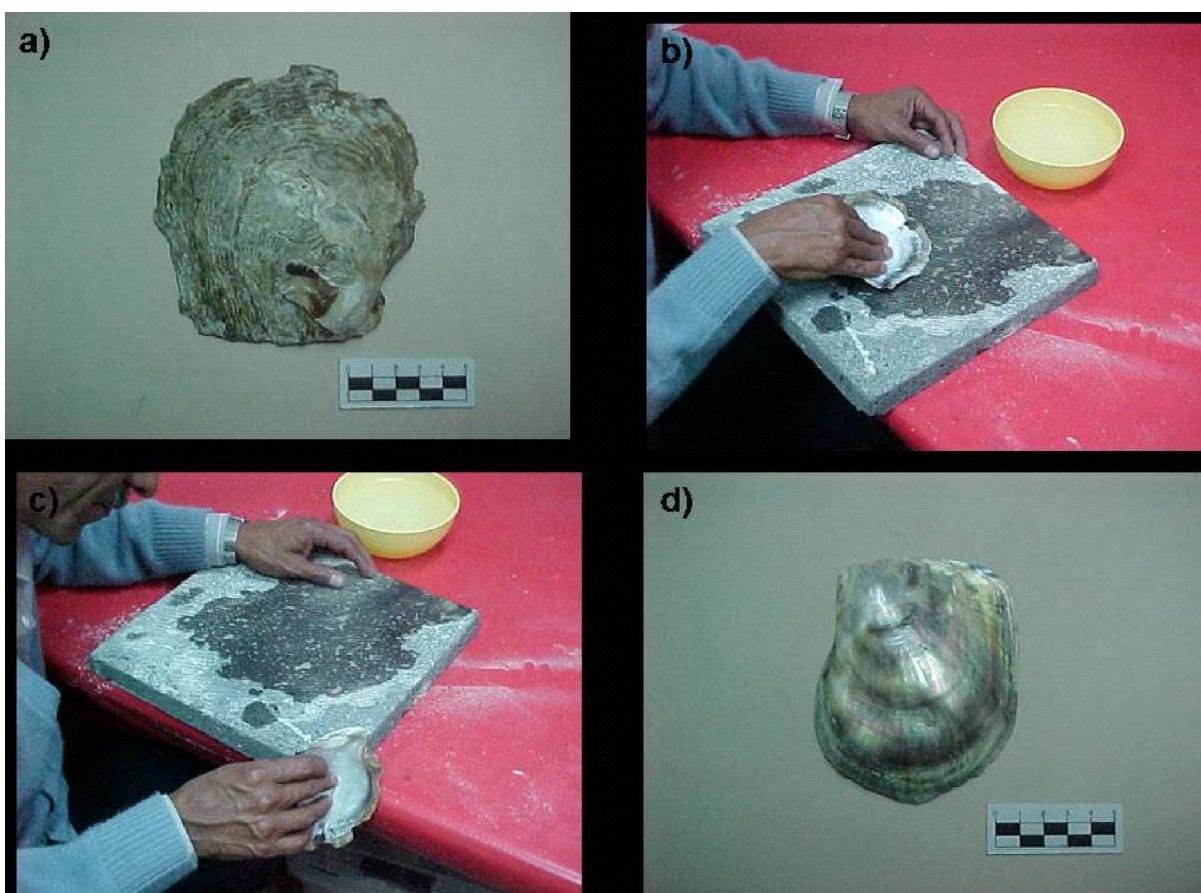


Fig. 1. Work process of abrasion of outer and middle layers of *Pinctada mazatlanica*: unmodified material (a), abrasion process (b & c), final result (d). Photos: SOMTPM.

Analysis of manufacturing traces was conducted at both a macroscopic level (the naked eye) as well as with the help of low amplification microscopy; 10x and 20x magnifiers were used, as well as an Olympus stereoscopic microscope, model TLZ S2-STS, yielding photos with a magnification of 10x, 30x, and 63x. The results of this first phase were encouraging. For example, it was possible to determine that for the identification of techniques such as percussion, it was not necessary to employ any sort of magnifying device, because the characteristic irregular edges that it produced were clearly visible to the naked eye (figure 2). It was determined that the use of lithic tools to perform abrasion on surfaces or edges, cuts, perforations, and incisions produced clearly marked scratched patterns that could even be identified without magnification (figure 3); these traces differed considerably from the traces left by the use of abrasives, whose fine lines are imperceptible on a macroscopic level, barely distinguishable at a magnification at 10x or 30x (figure 4). However, it was also evident that with the means of observation employed it was not possible to differentiate between the traces left by similar tools made of different materials. This was the case of obsidian and flint instruments, which indistinctly produced similar patterns of straight, parallel lines on cuts, or else concentric linear patterns on perforations (figure 5).

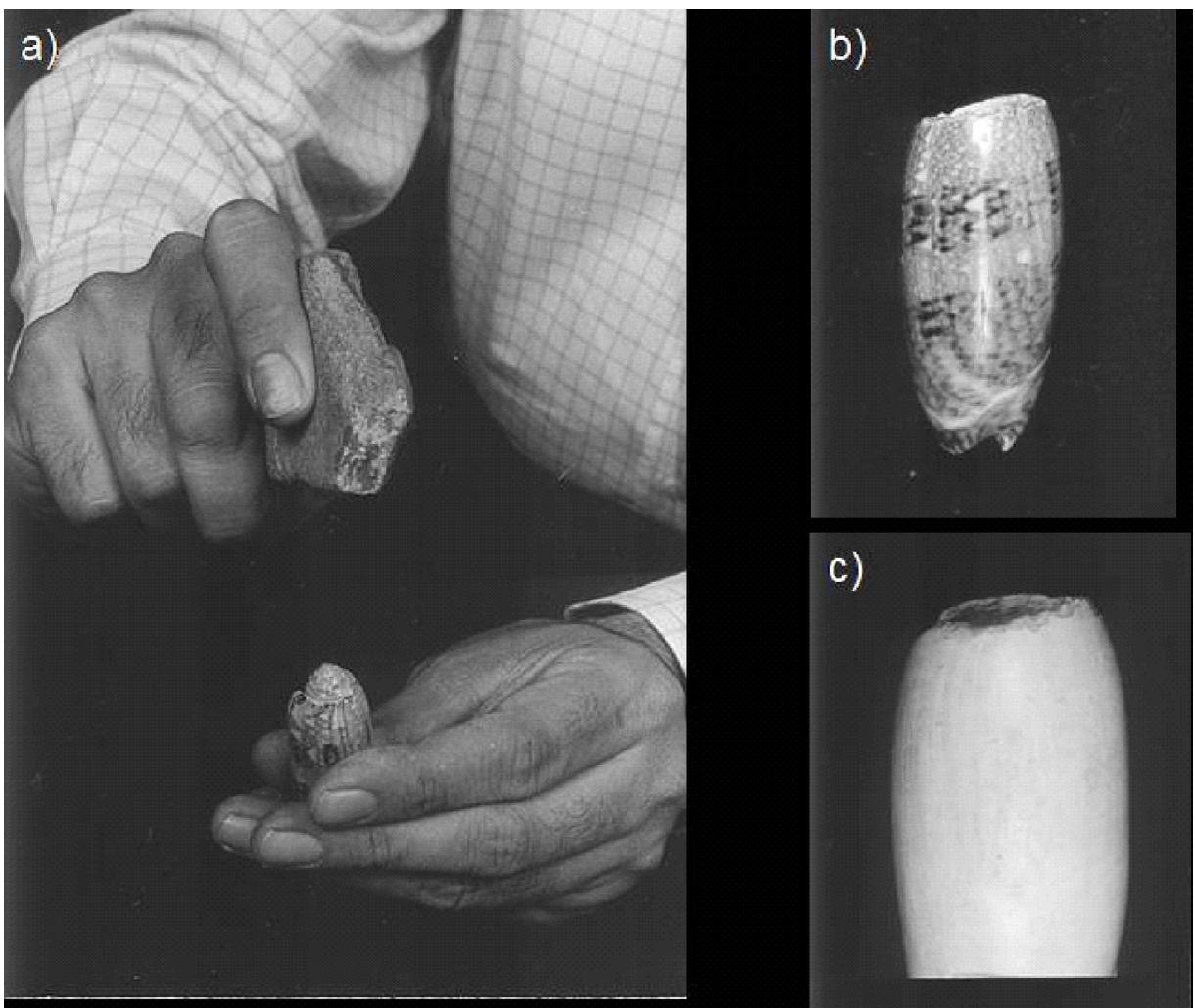


Fig. 2. Process of removing spire from an *Oliva sayana* shell (a), experimental result (b), archaeological piece (c). Photos: G. Zúñiga.

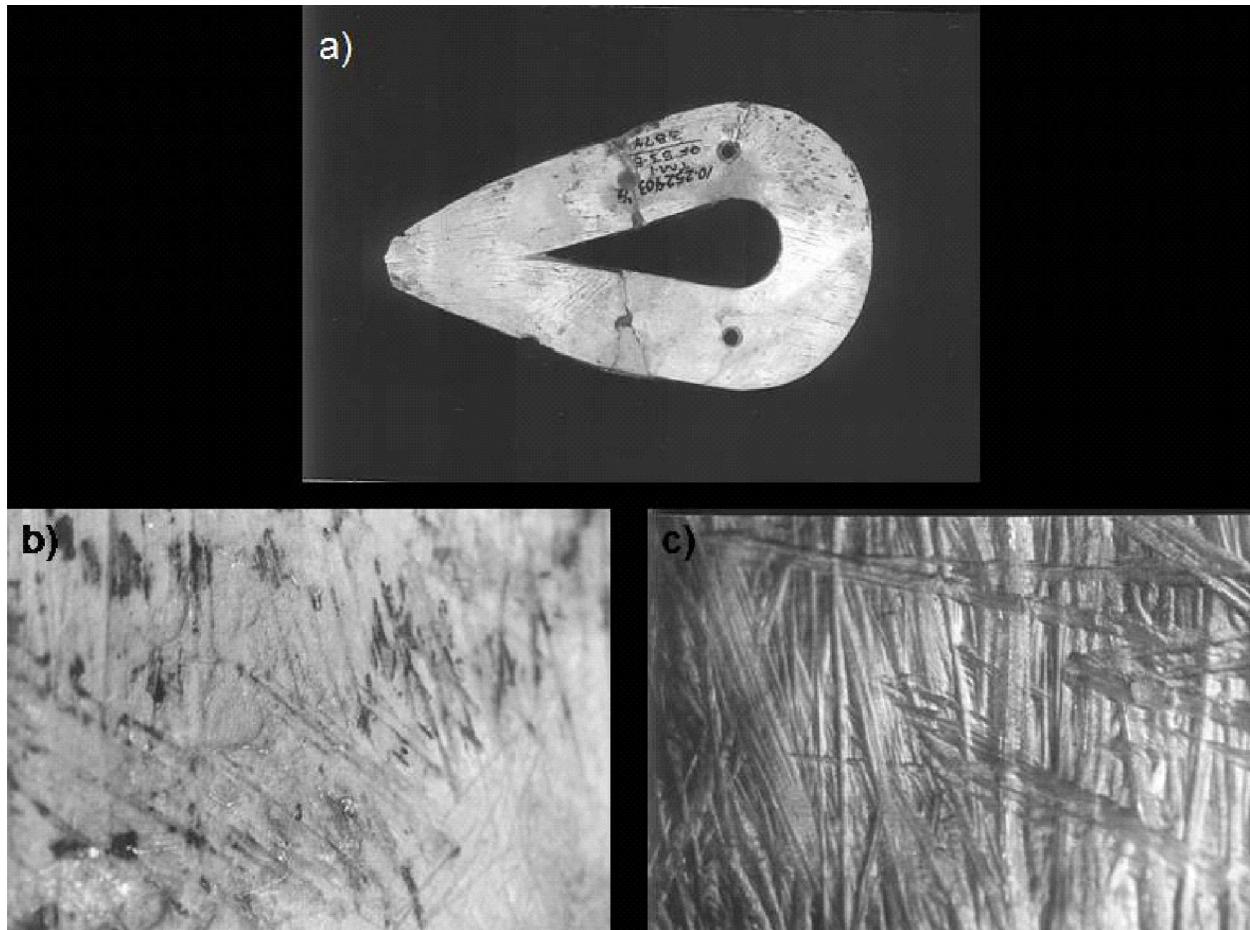


Fig. 3. Archaeological *Pinctada mazatlanica* piece with surface scratches visible to the naked eye (a), magnified 10x (b), experimental scratches produced by abrasion with basalt magnified 10x (c). Photos: G. Zúñiga & J.L. Alvarado

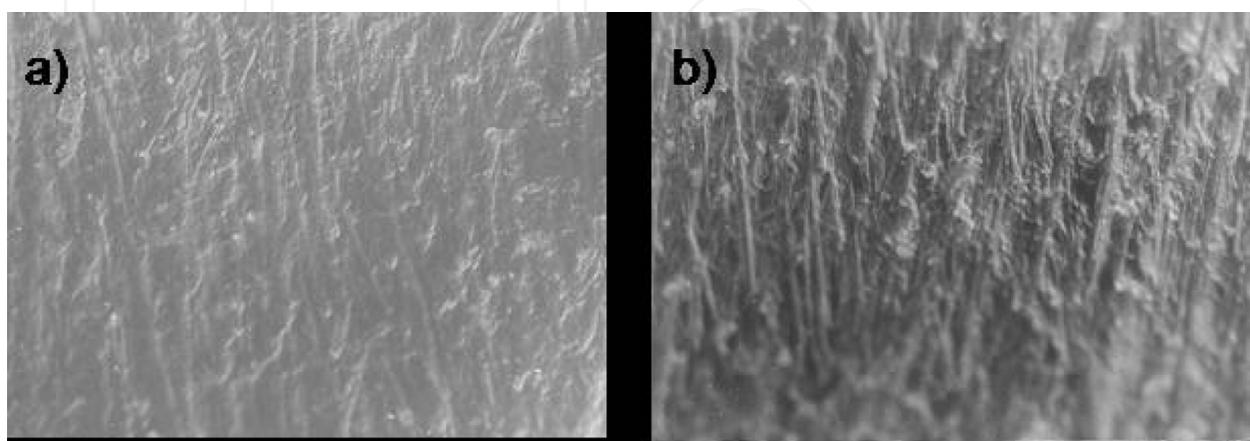


Fig. 4. Traces produced by abrasion with basalt and sand on a *Pinctada mazatlanica* valve magnified 10x (a) magnified 30x (b). Photos: J.L. Alvarado.

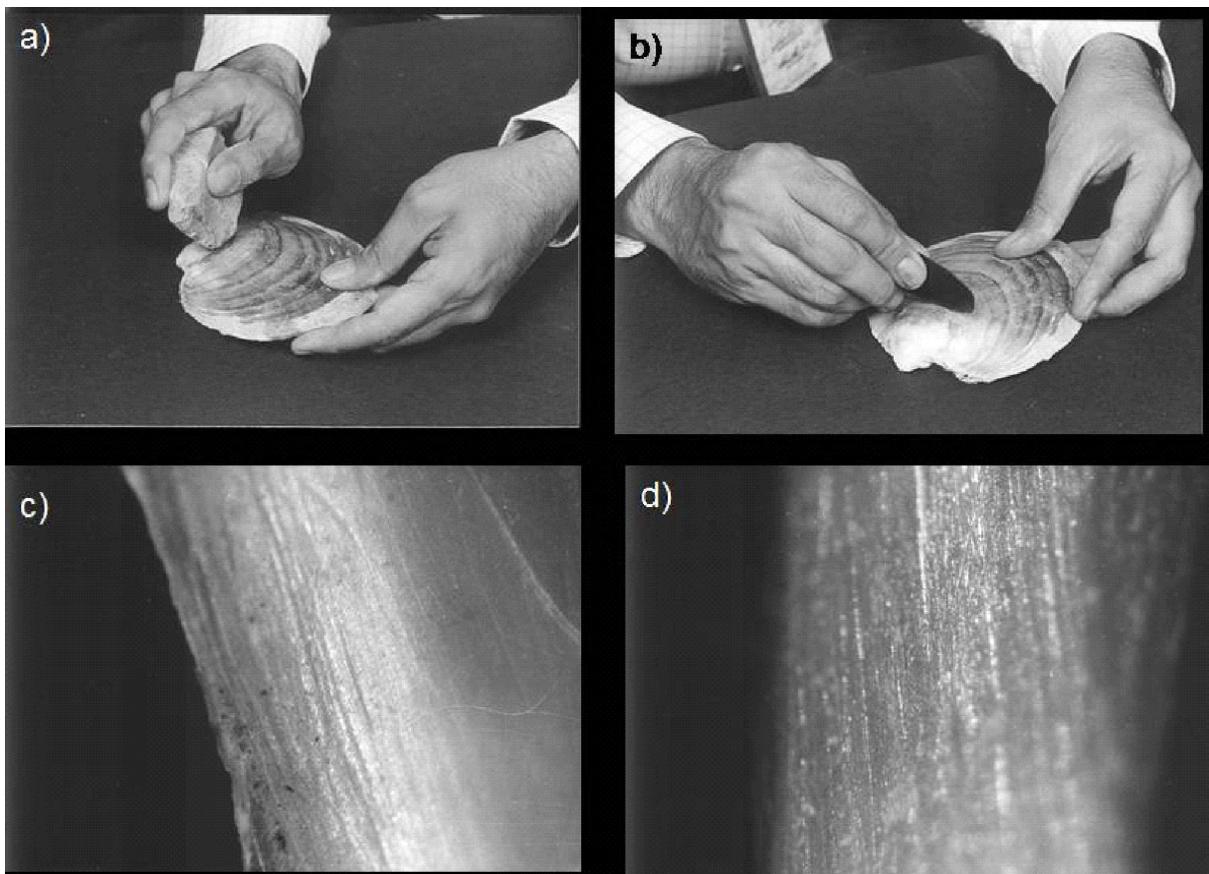


Fig. 5. Process of cutting a *Pinctada mazatlanica* valve with flint tools (a) with obsidian tools (b); traces of the cut magnified 30x worked with flint flake (c) and obsidian flake (d). Photos G. Zúñiga & J.L. Alvarado.

3.2 The Shell Object Manufacturing Techniques in Pre-Hispanic Mexico project (SOMTPMP)

The need for observation techniques that would allow for greater precision in analysis led to establishing contact with the Instituto Nacional de Investigaciones Nucleares (ININ), specifically with Dr. Demetrio Mendoza Anaya, who works with high- and low-vacuum scanning electronic microscopy (SEM). SEM is an ideal technique for the analysis of the surface characteristics of materials. For this technique a high-energy beam is aimed at the sample, which produces electrons and other signals that are captured by special detectors; based on this process it is possible to form a highly detailed digital image of the surface of the material, permitting characterization of its topology, texture, porosity, and other features. In early microscopes it was necessary for the sample chamber to be in a high vacuum, so the samples had to be conductors of electricity; and for those that were not conductors, they had to be coated with a fine layer of metal. However, in recent models it is possible to make observations in a low vacuum and even at environmental pressure, which has made it possible to analyze moist, organic materials without any coating. SEM permits extremely high magnification (theoretically as high as 300,000x), also enabling semi-quantitative analyses of the elemental composition of the samples. Prior to the observation of manufacturing traces, it was necessary to become familiar with the structural characteristics of shells; the surfaces of various modern biological specimens, as well as

parts of them that had been previously corroded by immersion in acetic acid were observed for this purpose; this allowed for discovery of the inner layers of the material without having to resort to the intervention of any type of tool.

At the start of the project, a number of archaeological pieces were taken to the SEM lab; this presented certain complications, because to move the material it was necessary to request special permission and the samples had to be escorted by security guards. In addition, the size and shape of some of the pieces hindered their analysis, because the microscope's sample chamber is relatively small (approximately 10 x 10 cm) and it is not possible to produce a clear focus on elements that are not flat (i.e., that are curved or three-dimensional). Therefore, tests were made to produce replicas in polymers softened with acetone, which were pressed onto the zones of the objects to be analyzed (figure 6) and later they were covered with gold ions for their observation in a high vacuum. The replica method, typical of metallography, avoided having to move the archaeological materials, because the polymer samples were produced in the repositories where the original material was kept; it made it possible to examine pieces that would not have fit into the microscope's sample chamber and also to produce high-quality images of modifications that did not conform to a flat plane, such as perforations; finally, it facilitated work sessions in which up to twenty samples could be examined in a two-hour session. Based on the experience of these initial analyses, the decision was made to undertake systematic observations of manufacturing traces at 100x, 300x, 600x, and 1000x, because at higher magnification the crystalline structure of the material dominated the image. For

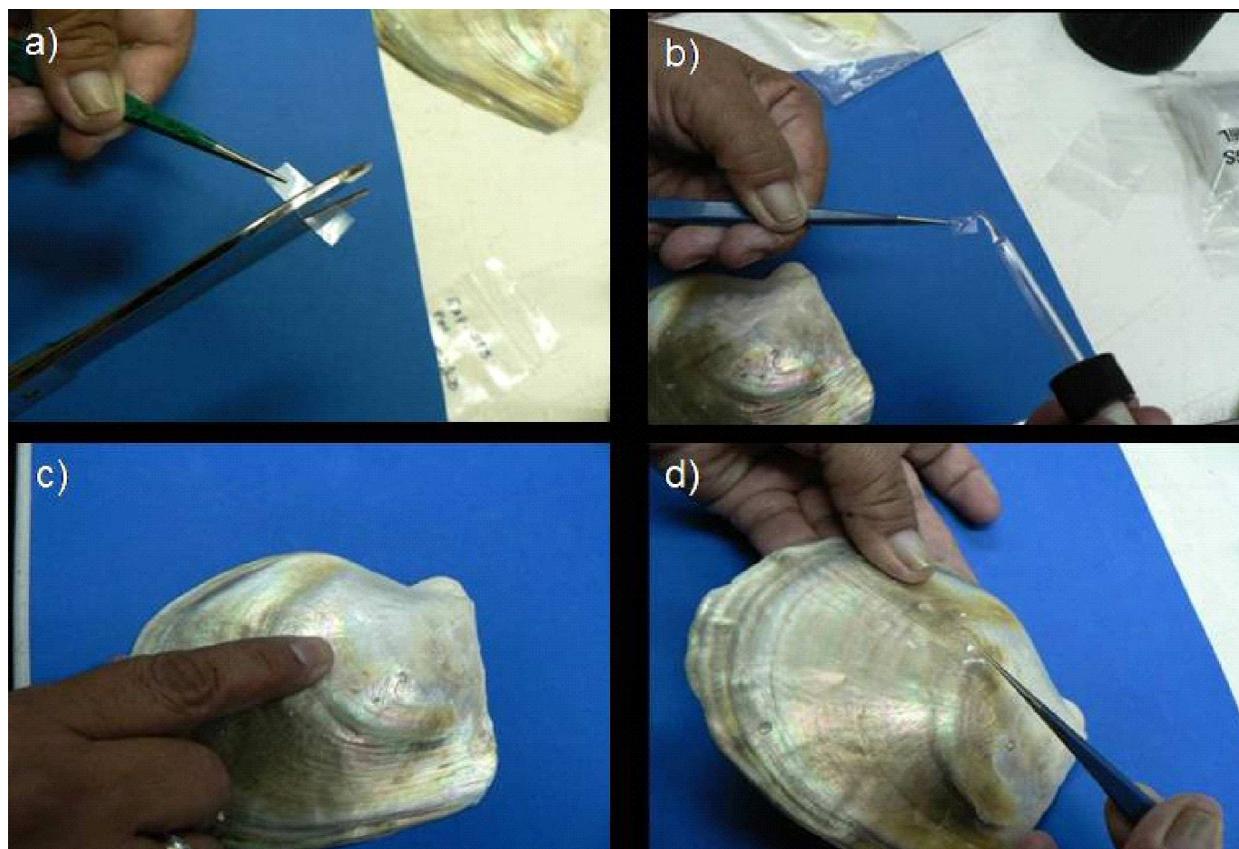


Fig. 6. Obtaining polymer replicas of manufacturing traces: cutting the polymer (a), moistening it with acetone (b), pressing it against the object (c), obtaining the replica (d). Phtos: A. Velázquez.

purposes of characterizing work traces, it was necessary to describe their shape (lines, bands, particles), their thickness, their tendency to form larger elements (agglomerations of lines or bands), the appearance of surfaces (smooth, rough, porous), among other traits. As a result of this technique, it has been possible to find patterns of work traces that permit the establishment of clear distinctions between materials, which permit their identification in archaeological objects (figure 7); now traits that seemed undifferentiated at low magnifications can be distinguished with SEM (figure 8).

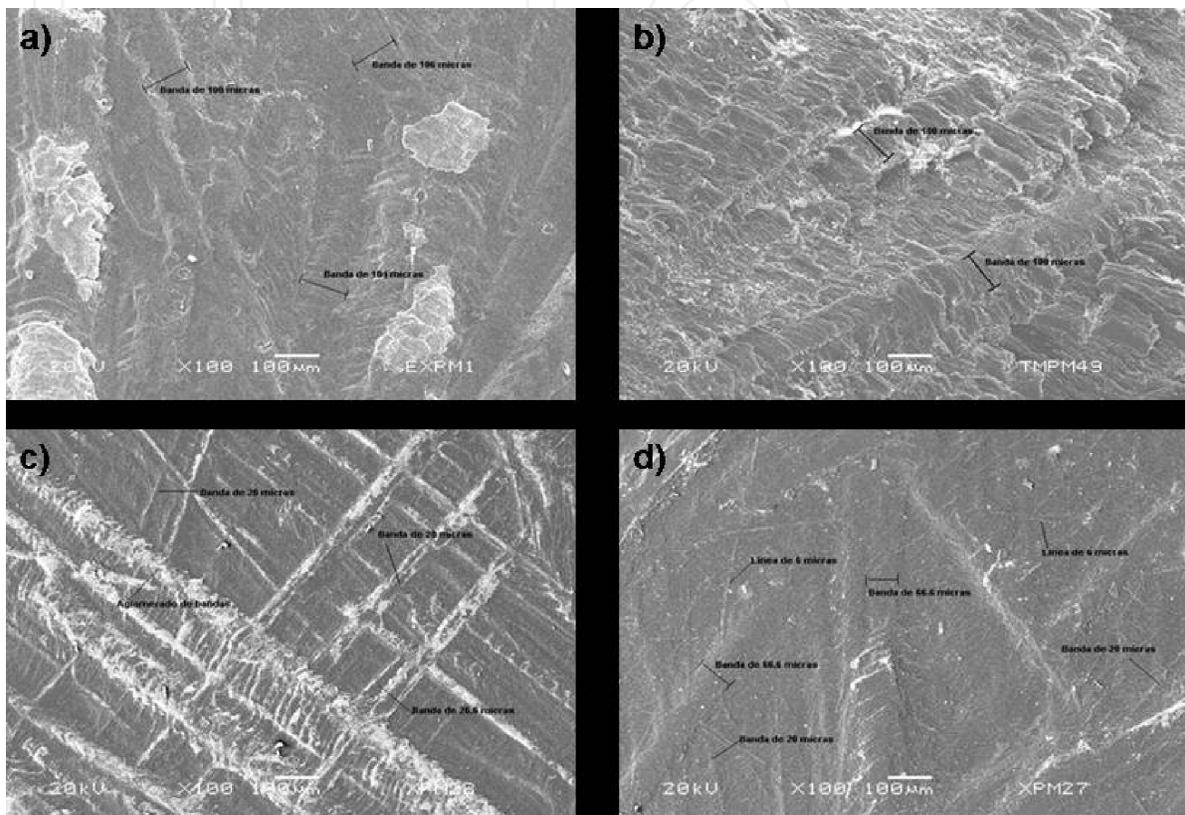


Fig. 7. Abrasion traces on *Pinctada mazatlanica* valves seen with SEM at 100x: basalt (a), archaeological piece from Templo Mayor of Tenochtitlan (b), rhyolite (c), and limestone (d). Photos: SOMTPMP.

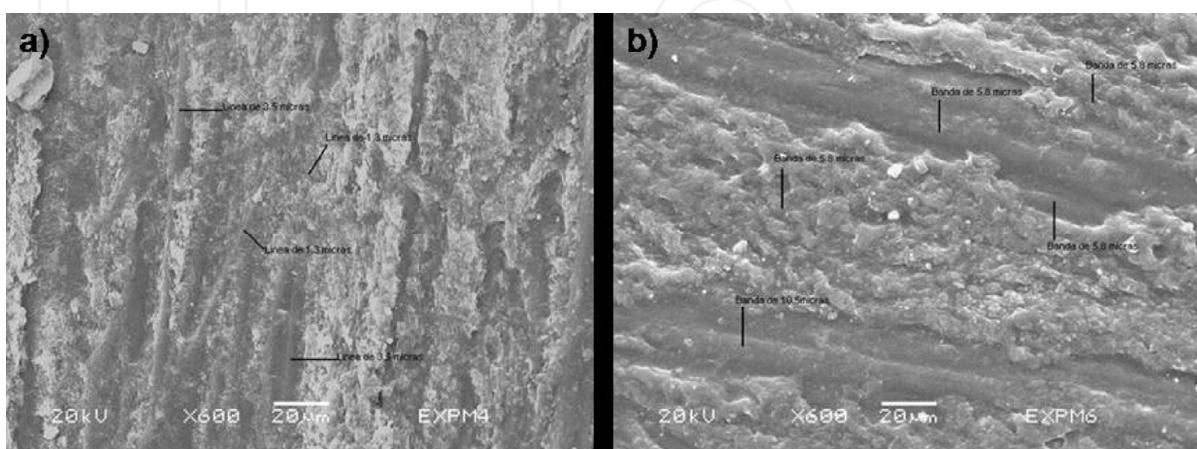


Fig. 8. Traces of cutting on *Pinctada mazatlanica* valves seen with SEM at 600X: obsidian flake (a) and flint flake (b).

As its name indicates, this project – which was formally instituted in 2000, when the specific collaboration agreement between the INAH (Instituto Nacional de Antropología e Historia) and ININ was signed – has studied and continues to research shell materials from different sites and periods of pre-Hispanic Mexico. The researchers have included the present author, as well as undergraduate and graduate students in Archaeology; the project has grown by increasing the materials and tools used in experimentation. Therefore, it has been necessary to establish a methodology that consists of the following steps:

1. Analysis of the material, which consists of the biological identification of the species and the characterization of its morphological and functional typology. During this phase, it is necessary to research the type of materials and tools that appear at the site or in the region of study and it is useful to conduct experiments with materials that have not been studied before.
2. Parallel to this phase, observations are made of the manufacturing traces with the naked eye and with the help of 20x magnification.
3. Selection of a sample to obtain photos at low magnification with a stereoscopic microscope (10x, 30x, and 63x). Specimens should include recurrent traits as well as uncommon features in the archaeological collection.
4. Based on the results of the preceding phase, the selection is made of the sample of objects from which replicas will be made.
5. Observation of the replicas with SEM (100x, 300x, 600x, and 1000x).
6. Analysis of the micrographs and comparison with the project's database of experimental work traces.

To date more than 700 experiments (table 1) have been carried out and archaeological collections spanning roughly 2700 years of the pre-Hispanic history of Mexico (1250 BC to AD 1521) have been studied. The experiments include material from sites in the Maya zone (Moral-Reforma, Tabasco; Calakmul, Campeche; Oxkintok and Xuenkal, Yucatán; CALICA, Oxtankáh, Ichpaatun and Kohunlich, Quintana Roo), from the Central Highlands of Mexico

Modifications	Tools
Abrasion	Basalt, andesite, rhyolite, granite, sandstone and limestone, adding water and occasionally sand
Cuts	Abrasives (sand and powdered obsidian), water and strips of leather; flint and obsidian lithic tools (flakes with sharp edge reworked by pressure and percussion: scrapers, knives, and blades)
Perforations	Abrasives (sand, volcanic ash, and powdered obsidian and flint) used with reed stalks, adding water. Flint and obsidian lithic tools
Openwork	Abrasives (sand, volcanic ash, and powdered flint) used with reed stalks wide in diameter, adding water. Flint and obsidian lithic tools
Incisions	Flint and obsidian lithic tools
Finishes	Polished with abrasives (sand and volcanic ash), water and pieces of leather; polished with flint nodules. Burnished with pieces of dry leather. The use of both finishes

Table 1. Modifications and tools used in the experiments

(Las Bocas and Cantona, Puebla; Teotihuacan and Xaltocan, State of Mexico; Xochicalco, Morelos; Tula and Tizayuca, Hidalgo; and Tenochtitlan, Mexico City), from the state of Guerrero (Teopantecuanitlán, Pezuapan and Malinaltepec), Oaxaca (Monte Albán), the Gulf of Mexico (Tlacojalpan, Veracruz; Tamtoc, San Luis Potosí, and sites in the valleys of the Sierra Gorda in Querétaro); West Mexico (La Presa del Cajón, Nayarit, and sites in the Sayula Basin, Jalisco), Northern Mexico (Chalchihuites, Altavista, Pajones, and Cerro Moctehuma, Zacatecas, and sites in northern Sinaloa and Nuevo León).

4. Results from the study of Aztec shell objects

The Mexicas or Tenochca, as the Aztecs are also known, established the largest empire in Mesoamerica during the Late Postclassic period. According to sources written in Spanish from the time of the conquest, in a lapse of less than two hundred years (1325–1521), they went from being a semi-nomadic group of recent arrivals in the Basin of Mexico to a tributary of the Tepanecs of Azcapotzalco, to ultimately forge a vast empire conquered by force, which extended as far north as the Huastec region, and as far south as Soconusco, encompassing settlements from Atlantic to Pacific coasts of the territory today comprising Mexico. Their capital, Tenochtitlan, located in the heart of modern-day Mexico City, inspired awe among the Spanish conquerors for its magnificence, scale, and order (Díaz, 1986:160 & 173). From 1978 to the present, the Templo Mayor Project has been in charge of the excavation and study of all the archaeological vestiges found in the area occupied by the ceremonial center of the Aztec capital (Matos, 1990:27). Seven construction stages or phases of major architectural expansion have been identified at the Templo Mayor (Great Temple) and in the surrounding ceremonial precinct (Matos, 1988:176), which have served as the basis for a chronology. Based on this sequencing, the first stage corresponds to the foundation of Tenochtitlan, which occurred in 1325; the second, to the first three Mexica rulers (Acamapichtli, Huitzilihuitl, and Chimalpopoca); and the following, to successive kings (*tlatoque*, “great speakers” as the emperors were known [*tlatoani* in singular]) (Itzcoatl, Moctezuma I, Tizoc, Ahuizotl, and Moctezuma II), with the exception of a partial expansion known as stage IVb, which was attributed to Axayacatl (Matos, 1988:64, 70, 73, 74 & 176).

What stand out among the vast quantities of discoveries made by the Templo Mayor Project are the ritual deposits composed of objects, referred to as offerings, which were buried in and around the structure of the Templo Mayor and the buildings in the sacred precinct; they now number almost 200 offerings in total. These deposits display striking variability in terms of their arrangement, the type of receptacle containing them, their composition, and the placement of their diverse contents. The study of forty-eight offerings buried in the Templo Mayor and the nearby structures dealt with a total of 2,245 complete shell pieces and 745 fragments (Velázquez, 1999:117). The materials employed for the production of these elements came from both Atlantic and Pacific coasts of Mexico, and the corpus yielded the identification of three classes (Gastropoda, Bivalvia, and Polyplacophora), 14 families, 16 genera, and 15 species (Velázquez, 1999:116). The collection of shell objects is comprised of ornamental pieces (pendants, pectorals, inlays, beads, earflares, noseplugs, and lipplugs), musical instruments (trumpets), and what seem to be purely votive elements (an anthropomorphic plaque, a disk with an incised spiral, the representation of spearthrowers, slightly flaring rectangular objects, a disk with four perforations, a pigmented gastropod, worked valves, and a section of a columella) (Velázquez, 1999). Although shell objects

predating stage IV of the Templo Mayor, which corresponds to the reign of Moctezuma I—a time of the conquest of settlements in the region of the Gulf Coast of Mexico—have not been found to date, there does not seem to be a direct relationship between the presence of this type of materials and Mexica imperial expansion. It should be pointed out in this regard that the large quantity of specimens from the Pacific in the above-mentioned architectural expansion, as well as in stages IVb and V, predate the conquest of settlements on the Pacific coast, which took place during the rule of Ahuizotl, who is linked to stage VI.

As a result of the bellicose nature of Mexica society, one of its principal motivations for its expansionism was the collection of tribute. Little attention has been given to the effects of tribute on Aztec material culture, much of which has traditionally been regarded as foreign in nature (i.e., not produced in the capital). For example, it has been posited that the majority of the manufactured objects from the Templo Mayor offerings were acquired through tribute, trade, gift-giving, or looting (López, 1993:137). Specifically in terms of shell objects, Matos does not regard them as Mexica products (Matos, 1988:92-101) and there is a deeply rooted idea in academic circles that shell objects were produced on the coasts. However, despite the non-local character of the raw materials, what is puzzling is that many of these objects represent iconographic elements characteristic of Nahua deities from Central Mexico. This is the case of the ring-shaped *anahuatl* pectorals, associated with Tezcatlipoca (Smoking Mirror) and bellicose stellar deities; the droplet-shaped *oyohualli* pendants of Tlahuizcalpantecuhtli (Venus as the Morning Star) and divinities of music and dance; the crescent *yacametzilti* noseplug of goddesses of the moon and pulque, to name only a few (Velázquez, 2000) (figure 9). It is important to emphasize that many of these objects are

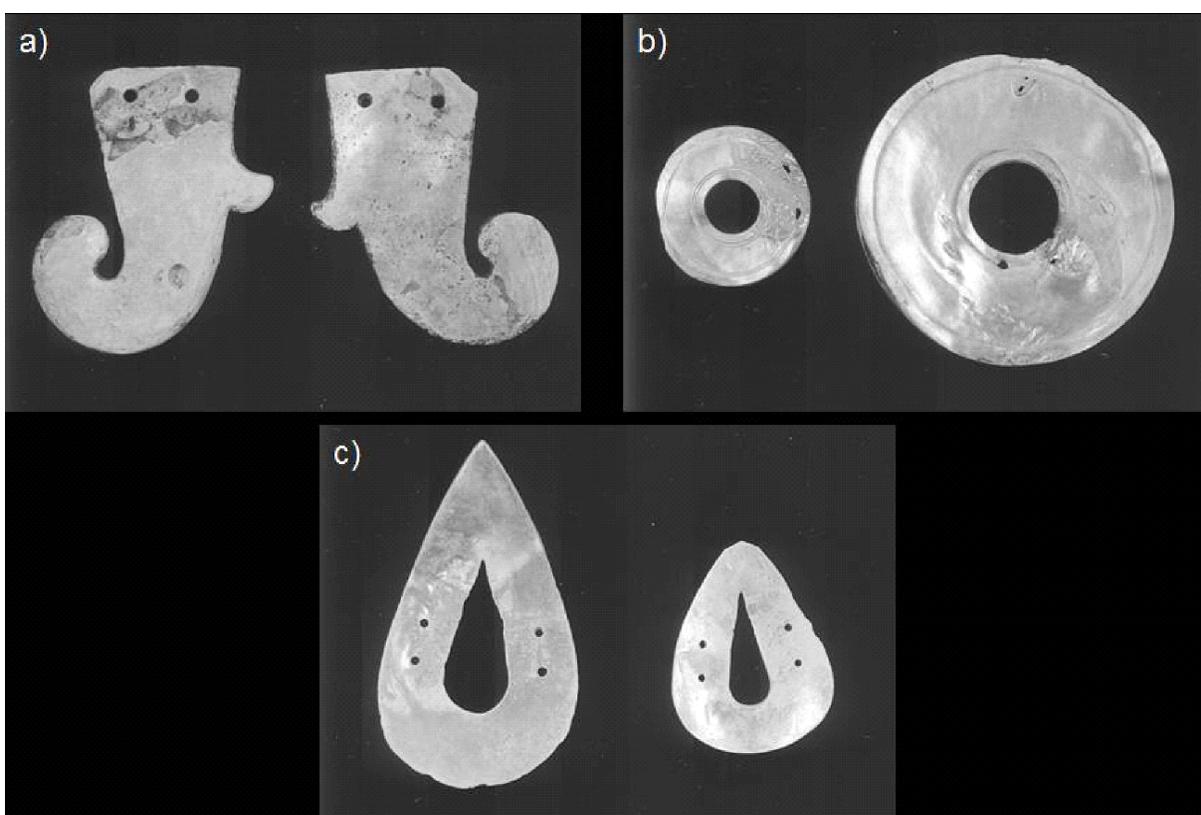


Fig. 9. *Pinctada mazatlanica* objects found in Mexica offerings: *epcololli* ear ornaments (a), *anahuatl* pectorals (b), and *oyohualli* pendants (c). Photos: G. Zúñiga.

found almost exclusively in the offerings found in the Templo Mayor itself and are absent in many of the neighboring buildings; significantly, no specimens identical in shape or raw material have been found at any other site in the Basin of Mexico. An interesting example is the spiral-shaped *ehcacozcatl* (wind jewel) found at Hualquilla, Iztapalapa, which differs noticeably from specimens from Tenochtitlan, because the former was made of *Strombus gracilior* and displays perforations for suspension, while the latter are invariably made of *Turbinella angulata* and bears no bored holes (Mancha, 2002:212-215; Velázquez and Melgar, 2006). Therefore, many of the shell pieces appear to be exclusive, not only to Tenochtitlan, but to its most hermetic and elite ritual practice, namely the interment of offerings in the empire's principal temple. This in itself strongly suggests their manufacture must have been local and controlled by the state apparatus.

The study of manufacturing techniques employed in shell objects from Tenochtitlan offerings was carried out initially on a representative sample composed of pieces of the Pacific, *Pinctada mazatlanica* pearly bivalves and shell pendants of the *Oliva* genus, whose different species come from both the Pacific and Atlantic (figure 10). These elements were selected because they were the most numerous in the collection; together they form 61.46% of the complete pieces in the overall research corpus: 595 complete objects and 605 fragments of *Pinctada mazatlanica* and 785 pendants and 106 fragments of *Oliva* shells (1380 complete pieces and 711 fragments in total). They appear in the largest number of offerings



Fig. 10. Shell pendants of the *Oliva* genus from offering in the sacred precinct of Tenochtitlan. Photo: G. Zúñiga

(32 of the former and 35 of the latter), and they are the only shells that were present in all construction stages of the Templo Mayor and the sacred precinct of Tenochtitlan in which shell objects are present (stages IV–VII). Similarly, there is a diversity of forms and modifications of the specimens (Velázquez, 1999:110–117). In addition, it is important to mention that the *Pinctada mazatlanica* objects are exclusive to offerings found at the Templo Mayor, because they are absent in votive deposits from the neighboring structures and from any other location in the Basin of Mexico. Furthermore, shell pendants in general, including those manufactured from specimens of the *Oliva* genus, show a broader distribution, because they are even found in other Late Postclassic period dominions in the Basin of Mexico. This suggests two spheres of circulation for shell objects: one free and the other restricted.

Through the analysis of manufacturing traces, the objects made of *Pinctada mazatlanica* revealed strong standardization of production techniques. In all cases the pieces displayed traces of abrasion with basalt tools on surfaces and edges; the use of obsidian tools for cutting and incised designs, and of flint perforators in round borings. The few elements that show evidence of surface finishes reveal a combination of polishing with a still-unidentified abrasive and of burnishing with a soft material, similar to leather (table 2). In the case of the *Oliva* shell pendants, although it was possible to detect a tendency toward standardization, groups of objects were also found with specific modifications, made with unique procedures and tools. One of the most frequent work processes – the removal of the shell’s spire – was evidently done in most cases through abrasion with passive tools made of basalt; in fewer cases was this performed through direct percussion; and in an intermediate number of cases combining both procedures; in only one piece was the use of powdered obsidian detected as an abrasive to cut this part of the shell. The second most important modification numerically was the making of a grooved perforation in the dorsal zone of the shell; in all cases it was done with obsidian tools. In the few examples of conical boring the use of a sand abrasive or flint perforators was detected (table 3).

Modification	Stereoscopic microscopy				Scanning electronic microscopy	
	Present	Not identifiable	Absent	Total	Identified material	Pieces analyzed
Surface abrasion with stone tools	151	54	1	206	Basalt tool	5 (IVb & VI)
Cut with lithic tools	76	36	94	206	Obsidian tool	6 (IVb, VI & VII)
Abrasion of edge with stone tools	157	49		206	Basalt tool	4 (IVb & VI)
Perforation with lithic tools	92	29	85	206	Flint perforator	6 (IVb)
Incision with lithic tools	42	16	148	206	Obsidian tool	5 (IVb, VI & VII)
Openwork with lithic tools	32	34	140	206	Obsidian and basalt tool	6 (IVb & VII)

Table 2. Manufacturing traces identified on *Pinctada mazatlanica* pieces

Modification	Stereoscopic microscopy		Scanning electronic microscopy	
	Technique	No. of pieces	Material	Pieces analyzed
Spire cut	Abrasion with passive tool	339	Basalt	9 (IVa, IVb, VI & VII)
	Percussion	94		
	Abrasion and percussion	188		
	Abrasion with active tool		Powdered obsidian	1 (IVb)
Grooved perforation	Abrasion with lithic tools	430	Obsidian tool	10 (IVb, V, VI & VII)
Conical perforation	Abrasion with abrasives	23	Abrasive sand	1 (IVb)
	Abrasion with lithic perforator		Flint perforator	1 (VII)
Total pieces analyzed: 652				

Table 3. Manufacturing traces identified on *Oliva* genus pieces

After determining the specific procedures and tools used in the manufacture of shell objects, some of the *Pinctada mazatlanica* objects that occurred in standardized forms and that appeared in several offerings and construction stages of the Templo Mayor were experimentally replicated. In addition to the opportunity to focus on particular issues related to the production of certain pieces, this made it possible to calculate, although only hypothetically, a portion of the production time that the workshop(s) must have devoted to preparing for an important ritual event: the inauguration of construction stage IVb, when ten sumptuous offerings, among the richest found to date (López, 1993:237), were interred. In this regard, suffice it to say that among the different types of objects and materials contained in these deposits, 731 pieces of shell were found, including the three types of replicated elements: the droplet-shaped pendant (*oyohualli*), the ear ornament with a volute (*epcololli*), and the round, incised, openwork pectoral (*anahuatl*). The steps to produce these pieces were as follows:

1. Removal of outer and middle layers of the shells through abrasion with a basalt tool.
2. Producing a preform, making straight cuts on the contour of elements with sharp obsidian bladed tools.
3. Correcting the preform, smoothing the edges with basalt tools. In the case of the *epcololli* ear ornament, the preform had to be made thin through friction with the rock to later shape the specific parts of the object, cutting it with obsidian tools.
4. Producing the openwork parts in the middle for the *oyohualli* pendant and the *anahuatl* pendants, cutting with sharp-edged obsidian tools and correcting the edges through abrasion with obsidian implements.
5. Making the biconical perforations, smoothed with sharpened flint tools in the *oyohualli* pendant and the *epcololli* ear ornament.

Producing two concentric incised lines with an obsidian instrument on the *anahuatl* pectoral (figure 11, table 4).

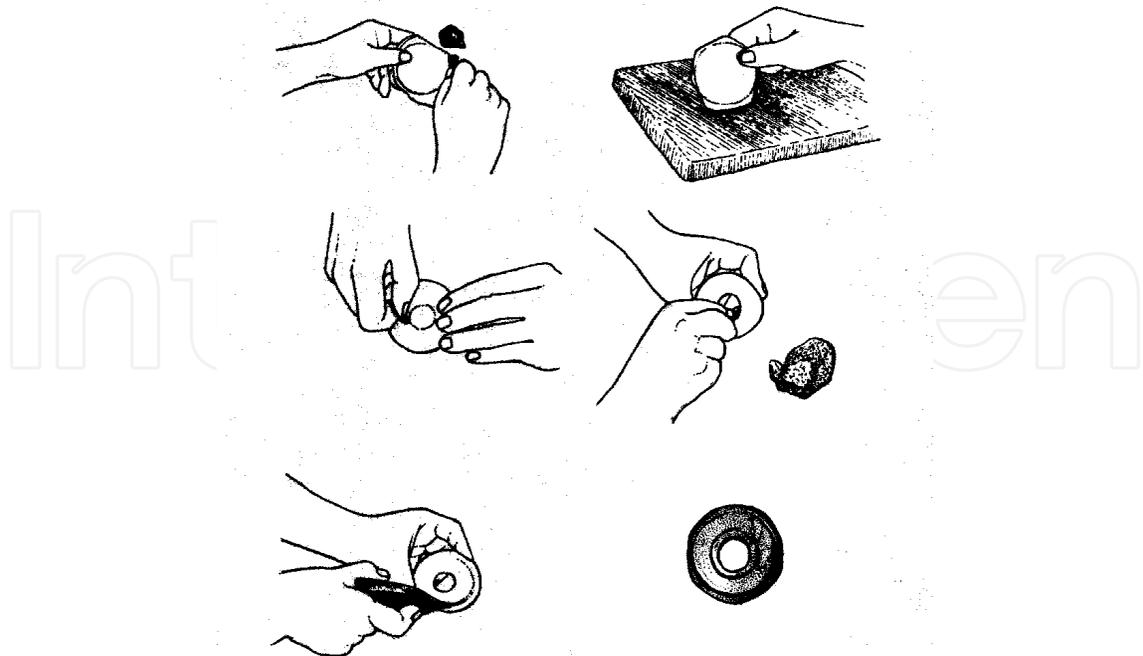


Fig. 11. Process of making an *anahuatl* pectoral. Drawing: J. Romero.

Type of piece	Number of specimens	Production time for each piece	Total time
<i>Epcolloli</i> ear ornament	11	91 hours 32 minutes	1006 hours 52 minutes
<i>Anahuatl</i> pectoral	35	39 hours 29 minutes	1381 hours 55 minutes
Droplet-shaped pendant	10	24 hours 59 minutes	249 hours 50 minutes
TOTAL			2638 hours 37 minutes

Table 4. Production times for *Pinctada mazatlanica* objects from offerings in Templo Mayor construction stage IVb

As for the *Oliva* shells, a similar calculation was made by multiplying the production times obtained in the experiments by the number of archaeological pieces displaying these features. It is worth noting that in the cases in which the deteriorated condition of the objects made it impossible to determine the specific techniques used in their production, they were regarded as the product of the more efficient processes and tools (table 5).

Discerning the processes and tools used to manufacture Mexica shell objects makes it possible to draw inferences regarding specialized production, in which specialization is understood as an institutionalized form of organizing production, in which certain groups are at least partially removed from subsistence activities, by receiving remuneration, in money or in specie, for work or knowledge that is exclusively theirs (Clark & Parry, 1990:297; Costin, 1991:3-4; Evans, 1987: 113; Longacre, 1999:44). The striking homogeneity detected in tools and techniques, in the case of *Pinctada mazatlanica* pieces, makes it possible

Modification	No. of pieces	Individual production time	Total production time
Removal of spire by abrasion using basalt	76	50 minutes	63 hours 20 minutes
Removal of spire by percussion	21	18 minutes	6 hours 18 minutes
Removal of spire by percussion and abrasion	39	35 minutes	22 hours 45 minutes
Removal of spire by unidentified means	50	18 minutes	15 hours
Grooved perforation with obsidian tools	113	41 minutes	77 hours 13 minutes
Grooved perforation with unidentified means	66	41 minutes	45 hours 6 minutes
2DRC perforation with obsidian flakes	3	1 hour 30 minutes	2 hours 30 minutes
Total modifications	368	Total time	234 hours 12 minutes

Table 5. Production times for *Oliva* genus shell pendants from offerings in Templo Mayor construction stage IVb

to infer a concentration of productive activities, because it has been proposed that standardization is indicative of large-scale production in few locations, while variability attests to production in low volumes in multiple independent workshops (Costin, 1991:35-36). This idea, together with the exclusiveness of the objects, not only in the sacred precinct of Tenochtitlan, but also in its supreme religious building, gives rise to the notion that production was local and must have been carried out under the strict supervision of the upper echelons of the priesthood—possibly in a context of dependency or patronage (Costin, 1991:5, 7 & 12)—within workshops located in the very palace of the Mexica ruler. From documentary sources we know these workshops were devoted to producing luxury goods made of feathers, lapidary stone, silver and gold (Sahagún, 1989:521). Based on the reconstruction of the hypothetical time required to make some of the most important pearly shell objects, and multiplying it by the number of elements produced for the consecration of architectural stage IVb, it has been possible to calculate the number of hours employed to produce a small part of the total number of pieces of shell buried on that occasion. Although it was an event of singular importance, for which there must have been an exceptional investment of labor, the above-mentioned calculation gives us an idea of the intensive activity that must have involved workshops producing luxury objects; it should also be recalled their production was not only intended to be buried in offerings for special events, but also for other celebrations scheduled throughout the year, public ritual, as well as elite ostentation and use. Therefore, it seems highly probable that the specialists responsible for producing these pieces worked full-time in this activity.

In contrast to the strong standardization of the *Pinctada mazatlanica* pieces, the shell pendants made from the *Oliva* genus display a generalized tendency to homogeneity in their manufacturing techniques, in which some pieces with particular variants stand out, suggesting a certain dispersion of production groups. Perhaps there were several

workshops, each of which could have had its own way of working objects, which would explain their relative diversity. Hypothetically, one might propose that the objects that display the most recurrent techniques (removal of spire by abrasion with a passive basalt tool, percussion, or a combination of both techniques, as well as the production of a grooved perforation with obsidian tools) might be pieces produced in the Basin of Mexico—perhaps even in Tenochtitlan itself—while the less numerous groups of pieces (those that display cutting of the spire through abrasion with active tools and conical perforations) might be non-locally made pieces. Another explanation for this lack of standardization might reside in the wider circulation of these ornaments, with which the Mexican state could have recognized plebeians who excelled in warfare; therefore, they might have been elements of lesser status than the *Pinctada mazatlanica* objects, produced in greater volumes, perhaps sacrificing uniformity and quality of production for the sake of greater technological efficiency. Suffice it to compare the hour and a half of work spent manufacturing an *Oliva* shell pendant, removing its spire through abrasion with a passive basalt tool, and producing a grooved perforation at its base with an obsidian tool, with the twenty-four hours fifty-nine minutes that it took to make an *oyohualli* pendant, which is the least laborious *Pinctada mazatlanica* piece from the technological standpoint. Although information available at this moment is not sufficient to draw conclusions regarding centralization, context, and intensity of *Oliva* genus pendant production, it is difficult to imagine the Mexica state did not have direct control of the manufacture of an important element of social mobility. It is tantalizing to suppose that in the workshops located in the ruler's palace, artists with greater expertise performed the most delicate production processes on the most complex pieces, while apprentices were responsible for carrying out the more monotonous work and the manufacture of simpler objects of lesser value.

As mentioned above, the study of the production technology of shell pieces in Mexica offerings has contributed information for further discussion of the origin of their manufacture. In the case of *Pinctada mazatlanica* objects, the fact they are exclusive to Tenochtitlan and specifically to its most important religious and political building, together with their strong technological standardization have made it possible to posit not only the local character of their production, but even the existence of a technological style characteristic of the Aztec capital (Velázquez, 2007:182-183). The concept of technological style is based on the fact that in the different phases of the technical processes—also known as operational chains (Leroi-Gourhan, 1943, 1945)—producers have to make decisions when faced with a variable array of choices, restricted by environmental, historical, social, and cultural factors (Lemmonier, 1986:153; Schiffer, 1992:51). There are no external limiting factors for a sufficiently powerful human group to be the only causal factors in the entire decision-making process in the operational chains (Pfaffenberger, 1988:241), which according to ethno-archaeological research tend to be systematic and consistent, dictated to a large extent by custom (Sackett, 1990:33), in which technological limits coincide with those of communities. Therefore, the notion of technological style has been proposed as the group of choices a human groups makes, which constitute knowledge of a manufacturing tradition (Stark, 1990:27). When it comes to *Oliva* gastropod pendants, their relative heterogeneity suggests they are the product of different technological traditions, a principal one in which two techniques (abrasion and percussion) are used and the combination of them to remove the shell spires, as well as abrasion with an obsidian tool to produce grooved perforations,

which is displayed by the greatest number of pieces and appears from construction stages IV to VII; and others that are represented by few examples and that appear dispersed in different offerings or else concentrated in particular votive deposits. Again, the principal style is tentatively proposed to pertain to Tenochtitlan itself, while the techniques and tools that appear sporadically might be indicative of non-local traditions, whether from the Basin of Mexico, tribute-rendering provinces in the Aztec Empire, or regions beyond their sphere of domination (Velázquez, 2007:183–184).

Recently another group of shell pendants also found in Mexica offerings was studied. These belonged to genera other than *Oliva* (*Nerita*, *Neritina*, *Cassis*, *Polinices*, *Columbella*, *Nitidella*, *Olivella*, *Agaronia*, *Marginella*, and *Conus*). In these cases, the use of sandstone, not found in the Basin of Mexico, was identified as the material used to remove the spire of some examples, abrade the surface of others, and produce irregular perforations. The fact that the majority of the species identified come from the Atlantic littoral makes it highly likely that these objects came from the Gulf Coast, perhaps from the Huasteca region, where there is an abundance of sedimentary rock and which was conquered by the Aztec Empire during the reign of Moctezuma Xocoyotzin (1440–1469), and remained a subject of the empire until the rule of Moctezuma Ilhuicamina (1502–1520) (Velázquez et al., 2010; Velázquez & Zúñiga, 2010). Six *Olivella volutella* pendants found in Burial 1 of Building 1 in Tancama, Querétaro, a Postclassic period site pertaining to the Huastec culture, are relevant to the case in point. These objects are identical to those found in the offerings in the Templo Mayor of Tenochtitlan and the study of their manufacturing traces made it possible to identify sandstone as the material employed to make the irregular perforations by abrasion (Velázquez et al., 2010) (figure 12).

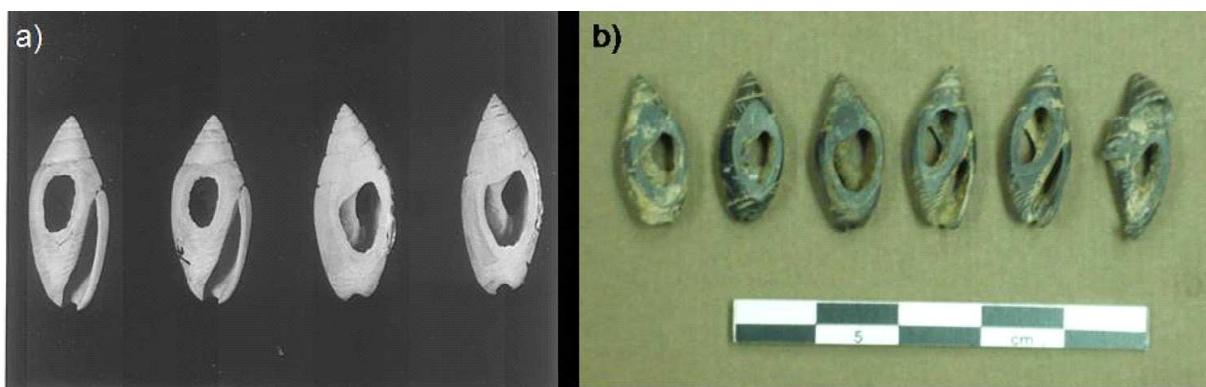


Fig. 12. Shell pendants of the *Olivella* genus from the sacred precinct of Tenochtitlan (a) and from Tancama, Querétaro (b). Photos: G. Zúñiga.

5. Conclusion

The analysis of experimentally replicated manufacturing traces has shown that the different processes and tools produced different features with distinctive characteristics that make it possible to differentiate them and identify them with archaeological materials; this can be conducted on several levels (macroscopic and microscopic), depending on the extent of fineness that one requires. In the specific case of the present research project, it was of vital importance to distinguish between tools and materials with the greatest degree of precision possible, because it provided the key to obtaining important information on technological

homogeneity or heterogeneity, the basis for discussion of the origin of shell artifacts and regarding some parameters of specialization; in this work, the use of the scanning electronic microscope (SEM) has been invaluable. Nevertheless, it is important to mention that SEM analysis of manufacturing traces is not an easy, mechanical task, because it is necessary to know the material that is being studied and to be familiar with it, to avoid confusing aspects of its structural characteristics with human modifications or with deterioration processes. For the characterization and identification of work traces, characteristics of relief, texture, bands, lines, and particles visible in micrographs on four magnification settings (100x, 300x, 600x, and 1000x), which seem to be the most adequate for present purposes, are taken into account. One cannot overlook the fact that characterization and identification of the micrographs implies interpretational work in which training and experience play a crucial role; this is an especially delicate matter in the case of archaeological objects, which almost always display some degree of deterioration, even when their condition might appear to be optimum. In this way, although it is possible to define clear parameters to distinguish to a certain degree the different materials and tools, there is always an element of subjectivity in their assessment.

The information obtained from the analysis of work traces on archaeological materials from the sacred precinct of Tenochtitlan has made it possible to discuss aspects such as their origin and specialized production. The discovery of strong formal and technological standardization in *Pinctada mazatlanica* pieces and of a general tendency toward standardization in the case of *Oliva* genus shell pendants have made it possible to propose their production pertains to a style that can be regarded as identified with Tenochtitlan. Other groups of objects that display different forms of production have also been found that seem to represent non-local styles. This is the case of the shell pendants of genera other than *Oliva* that can hypothetically be proposed as pieces of Huastec production. The high degree of technological standardization in the *Pinctada mazatlanica* pieces might suggest a strong concentration of production units, which were possibly in the very palace of the ruler and where the artisans worked and resided, sponsored by the elites. The elitist character of these pieces and their major symbolic and ritual importance support this idea. On the other hand, their lengthy production times, the skill necessary to produce them, and their high demand in Mexica ceremonial life strongly suggest the individuals in charge of their production were full-time artists, expert in the production of divine attributes.

On the other hand, the relative variability of manufacturing features of *Oliva* shells, pertaining to the style posited as Mexica, suggests the dispersion of groups of artisans responsible for their production. The low production time for these elements, compared to *Pinctada mazatlanica* pieces, are congruent with their lesser status, because they were circulated among lower social groups as a means of recognition for services rendered to the state in warfare. Therefore, their production seems to have taken into account technological efficiency for the sake of the high volume of production and in lieu of optimum results. The preceding provides an alternative explanation for the heterogeneity of the pieces, which might have been produced in the same workshops as the pearly objects, but by less experienced artisans or perhaps apprentices.

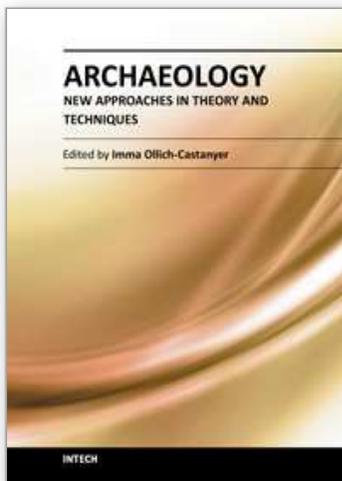
In closing, the purpose of this text has been to show the potential of the study of manufacturing traces through scanning electronic microscopy in elucidating different aspects of ancient societies.

6. References

- Allen, J.; S.G. Holdaway & R. Fullagar. (1997). Identifying specialisation, production and exchange in the archaeological record: the case of shell bead manufacture on Motopure Island, Papua. *Archaeology in Oceania*, Vol.32, No.1, pp. 13-38, ISSN 0003-8121.
- Ascher, R. (1961). Experimental Archaeology. *American Anthropologist*, Vol.63, No.4, pp. 793-816, ISSN 0002-7294.
- Binford, L.R. (1977). *For Theory Building in Archaeology*, Academic Press, ISBN 978-0121000509, London, England.
- Binford, L.R. (1991). *Bones, Ancient Men and Modern Myths*, Academic Press, ISBN 978-0121000363, London, England.
- Callender, D. W., Jr. (1976). Reliving the Past, Experimental Archaeology in Pennsylvania. *Archaeology*, Vol.29, No.3, pp. 173-177, ISSN 0003-8113.
- Clark, J. & W. Parry. (1990). Craft Specialization and Cultural Complexity, In: *Research in Economic Anthropology*, Vol.12, B.L. Isaac, (Ed.), 289-346, JAI Press, ISBN 978-1559381185, Greenwich, Connecticut, USA.
- Costin, C.L. (1991). Craft Specialization: Issues in Defining, Documenting and Explaining the Organization of Production, In: *Archaeological Method and Theory*, Vol.3, M. Schiffer, (Ed.), 1-56, University of Arizona Press, ISBN 978-0120031030, Tucson, Arizona, USA.
- Dacal Moure, R. (1978). *Artefactos de concha en las comunidades aborígenes cubanas*, Museo Antropológico Montané, Havana, Cuba.
- Dales, G.F. & J.M. Kenoyer. (1977). Shell Working at Ancient Balakot, Pakistan. *Expedition*, Vol.17, No.2, pp. 13-19, ISSN 0014-4738.
- Di Peso, C. (1974). *Casas Grandes, a Falling Trading Center of the Great Chichimeca*, The Amerind Foundation/ Northland Press, ISBN 978-0873580564, Dragoon/Flagstaff, Arizona, USA.
- Díaz del Castillo, B. (1986). *Historia de la conquista de la Nueva España*, Porrúa, ISBN 999-90-3682-A, Mexico City, Mexico.
- Evans, R.K. (1988). Early Craft Specialization: An Example from the Balkan Chalcolithic, In: *Social Theory and Archaeology*, M. Shanks & C. Tilley, (Eds.), 113-129, ISBN 978-0826310644, University of New Mexico Press, Albuquerque, New Mexico, USA.
- Fash, W. (1991). *Scribes, Warriors and Kings: The City of Copan and the Ancient Maya*, Thames and Hudson, ISBN 978-0500390283, London, England.
- Feinman, G.M. (1999). Rethinking Our Assumptions: Economic Specialization at the Household Scale in Ancient Ejutla, Oaxaca, Mexico, In: *Pottery and People, a Dynamic Interaction*, J.M. Skibo & G.M. Feinman, (Eds.), 81-98, ISBN 9780874805772, The University of Utah Press, Salt Lake City, Utah, USA.
- Feinman, G. & L.M. Nicholas. (1995). Household Craft Specialization and Shell Ornament Manufacture in Ejutla, Mexico. *Expedition*, Vol.37, No.2, pp. 14-25, ISSN 0014-4738.
- Flannery, K.V. & M.C. Winter. (1976). Analyzing Household Activities, In: *The Early Mesoamerican Village*, K.V. Flannery, (Coord.), 34-47, ISBN 978-0122598524, Academic Press, London, England.
- Gándara Vázquez, M. (1990). La analogía etnográfica como heurística: lógica muestral, dominio etnográfico e historicidad, In: *Etnoarqueología, primer congreso Bosch Gimpera*, Y. Sugiura & Maricarmen Serra, (Eds.), 43-82, ISBN 968-3620213, Universidad Nacional Autónoma de México, Mexico City, Mexico.

- Gibaja Bao, J.F. (1993). El cómo y el porqué de la experimentación en análisis funcional. *Revista de arqueología*, No.148, pp. 10-15, ISSN 0212-0062.
- Gómez Chávez, S. (2000). La Ventilla, un barrio de la antigua ciudad de Teotihuacan. Licentiate thesis in Archaeology, Escuela Nacional de Antropología e Historia, Mexico City, Mexico.
- Hartzell, L.L. (1991). Archaeological Evidence for Stages of Manufacture of *Olivella* Shell Beads in California. *Journal of California and Great Basin Anthropology*, Vol.13, No.1, pp. 29-39, ISSN 0191-3557 .
- Haury, E.W. (1976). *The Hohokam: Desert, Farmers and Craftsmen*, University of Arizona Press, ISBN 9780816504459, Tucson, Arizona, USA.
- Hocquenghem, A.M. & M. Peña Ruiz. (1994). La talla del material malacológico en Tumbes. *Bulletin de l'Institut Française d'Etudes Andines*, Vol.23, No.2, pp. 209-229, ISSN 0303-7495.
- Hohmann, B.M. (2002). Preclassic Maya Shell Ornament Production in the Belize Valley, Belize. Doctoral dissertation, University of Albuquerque, New Mexico, USA.
- Kenoyer, J.M. (1989). Harappan Craft Specialization and the Question of Urban Segregation and Stratification. *The Eastern Anthropologist*, Vol.45, Nos.1-2, pp. 39-54, ISSN 0012 8686.
- Lemonnier, P. (1986). The Study of Material Culture Today: Toward an Anthropology of Technical Systems. *Journal of Anthropological Archaeology*, Vol.5, pp. 147-186, ISSN 0278-4165.
- Leroi-Gourhan, A. (1943). *L'homme et la Matière*. Albin Michel, ISBN 978-2226062130, Paris, France.
- Leroi-Gourhan, A. (1945). *Milieu et Techniques*. Albin Michel, ISBN 978-2226062147, Paris, France.
- Longacre, W. (1999). Standardization and Specialization: What's the Link?, In: *Pottery and People, a Dynamic Interaction*, J.M. Skibo & G.M. Feinman, (Eds.), 44-48, ISBN 978-0874805772, The University of Utah Press, Salt Lake City, Utah, USA.
- López Luján, L. (1993). *Las ofrendas del Templo Mayor de Tenochtitlan*. Instituto Nacional de Antropología e Historia, ISBN 978-9682945304, Mexico City, Mexico.
- Mancha González, E. (2002). Objetos de concha en contextos arqueológicos de la Cuenca de México, en la época prehispánica. Licentiate thesis in Archaeology, Escuela Nacional de Antropología e Historia, Mexico City, Mexico.
- Matos Moctezuma, E. (1988). *The Great Temple of the Aztecs*. Thames and Hudson, ISBN 978-0500277522, New York, New York, USA.
- Matos Moctezuma, E. (1990). El Proyecto Templo Mayor: objetivos y programas, In: *Trabajos arqueológicos en el centro de la ciudad de México*, E. Matos Moctezuma, (Coord.), 17-39, ISBN 978-9686487428, Instituto Nacional de Antropología e Historia, Mexico City, Mexico.
- Mayer, D.E. (1997). Neolithic Shell Bead Production in Sinai. *Journal of Archaeological Science*, Vol.24, pp. 97-111, ISSN 0305-4403.
- Miller, M.A. (1996). The Manufacture of Cockle Shell Beads at Early Neolithic Franchthi Cave, Greece: a Case of Craft Specialization? *Journal of Mediterranean Archaeology*, Vol.9, No.1, pp. 7-37, ISSN 0952-7648.
- Pfaffenberger, B. (1988). Fetishised Objects and Humanised Nature: Towards an Anthropology of Technology, *Man*, Vol.23, No.2, pp. 236-252, ISSN 0025-1496.
- Sackett, J. R. (1990). Style and ethnicity in archaeology: the cause for isochrestism, In: *The Uses of Style in Archaeology*, M. Conkey & C. Herstof, (Eds.), 32-43, ISBN 9780521445764, Cambridge University Press, Cambridge, England.

- Sahagún, B. (1989). *Historia general de las cosas de Nueva España*, Alianza Editorial Mexicana & Fondo de Cultura Económica, ISBN 978-9682925078, Mexico City, Mexico.
- Schiffer, M.B. (1992). *Technological Perspectives on Behavioral Change*, University of Arizona Press, ISBN 9780816511952, Tucson Arizona, USA.
- Stark, M.T. (1999). Social Dimensions of Technical Choice in Kalinga Ceramic Tradition, In: *Material Meanings*, E.S. Chilton, (Ed.), 24-44, ISBN 978-0874806083, The University of Utah Press, Salt Lake City, Utah, USA.
- Suárez Diez, L. (1977). *Tipología de los objetos prehispánicos de concha*. Instituto Nacional de Antropología e Historia, ISBN 978-9707013391, Mexico City, Mexico.
- Turner, M.H. (1987). The Lapidaries of Teotihuacan, Mexico: a Preliminary Study of Fine Stone Working in the Ancient Mesoamerican City, In: *Teotihuacan, nuevos datos, nuevas síntesis, nuevos problemas*, E. McClung de Tapia & E.C. Rattray, (Eds.), 465-471, ISBN 978-9688379684, Universidad Nacional Autónoma de México, Mexico City, Mexico.
- Vargas Arenas, I.; M.I. Toledo; L.E. Molina & C.E. Montcourt. (1993). *Los artífices de la concha*, USDA Forest Service Southern Region, Organización de los Estados Americanos, Puerto Rico.
- Velázquez Castro, A. (1999). *Tipología de los objetos de concha del Templo Mayor de Tenochtitlan*, Instituto Nacional de Antropología e Historia, ISBN 978-9701820674, Mexico City, Mexico.
- Velázquez Castro, A. (2000). *El simbolismo de los objetos de concha encontrados en las ofrendas del Templo Mayor de Tenochtitlan*, Instituto Nacional de Antropología e Historia, ISBN 9789701841983, Mexico City, Mexico.
- Velázquez Castro A. (2007). *La producción especializada de los objetos de concha del Templo Mayor de Tenochtitlan*, Instituto Nacional de Antropología e Historia, ISBN 978-9680302796, Mexico City, Mexico.
- Velázquez Castro, A. & E. Melgar Tísoc. (2006). La elaboración de los ehecacozcatl de concha del Templo Mayor de Tenochtitlan, In: *Arqueología e historia del Centro de México, Homenaje a Eduardo Matos Moctezuma*, L. López Luján, D. Carrasco & L. Cué, (Eds.), 525-537, ISBN 9789680301805, Instituto Nacional de Antropología e Historia, Mexico City, Mexico.
- Velázquez Castro, A. & B. Zúñiga Arellano. (2010). Pendientes de caracol de las ofrendas del Templo Mayor. Paper given at the "Congreso Internacional Culturas Americanas y su Ambiente: Perspectivas desde la Zooarqueología, Paleobotánica y Etnobiología," Mérida, Yucatán, Mexico.
- Velázquez Castro, A.; B. Zúñiga Arellano & Á. González López. (2010). *Nerita Shell Objects in the Offerings of the Great Temple of Tenochtitlan*, In: *2nd Latin American Symposium on Physical and Chemical Methods in Archaeology, Art and Cultural Heritage Conservation & Archaeological and Arts Issues in Material Science – IMRC 2009*, J.L. Ruvalcaba Sil, J. Reyes Trujeque, J.A. Arenas Alatorre & A. Velázquez Castro, (Eds.), 107-111, ISBN 978-6070220173, Universidad Nacional Autónoma de México, Universidad Autónoma de Campeche, Instituto Nacional de Antropología e Historia, Mexico City, Mexico.
- Villalpando Canchola, M. E. & M. Pastrana Oliver. (2003). La manufactura prehispánica de ornamentos en el sitio La Playa. *Noroeste de México*, No. 14, pp. 35-41.
- Woodford, C.M. (1908). Notes on the Manufacture of the Malaita Shell Bead Money of The Solomon Group. *Man*, Vol.8, pp. 81-84, ISSN 0025-1496.
- Yerkes, R. W. (1983). Microwear, Microdrills, and Mississippian Craft Specialization. *American Antiquity*, Vol.48, No.3, pp. 499-518, ISSN 0002-7316.



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The contents of this book show the implementation of new methodologies applied to archaeological sites. Chapters have been grouped in four sections: New Approaches About Archaeological Theory and Methodology; The Use of Geophysics on Archaeological Fieldwork; New Applied Techniques - Improving Material Culture and Experimentation; and Sharing Knowledge - Some Proposals Concerning Heritage and Education. Many different research projects, many different scientists and authors from different countries, many different historical times and periods, but only one objective: working together to increase our knowledge of ancient populations through archaeological work. The proposal of this book is to diffuse new methods and techniques developed by scientists to be used in archaeological works. That is the reason why we have thought that a publication on line is the best way of using new technology for sharing knowledge everywhere. Discovering, sharing knowledge, asking questions about our remote past and origins, are in the basis of humanity, and also are in the basis of archaeology as a science.

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