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► **To cite this version:**

Naya Cadalen, Sylvie Beyries, Felipe Trabanino, Chloé Andrieu. When Che' (wood) meets tun (stone): Experimental programs and functional analysis of stone tools. The case of the Classic Maya site of Cancuén (Guatemala). *Journal of Archaeological Science: Reports*, 2023, 49, pp.1-13. 10.1016/j.jasrep.2023.103991 . hal-04174331

HAL Id: hal-04174331

<https://hal.science/hal-04174331v1>

Submitted on 22 Nov 2024

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When Che' (wood) meets Tun (stone): Experimental Programs and Functional Analysis of Stone Tools. The Case of the Classic Maya Site of Cancuén (Guatemala)

(author's version)

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Keywords: Maya city; Lithics tools; Functional analysis; Experiments; Craft activities

Abstract

The importance of plant resources in Maya economies during the colonial and modern periods is widely recorded in ethno-historical and ethnographic studies. However, it is still difficult to determine the place of these resources in the Classic period, especially because of poor preservation of perishable materials. We propose in this article a study of the function of lithic tools from the site of Cancuén (Guatemala), a site that, because of its short chronology, is an ideal case study for determining spatial distribution of activities within a city. For this, we carried out experiments on the working of several species of wood and a gourd specific to Central America, to constitute a frame of reference for traces that are appropriate to the study of pre-Columbian populations.

The functional analysis of a sample of flint drills and obsidian blades from this site indicates the importance of activities related to the working of wood. It is particularly through study of the blades that we may identify these activities in contexts that are domestic as well as ceremonial, public or for artisanal production. This analysis enables reflection on the possibility of the existence of *multicrafting* zones and on the type of tools used for working wood.

1. Introduction

During the Classic period (250-950 AD) in Central America, the Maya cities were located in the heart of dense forests, which contained highly diversified plant resources that are presumed to have been intensely exploited by these pre-Columbian populations (StavrakisPuleston, 1969). The working of these materials would have had an important place in the everyday life of the Maya, who would have cleared the surroundings of the communities and areas of land to plant their fields of staple crops, *milpas* (Lewenstein, 1987), as well as to obtain materials for the fabrication of everyday objects and for purposes of construction (Kidder 1947) and religious use (Landa, 1941). However, because of poor preservation conditions (Emery and Aoyama, 2007), such artifacts are very rarely discovered in archaeological contexts.

The ethnohistorical records indicate that these plant resources were essential in the construction of domestic structures. They were used to make specially crafted objects for daily use as well as articles of luxury; they have been discovered in graves in the form of idols, as offerings of food and drink, and objects in ceramic and stone (Landa, 1941). The ethnographic data from present-day Maya populations provide details of the species selected and the techniques used. Among the Lacandon, the sap of certain woods was used to make ritual drinks or therapeutic balms. Bark was used to make hammocks and bowstrings, and for tying. The climbing lianas of latex-producing rubber trees were used as incense, and those of other species could have been used as ropes. The trunks of trees were essential in the construction of houses, canoes, and a large panoply of utensils (Soustelle, 1937). Gourds were used for a majority of recipients, utensils, and musical instruments (Hartman, 1910). Besides the problems related to the subjectivity of authors (Gruzinski, 1976), these examples are taken from specific geographic zones, and the chronological period concerned is far distant from the Classic period, which leads us to question how representative these data are of the populations that interest us.

It is thus clear that plant materials would have occupied a central place in Classic Maya societies (Kidder, 1947). However, the objects fabricated in plant materials are under-represented in the archaeological record. We also have little information on the tools that were used to work the plant materials. The place occupied by the working of plant materials as well as the tools used to work them are thus the questions to be answered.

In this article, we present the results of the functional analysis of two types of lithic tools which could have been used to work plant materials, that is, flint drills and obsidian blades from the site of Cancuén (Guatemala). This site was selected because its precise chronology and short occupation, limited to the Late Classic (600-800 AD), enables a spatial analysis of activities that is more exact than those usually carried out in Maya cities. The objective is to visualize the place occupied by the working of plant materials within the city through functional analysis of the lithic tools found on this site. This consists of examining a limited number of tools to determine the frequency of the presence of activities related to plant materials within well-defined structures. We have compared our functional analysis results with those of the contemporary and neighboring site of Aguateca, whose abrupt abandonment enables a spatial analysis that is just as exact (Inomata, 2001). We may thus consider how representative the results obtained are, while presenting a methodology different from that used to analyze the tools of the neighboring site of Aguateca.

To create a frame of reference that is adapted to our questions, we have constructed experiments that bring together tools in obsidian and flint with various types of wood and a gourd from Central America. This frame of reference consists of functional macro- and micro-traces, to identify the activities carried out with the archaeological tools on the plant materials. We take into account the

parameters that were not explored in the rare frames of reference that have been used in studies of the ancient Maya (Lewenstein, 1987; Aoyama, 1989; Sievert, 1992; Stemp, 2016): movement, location of the traces, plant species with well-identified physical properties, etc.

2. Materials and methods

2.1 Methodology

For the functional analysis, we decided to examine the macro-traces as well as the micro-traces present on the lithic tools, the study of which provides complementary information. This combination of two scales is rare in the few functional studies so far carried out on Maya material.

We are also interested in the question of the gesture used in the application of the tool. This is a central question in functional studies because, by identifying the assemblage of mechanical gestures which constitute the activities, it is possible to approach the question of the systems of production (Gutiérrez Saez, 1993). This is a subject that up to now has been little addressed in studies of the Maya, where the emphasis has mostly been placed on the identification of the worked materials, without examining the correlation between the type of tool and the movement applied. This article thus proposes a study employing a methodology rarely used in previous research on the Maya, to provide new data on the functioning mode of certain lithic tools, especially concerning the working of plant materials. We wish to pursue through this methodology the study of the extension of use-wear on the tools, in relation to kinematics, the composition of the wood and the duration of use in order to observe the development of the traces. To closely approach the archaeological reality, we have selected the best-documented wood species in Central America, from the pre-Hispanic period to the present day.

For our macroscopic analysis, we used a Leica Z16 Stereomicroscope with enlargement from x11.4 to x184 and at times a Dino-Lite to take photographs. For the microscopic analysis, two microscopes were used with enlargements of x100 and x200: a Leica DMRM with an Olympus camera and an Olympus BHM with a Leica camera.

2.2 The archaeological assemblage

Cancuén

Located in the present-day district of Petén in Guatemala, the site of Cancuén was founded in about 600 AD on the shores of the river Pasión (Barrientos et al., 2006; Demarest, 2013). Cancuén was constructed in a strategic position, at a point between the highlands and the lowlands, enabling the city to have control over the trade of raw materials and finished products that occurred between these two geographic zones (Demarest et al., 2014). But this control did not last because the occupation was short, ending with the massacre of the city's elite populations around 800 AD (Forné et al., 2009).

This site possesses the particularity of having many deposits directly associated with different structures in the city. They have been studied systematically, bringing to light at least one workshop for the production of beads and pendants in jade (Andrieu et al., 2014) and several places of production, or zones of rejection of production waste, of mirrors made of pyrite (Andrieu and Cadalen, *in press*).

Corpus

We applied functional analysis to two types of tools that were frequently discovered in waste deposits at Cancuén: flint drills and obsidian blades. The obsidian blades represent one of the most widespread types of tool in Mesoamerica (Clark, 1989), and constitute almost half of the lithic

collection of Cancuén (more than 12,000 artifacts in obsidian were discovered at Cancuén). The flint drills, rarely represented in the lithic assemblages of the lowlands (Andrieu, 2009), are very numerous at Cancuén, numbering 1,800 pieces. These two types of tools are found in large concentrations, in waste dumps as well as in ritual deposits. They have been found in many different contexts, thus their study may provide a preliminary outline of the activities that took place in various structures, enabling determination of the frequency of plant materials being worked on the scale of a site.

As our goal is to propose a first test-analysis of a sampling of tools from the whole of the city, we selected tools from a wide diversity of structures (cf. Figure A). Thus, a total of 1,452 obsidian blades and 577 flint drills were examined with a binocular microscope, to separate the most altered tools. A second selection phase retained the best-preserved pieces that presented potential traces of use, that is, 138 obsidian blades and 122 flint drills.

2.3 Experimental frame of reference

To compare the traces observed on the archaeological tools with those used in the experiments, we worked plant materials with tools made of obsidian from El Chayal (Guatemala, n=6 blades), which was the major source of obsidian for the site of Cancuén (Demarest et al., 2014), as well as obsidian from Walter Mounts, located in California (n=9 blades), which has an aspect very similar to that of the El Chayal source. The blades were pressure-knapped by Jacques Pelegrin (PreTech UMR 7055), who also provided us with nine flakes and blades in flint for use in the experiments. Besides these experiments, the analysis of the archaeological collections was compared with the experimental collection of the laboratory of the CEPAM (UMR 7264), which contains many flint tools which have been used to work with different materials, and more than 200 tools that have been used to work several plant materials with various movements.

For the experiments, we worked *cedro* (Spanish cedar, *Cedrelaodorata*), *caoba* (*Swieteniamacrophylla*), and *chicozapote* (*Manilkarazapota*). These three kinds of wood were selected because they are part of the dominant forest vegetation in the lowlands (Dussol et al., 2016), and their presence is attested in the district of Petén (Campbell et al., 2006). These woods fall into two groups according to hardness: *cedro* and *caoba* are less hard, while *chicozapote* is much harder. The goal is to discover criteria that distinguish different degrees of hardness of the wood, and to create categories that are more exact than those related to working the wood.

To better understand the extension of the use-wear, we conducted a sequential experiment: we used each of the tools for an hour, stopping at specific intervals (10, 15, and 30 minutes), to analyze the tools.

We also included a gourd among the plant species worked; they are highly present in the environment of the site (Dussol, 2017). They have been used by the Maya to fabricate recipients and utensils since the Spanish conquest (Hartman, 1910), and their seeds have been found in archaeological contexts across Central America (e.g. Cutler and Whitaker, 1961; Lentz, 1991). Thus a type of gourd commonly called *Tecomate* (*Lagenaria* sp.) was worked exclusively with obsidian tools by a specialized craftsman, Jaime Carillo, to engrave the gourd.

3. Results

3.1 Frame of reference

3.1.1 *Cedro* (*Cedrelaodorata*)

The *cedro* is a tree typical of Central and South America and the Caribbean region. The wood of the trunk is easy to work with, as its density is low, and it is a supple wood. In its composition, the

silica content is not significant, in contrast to that of the prismatic crystals, which correspond to oxalates of calcium and are found in various types of cells (upright, square, chambered, and non-chambered axial parenchyma cells) (Wheeler, 2011). Some researchers assume that the Maya of the Classic period used *cedro* wood as a combustible fuel (Lentz et al., 2014), but studies tend to show that it was above all used for construction (Dussol, 2017) and the fabrication of various objects, such as religious idols (Landa, 1941; Dussol et al., 2016).

Four obsidian blades were used for sawing (bidirectional movement); the angle of the tool upon the material worked was in general perpendicular. One blade was used with a drilling movement (bi-directional rotary movement). Almost all the blades were used to work dry wood, except for one that was used to work wood that had been soaked in water for 48 hours, to observe the differences in the traces that occurred. Two flint blades were also used to work the wood with a drilling movement, and a flake was used with a sawing movement (cf. Table A.1), with the same kinematics as the obsidian tools. None of the tools were hafted.

3.1.1.1 Obsidian tools

Whatever the state of the wood or the movement used, the obsidian pieces present bulb scars that are often alternate and semi-circular. Blunting is sometimes present, with an intensity that varies according to the duration of use. Its form is rounded, showing the abrasive nature of this work. It is accompanied by an abraded area confined to the edge. Abrasion can also appear on the tool surface in the form of lines with semi-circular micro-fractures. On the microscopic scale, there is a slight and undulating polish, absent when the wood has been soaked, which affects the edge of the bulb scars and certain striations. This polish could be due to the presence of prismatic crystals. Two types of striation develop (cf. Figure B). The first type consists of the striations that begin at the bulb scar of the edge. These striations are fine, with diffused (because affected by the polish) and rectilinear margins, the section often V-shaped and the bottom of it polished. The second type is probably characteristic of contact with the wood. These striations are wider, with clear and irregular margins, a U-shaped section having a matte bottom. The microscopic traces develop beyond the cutting edge, indicating good penetration into the worked material. The longer the use, the more numerous these striations are and the more they develop beyond the edge.

3.1.1.2 Flint tools

The action of piercing creates many scars, causing other use-wear traces to disappear. For the action of sawing, at the macroscopic scale, the presence of a non-alternating, semi-circular bulb scar is observed. Even if the duration of use is short, the presence of rounded blunting is observed, which indicates the abrasive nature of this work. This blunting intensifies with longer use. At the microscopic scale, an undulating polish with blurred edges is observed, which gradually becomes clear (cf. Figure D). The polish becomes more intense with longer use (cf. Figure E). The striations are regularly apparent with the polish, and are mostly fine, having a V-shaped section with a matte bottom, their direction depending upon the movement applied. The microscopic traces develop beyond the cutting edge, which indicates good penetration into the worked material.

3.1.2 *Caoba* (*Swieteniamacrophylla*)

The *caoba* is indigenous to a vast region covering southern Mexico up to the center of South America. Because of its low density and its suppleness, this wood is very easy to work, but can cause scars, that is, blunting, on the modern tools used. Its silica content is low, but the presence of prismatic crystals is well attested, in different cells (Wheeler, 2011). The Maya attribute medicinal properties to the leaves and bark of this tree, and the wood is also used in furniture-making (Dussol, 2017).

For the experiments, the experimenters used four obsidian blades to saw the wood, with a bidirectional movement and a perpendicular working angle. Three of these were used to work dry wood, and the fourth to work wood that had been soaked in water for 48 hours. Three flint flakes were used to drill (with a bi-directional rotary movement) and saw the dry wood (cf. Table A.1). None of the tools have been hafted.

3.1.2.1 Obsidian tools

The macroscopic and microscopic traces observed on the obsidian tools used to work the *caoba* wood are very similar to those observed on the obsidian tools used to work the *cedro* wood, for scars and rounded blunt. At the microscopic scale, a slight and undulating polish is observed, which can be related to the presence of prismatic crystals. The polish is accompanied by an abrasion and does not develop when the wood is soaked. The two types of striations described on the blades that were used to work the *cedro* are observed on all the tools (cf. Figure B). The microscopic scars develop beyond the cutting edge, thus there is good penetration of the material worked. The duration of use also influences the quantity and extension of the striations: after 30 minutes of working, they are very numerous and cover the surface of the tool.

3.1.2.2 Flint tools

The flint tools used to saw the *caoba* present functional traces that are very similar to those used to work the *cedro*. The only difference is the intensity of the traces, which becomes more marked after one hour of use. The presence of edge-rounding, accompanied by abrasion, which increases with time of use, indicates the abrasive nature of this work. The polish is again undulating, with blurred edges that becomes clear and irregular (cf. Figure D). After one hour of use, the polish is particularly undulating and shiny (cf. Figure E), which is not a consequence of the very low silica content in the wood. The striations are identical to those present on the tools used to work the *Cedro*. The microscopic traces develop beyond the cutting edge, which again indicates good penetration. As for the tools having worked the *cedro*, the tools used as drills only present scars.

3.1.3 *Chicozapote (Manilkarazapota)*

The *chicozapote*, also called Sapodilla, is indigenous to southern Mexico and Central America. The wood of this tree is very dense, making it difficult to work, and modern tools used to work it become blunted. Its content in silica is low, but prismatic crystals are present in high numbers in several types of cells (Wheeler, 2011). The *chicozapote* is above all known for its latex, used to fabricate *chicle*, essential in the production of chewing gum (Mathews and Schultz, 2009). The wood can be used for construction (Hellmuth, 1989), fuel, and for making tools (Dussol, 2017).

For working this wood, the experimenters used four obsidian blades for sawing, with a bidirectional movement and a perpendicular working angle. The wood was dry for three of them and soaked for 48 hours in the water for the fourth. Two flint flakes were used to drill (with a bi-directional rotary movement), and a blade was used to saw the dry wood (cf. Table A.1). None of the tools were hafted.

3.1.3.1 Obsidian tools

At the macroscopic scale, there is very little difference between the tools used to work the dry wood and those used to work the wet wood. The bulb scars are alternating, often semi-circular. Blunting is not often present, as the bulb scar predominates and covers most of the surface of the edge. When it is present, it is rounded and low in intensity, with a little abrasion. At the microscopic scale, there is a polish that sometimes affects the edge of the bulb scars and a few striations (cf. Figure

B), although it stays close to the cutting edge. It is thus again possible that the number of prismatic crystals is high enough to favor the appearance of this polish. When the bulb scars do not take away all the cutting edge, the two types of striation are again present, which appears to be quite characteristic in general of the working of wood. After 30 minutes of use, a third type of striation develops which is very shiny polish. (cf. Figure B). The microscopic traces remain close to the cutting edge, which shows that penetration into the worked material is limited to 10 minutes of use.

3.1.3.2 Flint tools

The action of piercing creates many scars, causing other use-wear traces to disappear. At the macroscopic scale, the flint tools that were used to saw the *chicozapote* present a bulb scar. It often predominates and removes a large part of the cutting edge, preventing potential blunting from occurring on the cutting edge. When the blunting develops between scars, it is rounded and of low intensity. For the polish, we observe that the microtopography becomes smoother on the high points, which are affected more intensely (cf. Figure D). When the edge is stabilized, after 30 minutes of use the polish is intense, rounded, and very bright (cf. Figure E). This is not a consequence of the silica content in the wood, which is very low. The striations are like those observed on the flint tools that were used to work the *cedro* and the *caoba*. The cutting-edge changes very much during use, indicating that the material worked is quite hard.

3.1.4 *Tecomate* (*Lagenariasp.*)

The *tecomate* is the fruit of a small bush considered to be an annual climbing plant (Hartman, 1910). The *Tecomate* was used widely in the pre-Hispanic period as a container, as it is today (Lentz, 1991). Archaeobotanists identify the presence of gourds from Maya sites through the identification of seeds, phytoliths, and pollen, not by means of charcoal analysis. Thus, the structure of the gourds and their mineral content are still unknown.

For the experiments, three obsidian blades were used to work a *Tecomate*. The movements were mainly longitudinal, and the point of the tool was used preferentially, with short bidirectional movements, to engrave but not to saw the worked material (cf. Table A.2). The gourd was worked only in a dry state and the tools were not hafted.

3.1.4.1 Obsidian tools

The traces observed on the obsidian tools used to engrave the gourd are different from those observed on the tools used to work the ligneous materials. The bulb scars are not alternating, they are semi-circular. The rounded blunting is very intense, probably because of the longer duration of the work; it is developed on the two faces, with abrasion. This suggests the probability that the working of *Tecomate* wood is abrasive. At the microscopic scale, a light polish is sometimes observed on the edges of scars; it remains marginal and has often been removed by later working. Striations are rare as the development of the scar bulb removed the surface of the cutting edge, preventing striations from developing. Although low in number, striations of the first type previously described are observed, with clearer margins (cf. Figure C). They remain near the edge, which reveals that penetration into the quite hard material was limited.

3.1.5 Assessment

The flint tools were used to work only the three wood species, in a dry state. The flakes and blades used for drilling were not appropriate for this kind of movement, which caused the fracturing of the point and the disappearance of the use-wear traces. These tools were more suitable for sawing, which permitted traces of use to develop. There are similarities: the organization and form of the bulb scars,

the presence of a brilliant and undulating polish, striations that have the same appearance. It is observed that the polish is particularly marked on the tools that worked the *caoba* and *chicozapote*. The differences in the hardness of the wood can be seen in the intensity of the scars: for the *chicozapote*, the edge took longer to stabilize, and the scars prevented the development of blunting of the cutting edge (cf. Table B.1).

For the obsidian tools, there are three parameters: working ligneous or non-ligneous (Tecomate) materials, working wood that is dry or soaked in water, and working wood that is soft or hard. Whatever the parameters, the action of sawing perpendicular to the material being worked creates use-wear traces that develop similarly on both sides of the cutting edge. For all the tools, if we observe the presence of semi-circular bulb scars, rounded blunting or striations that indicate the movement, we observe differences related to these changes in parameters. For the first two, we observe the presence of polish when it is a dry ligneous material that has been worked. When the wood has been soaked (cf. Table B.2), or the gourd is worked (cf. Table B.3), we rarely observe polish, which is often erased by scars and remains marginal. On ligneous materials, it is also noticeable that striations are visible on a macroscopic scale. For the third parameter, the tools used to work the *chicozapote* present traces that indicate the working of a material that is harder than the *cedro* or the *caoba*: large scars, which erase blunting and micro-traces, and a new type of polished groove, which indicates the hardness of the wood worked by the tool (cf. Table B.4).

3.2 Archaeological results

The functional analysis of the obsidian blades from the site (n=138) shows that 65.9% of the sample (n=91) presents functional traces related to the working of plant materials (158 Independent Use Zones, after Vaughan, 1985), which can be divided into three categories (cf. Figure F). These are defined according to our frame of reference established by an experiment (that involved, besides woodworking, the working of animal materials (butchering, skin, bones, teeth, fish, etc.) and minerals (jade, shell)): the working of softwood (44.2%, 101 IUZs), the working of hardwood (18.8%, 46 IUZs) and the working of abrasive plant material (6.5%, 11 IUZs). This category includes tools with traces like those characteristic of woodworking (two types of striations, presence of rounded edges, polish, etc.) but with a stronger abrasive component. It is possible that the material worked corresponds to plant material not subjected to experiment in this study, but which has been explored by other researchers (Hurcombe, 1992; Kononenko, 2011): fibers, leaves, bamboo, or other plants. The other blades analyzed present a slight diversity in the traces, a certain number of them having been used to work minerals (3.6%, 8 IUZs) or had contact with bone material (2.8%, 4 IUZs) or with undetermined materials (1.4%, 3 IUZs); many of these blades are too affected by mechanical alteration or present no functional trace that is definable (26.8%). The 91 blades used to work plant materials were used with a sawing movement. We are aware that our study of obsidian blades has limitations: the first is that we have selected pieces with rather obvious functional traces, often the case when plants have been worked; the second is that our experiments do not represent the diversity of activities that took place in the Classic period, which may distort some of our interpretations.

However, in the assemblage of flint drills (n=122) that were analyzed, only seven (5.7%, 7 IUZs) present traces of use associated with working plant materials. These were above all used for perforation (n=5, 5 IUZs), of which one tool was used at both extremities to pierce the same material, as well as for reaming (n=2, 2 IUZs). These drills were found in three different contexts: one drill was found in structure K9-7 (cf. Figure G), presumed to be residential, and four were discovered in structures M6-12 and K6-34, which together provide indications of production of mirrors in pyrite (Andrieu and Cadalen, *in press*), and two others were found in burial E-110, the offering consisting of about 200 drills, which present mostly traces related to the working of a hard mineral.

Thanks to the analysis we were able to reveal several facts: the obsidian blades often present traces that can be associated with the working of plant materials, although the portion of work on these same plants is anecdotal for the flint drills. By placing these results in relation to the contexts of the discovery of the lithic tools, we may also discuss the relationship that the inhabitants of Cancuén had with the surrounding plant resources.

4. Discussion

4.1 The importance of the working of plant materials for the lowland societies

We thus find evidence for activity related to plant materials in a variety of contexts (cf. Figure H). The functional study of the obsidian blades shows that this kind of activity occurred throughout the city, whether in residential (Group F), public (Northern Ballcourt), or ceremonial (Royal Aguada) contexts. We observe a larger variability in the proportion of this type of activity in various structures (cf. Table C), which could be interpreted as an indication of multiple activities taking place in these contexts. We also find evidence for the working of plant materials in elite contexts, in particular the palace, but also workshops devoted to other activities, such as the production of objects in jade. Even though we have only studied two types of tools, obsidian blades and flint drills, we observe that the working of plant materials occupied an important place in the city, as we find evidence for it in all the studied structures. This shows that plant material was worked throughout the society, and not specifically within a social group or quarter.

This result reinforces the observations made in most of the functional analyses carried out in the Maya zone. Of the 13 structures studied at Aguateca, the working of wood represents between 12.5% and 61.4% of the activities identified, and the percentage of woodworking in the city is 32.3% (Aoyama 2009). At Cerros (Belize), 67% of the tools present traces of use related to the working of wood, whether occasional or prolonged (Lewenstein, 1987). At the site of La Libertad (Chiapas state, Mexico), 52% of the tools analyzed were used to work wood of differing hardness (Clark, 1979). In ritual contexts, we see a decrease in the proportion of these activities: in the *cenote* of Chichen Itza, 4.4% of the tools found were used for the working of wood (Clark, 1979), in comparison to 8.7% of the ritual cache at Pook's Hill in Belize (Stemp et al., 2018). The functional analysis of a portion of the tools at Cancuén, like the other studies of this kind, demonstrates the importance of the working of plant materials in the Maya cities, which made up a large part of the "day-to-day tasks" (Clark, 1979), as well as, to a lesser extent, part of the ritual activities. These daily activities, as well as the ritual ones, must have included a large variety of plant materials. We observe the widespread practice of working woods of differing hardness, but epigraphic studies have shown that plants such as bamboo must have occupied a central place in Mayan societies (Huston et al., 2017). Non-ligneous plants must have been ubiquitous, although we have not been able to demonstrate this. These plants may have been worked with tools other than those studied in this article, but it is also possible that our experiments were too limited to provide identification.

4.2 Toolkit for working wood

The question of the type of material worked according to the type of tool used is very rarely raised in Maya studies. The researchers are interested in the context of the discovery of tools, which they relate to activities that are identified through the analysis of the tools. But to relate the type of tool to those activities is rarely proposed. We are generally satisfied to differentiate "utilitarian tools" that are used for artisanal productions and domestic activities from what are called "informal tools", used for a wide variety of activities (Aoyama, 2007, 2009). However, we cannot assign a tool to a single category, as its value can change over time, from one context to another, according to how it fits into

the systems of production. It is thus necessary to place again the tool in its context, at the scale of a structure or of a site, before defining broad categories of tools.

This work demonstrates that the drills, which appear to have been used on a variety of different materials, are rarely used on plant materials, in contrast to obsidian blades, which are often assigned to those materials. The two sides of a blade are generally used in working a plant material, often the same one. We observe a predominance of the working of softwood, which was used to fabricate a variety of objects (containers, statuettes, tools, boats, etc.) (Landa, 1941; Dussol et al., 2016; Dussol, 2017). In a smaller proportion, it was possible to identify the working of hardwood, probably used to fabricate elements of architecture, but also objects (Hellmuth, 1989; Mathews and Schultz, 2009). Finally, we note the working of other plants, although the limitations of our experiments do not permit identification, except to indicate their abrasiveness.

This data is reinforced by the functional study of the Aguateca tools, in which it is observed that 40.9% of the obsidian tools were used to saw wood, but only 7.2% of the flint tools (Aoyama, 2009: 44). It is thus a type of tool that was favored for working plant materials, particularly wood and especially for sawing. Obsidian blades could of course be used for other activities, such as butchering or lapidary work. However, drilling is much less represented, which shows that wood, and plant materials in general, were only drilled occasionally. These materials were mainly worked using longitudinal movements, as the analysis of the blades has shown. The drills present greater variability in their uses, working minerals (soft and hard) and animal materials as well as plants. This type of tool appears to have been used opportunistically, but also possibly as a specialized tool, revealed by the analysis of burial E-110.

4.3 Multicrafting

Certain tools of our sample come from contexts of production workshops that have been well identified: 33 drills come from structures K6-34 and M6-12, both related to the production of mirrors in pyrite (Andrieu and Cadalen, *in press*), and 9 blades come from structures M10-4 and M10-7 which are associated with the jade workshop of Cancuén, and 27 blades come from structures near this workshop. The functional analysis has shown that the drills were used for several activities: drilling and perforation of wood and scraping and drilling of several minerals with differing hardness. For the blades, only a few (n=3) present traces from working jade, but the large majority were used for working soft wood, hardwood, and abrasive plant materials. Thus, in these spaces where specific artisanal productions have been identified, the analysis of lithic tools has enabled us to reveal other production activities which probably occurred in the same place.

We observe the same variety of activities in the workshops at Aguateca. For example, the analysis of the tools from the House of Axes (M8-8) shows a predominance of butchering (40.0% of the activities carried out in the structure) but also woodworking (30.9%), stone sculpture (6.7%), artisanal production in bone/shell material (3.0%), and unidentified activities (18%) (Aoyama, 2009: 180, Table D37). The House of Mirrors (M8-4), probably a workshop for the production of mirrors in pyrite (Inomata and Eberl, 2014), presents a large number of obsidian and flint tools used for the working of wood (35.9% of the activities carried out in the structure), for butchering/working of hide (27.9%), working of bone/shells (9.2%), stone sculpture (6.5%) and unidentified activities (20.5%) (Aoyama, 2009: 174, Table D26). Thus one workshop could contain a wide variety of artisanal and domestic activities in the same space (Emery and Aoyama, 2007), which was often residential (Inomata and Triadan, 2000). The coexistence of multiple activities attributed to a limited number of people is often interpreted as an indication of part-time artisanal specialization. It would therefore appear that in Maya cities a space was not limited to one single activity, on the contrary: in a residential space,

subsistence activities occurred at the same time as artisanal ones, and workshops involved in multiple productions probably existed (Feinman and Nicholas, 2000).

5. Conclusions

This study has enabled, thanks to specific experiments for understanding macroscopic and microscopic traces left on flint and obsidian tools by the working of woods that differ in hardness and of a type of gourd, the determination of a difference in use between two types of Maya tools: flint drills and obsidian blades. The working of gourds, however important in pre-Hispanic societies, has not been identified, most probably because the functional traces only consist of bulb scars, which makes identification difficult. It is also possible that neither flint drills nor obsidian blades were implicated in the working of this material.

The working of wood is attested in the whole of the city, and in all types of contexts, which supports the idea that plant materials were at the center of daily life for the Maya of Cancuén, but also in places recognized as workshops of specialized production, such as for the working of pyrite or jade. This leads us to presume that these artisans also produced wooden artifacts in these same workshops, which could have been related, or not, to the production of pyrite or jade objects (as supports for example).

However, the size of the sample of tools analyzed does not permit determination of whether there were specialized productions. For this it will be necessary to study all the tools from the site, not limited to two types, to obtain a picture that is representative of the activities that took place within the site. It will also be essential to develop experiments concerning the working of plant materials that include a larger number of species. This frame of reference will be essential in the future to refine our interpretation of the place occupied by this type of resource in the Maya cities and more widely in Mesoamerica. Our study has demonstrated that in combining the archaeobotanical data with functional analysis, it is possible to pursue questions concerning the process of the formation of traces, as well as to define groups of plants with differing hardness, thus refining the functional results. We have also been able to pursue the question of the gesture applied when using the tools, especially for the obsidian blades which are favored tools for sawing the different plants, which provides new data on the form of the tool and its function for the ancient Maya. Thus, with this preliminary study, we have been able to test a methodology that has proven to be effective in providing initial elements for understanding the relationship between the ancient Maya and the plant resources in their environment.

Acknowledgments

We would like to thank the Maison des Sciences Humaines et Sociales Sud-Est as well as the Institut des Amériques for their financial support for this project. We are also very grateful to Jaime Carillo, Sergio Jimenéz-Manchón, Juliette Guibert-Cardin, Leïla Hoareau and Doriane Agassis for their aide in the implementation of the experiments. We thank Jacques Pélegrin for the knapping of the lithic tools that were used for the experiments. Our thanks go to Lydie Dussol for her advice during the writing of this article. We thank Elizabeth Willcox for the translation of the article. Finally, our thanks go to the entire team of the Archaeological Project of Cancuén and its director Arthur Demarest and his co-director Paola Torres, as well as to the laboratories of the CNRS teams: Cultures et Environnements, Préhistoire, Antiquité, Moyen-Âge (UMR 7264) and Archéologie des Amériques (UMR 8096).

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Table A.1: list of tools used for the experiments of woodwork

Worked material		Tools		Work					
species	condition	type	material	movement	duration				
					5 min	10 min	15 min	30 min	1 hour
<i>Cedrela odorata</i>	dry	blade	flint	drilling	-	x	x	x	x
		blade	flint	drilling	x	x	x	x	x
		flake	flint	sawing	x	x	x	x	x
		blade	obsidian	sawing	-	-	-	x	x
		blade	obsidian	sawing	-	-	x	x	x
		blade	obsidian	drilling	-	x	x	x	x
		blade	obsidian	sawing	-	x	x	x	x
	soaked	blade	obsidian	sawing	-	x	x	x	x
<i>Swietenia macrophylla</i>	dry	flake	flint	drilling	x	x	x	x	x
		flake	flint	drilling	x	x	x	x	x
		flake	flint	sawing	x	x	x	x	x
		blade	obsidian	sawing	-	x	x	x	x
		blade	obsidian	sawing	-	x	x	x	x
		blade	obsidian	sawing	-	x	x	x	x
	soaked	blade	obsidian	sawing	-	x	x	x	x
<i>Manilkara zapota</i>	dry	flake	flint	drilling	x	x	x	x	x
		flake	flint	drilling	x	x	x	x	x
		blade	flint	sawing	x	x	x	x	x
		blade	obsidian	sawing	-	x	x	x	-
		blade	obsidian	sawing	-	x	x	x	x
		blade	obsidian	sawing	-	x	x	x	x
	soaked	blade	obsidian	sawing	-	x	x	x	x

Table A.2: list of tools used for the experiments of calabash work

Worked material		Tools		Work	
species	condition	type	material	movement	duration
Lagenaria sp.	dry	blade	obsidian	engraving	8h
		blade	obsidian	engraving	2h30
		flake	obsidian	engraving	54 min

Table B.1: Differences in the use-wear traces on flint tools used to saw different wood

Stigmatas	cedro	caoba	chicozapote
Scars	present	present	present
distribution	non-alternating bifacial	non-alternating bifacial	non-alternating bifacial
initiation	bending	bending	bending/cone
termination	feather/occasionally snap	feather, occasionally hinge/step	feather/hinge, occasionally step
form	semi-circular	semi-circular	semi-circular
relation polish/scars	lateral/beyond the scars	lateral/beyond the scars	lateral/beyond the scars
Blunt	present	present	not systematic
intensity	medium to intense	medium to intense	low
form	rounded	rounded	rounded
Polish	present	present	present
microtopography	undulated	undulated	undulated
bright	shiny	very shiny	very shiny
aspect	irregular to smooth	smooth	smooth
transverse extension	close and away from the edge	close and away from the edge	close and away from the edge
Striations	present	present	present
quantity	moderately numerous/numerous	moderately numerous	moderately numerous/numerous
distance from the edge	close and away from the edge	close and away from the edge	close and away from the edge

Table B.2: Difference of stigmata on obsidian tools working on dry and soaked wood

Stigmatas	dry wood	soaked wood
Scars	present	present
distribution	alternating bifacial	unifacial
initiation	bending, occasionally cone	bending, occasionally cone
termination	mostly feather/hinge	mostly feather/hinge

form	semi-circular, occasionally crescent moon	semi-circular, occasionally crescent moon
relation polish/scars	lateral/beyond/in the scars	mostly unpolished scars
Blunt	present (soft wood)	present
intensity	medium to intense	low
form	rounded	rounded
Polish	present	not systematic
microtopography	flat/rounded	flat/rounded
aspect	smooth	smooth
Striations	present	present
quantity	moderately numerous/numerous	moderately numerous/numerous
distance from the edge	close and away from the edge	close and away from the edge
Abrasion	present	present

Table B.3: Differences in the use-wear traces on obsidian tools used to work wood materials and non-ligenous materials

Stigmatas	ligneous plants	non-ligneous plants
Scars	present	predominant
distribution	alternating bifacial	non-alternating bifacial
initiation	bending, occasionally cone	cone, occasionally bending
termination	feather/hinge	step/feather
form	semi-circular, occasionally crescent moon	semi-circular
relation polish/scars	lateral/beyond/in the scars	mostly unpolished scars
Blunt	present	present
intensity	low to medium	medium to intense
form	rounded	rounded with flatbeds
Polish	present	not systematic
microtopography	flat/rounded	flat/rounded
aspect	smooth	smooth
Striations	present	present
quantity	moderately numerous/numerous	rare/moderately numerous
distance from the edge	close and away from the edge	close to the edge
Abrasion	present	present

Table B.4: Differences in the use-wear traces on obsidian tools used to work soft and hard wood

Stigmatas	soft wood	hard wood
Scars	present	present
distribution	bifacial mostly alternating	bifacial mostly alternating
initiation	bending	bending/cone

termination	feather/hinge	feather/hinge/step
form	semi-circular, occasionally crescent moon	semi-circular
relation polish/scars	lateral/beyond/in the scars	lateral/in the scars
Blunt	present	present
intensity	medium	low
form	rounded	rounded
Polish	present	present
microtopography	flat/rounded	flat/rounded
aspect	smooth	smooth
Striations	present	present
quantity	moderately numerous/numerous	moderately numerous/numerous
distance from the edge	close and away from the edge	close to the edge
Abrasion	present	present

Table C: Proportions of obsidian blades used to work plant materials for each structure [IUZ: Independent Use Zone (Vaughan, 1985)]

Structure	Pieces analyzed	Functional analysis					
		Plant work (% of total pieces analysed)	Butchery/ Bone contact	Lapidary work	Indetermined	Altered	No use
K7-24	1	1 (100%) [2 IUZs]	-	-	-	-	-
L8-2	9	5 (55,55%) [9 IUZs]	-	-	-	2	2
M10-1	11	3 (27,27%) [5 IUZs]	1 [1 IUZ]	-	-	4	3
M10-4	8	5 (62,5%) [9 IUZs]	1 [1 IUZ]	-	-	1	1
M10-7	1	1 (100%) [2 IUZs]	-	-	-	-	-
M9-17	8	6 (75%) [12 IUZs]	-	1 [1 IUZ]	-	1	-
M9-24	16	14 (87.5%) [23 IUZs]	-	1 [2 IUZs]	-	1	-
N9-7	3	3 (100%) [5 IUZs]	-	-	-	-	-
N10-2	1	1 (100%) [2 IUZs]	-	-	-	-	-
D Group	12	7 (58.33%) [13 IUZs]	-	1 [1 IUZ]	-	1	2
F Group	8	7 (87.5%) [12 IUZs]	-	-	-	1	-
Northern Group	7	3 (42,85%) [5 IUZs]	1 [1 IUZ]	2 [4 IUZs]	-	1	-
Palace	8	7 (87.5%) [13 IUZs]	-	-	-	-	1
Nothern ballcourt	14	9 (64,28%) [17 IUZs]	1 [1 IUZ]	-	-	1	3
Port	10	6 (60%) [9 IUZs]	-	-	-	1	3
Royal aguada	6	5 (83,33%) [6 IUZs]	-	-	-	1	-
Northern Aguada	11	6 (54,54%) [10 IUZs]	-	-	2 [3 IUZs]	2	1
Other contexts	4	2 (50%) [4 IUZs]	-	-	-	-	2

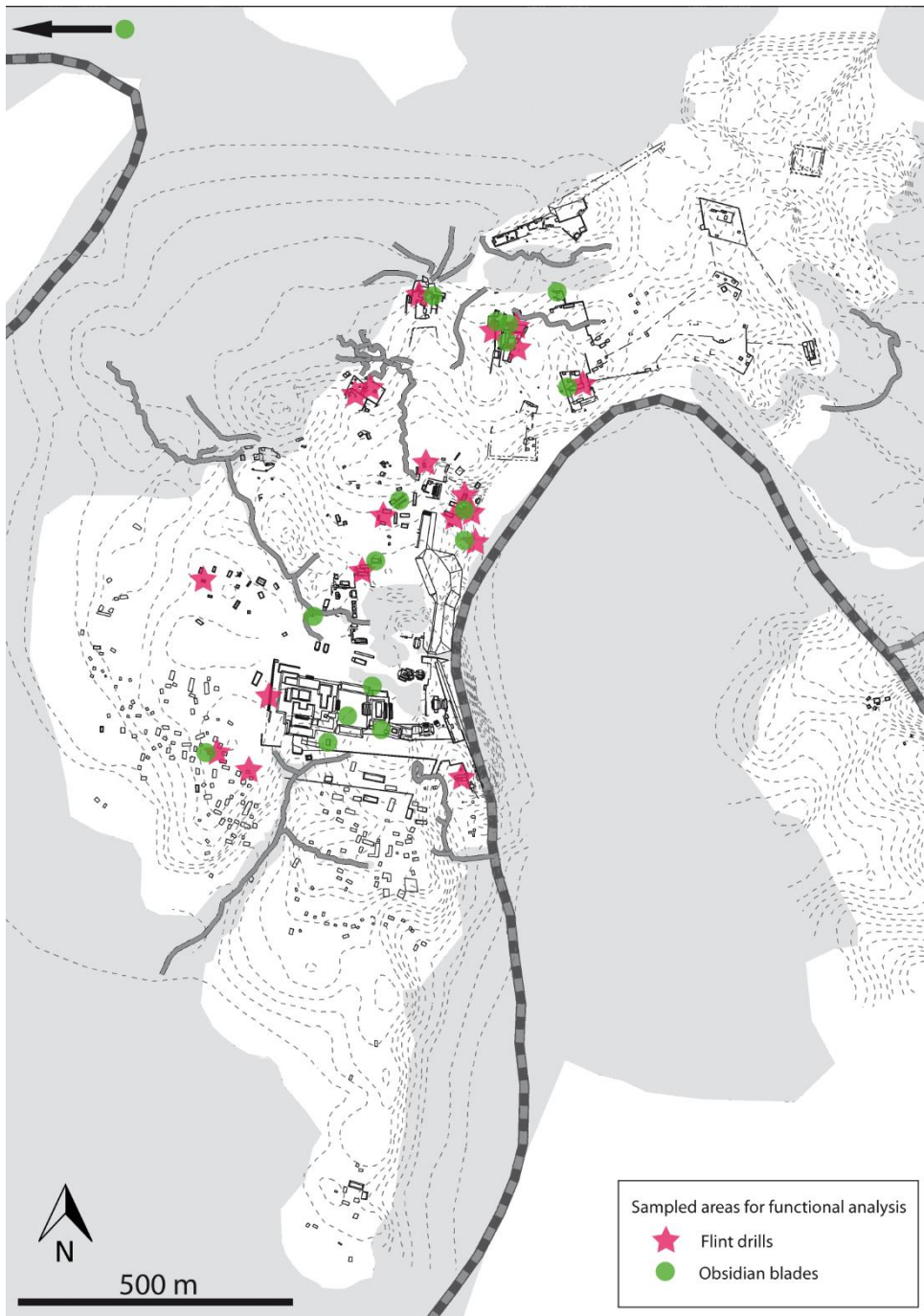


Figure A: Locations of the areas/structures in which the lithic tools that have been functionally analysed were found

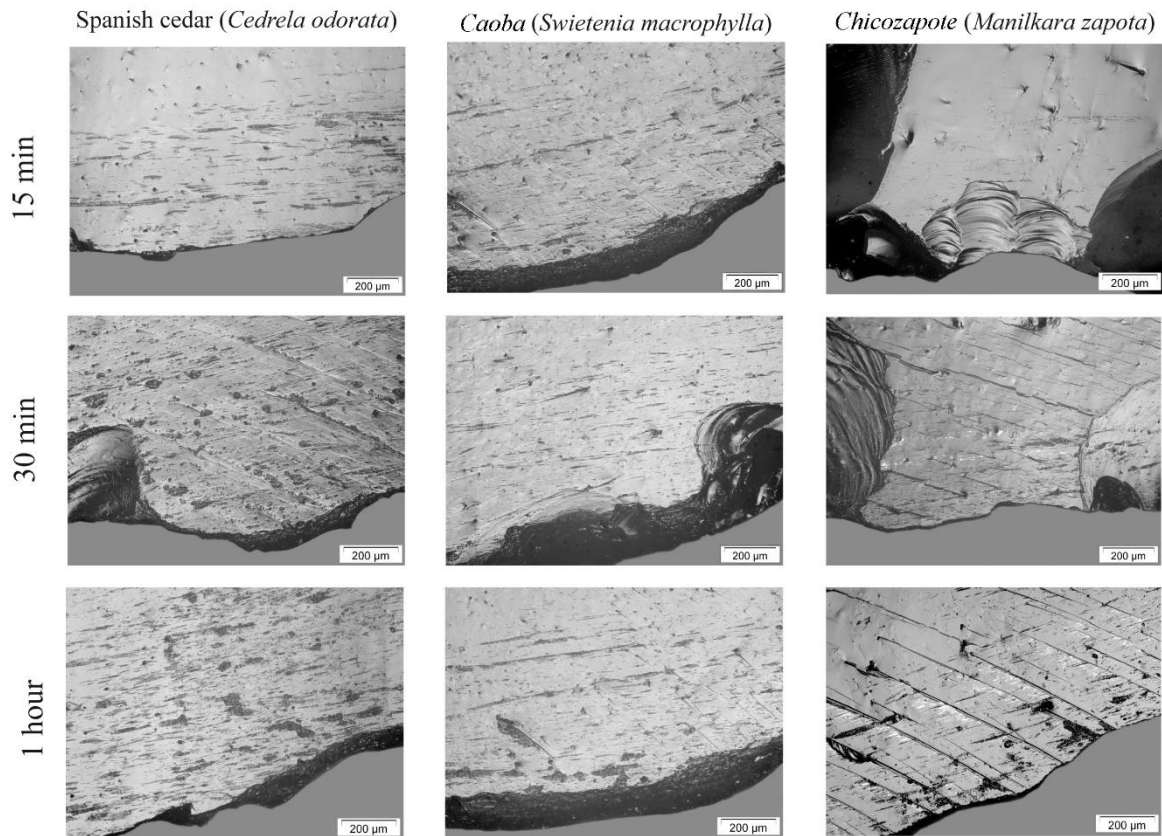


Figure B: Microscopic photographs (x100) of the use-wear traces characteristic of the different wood worked with obsidian tools, according to the time of use

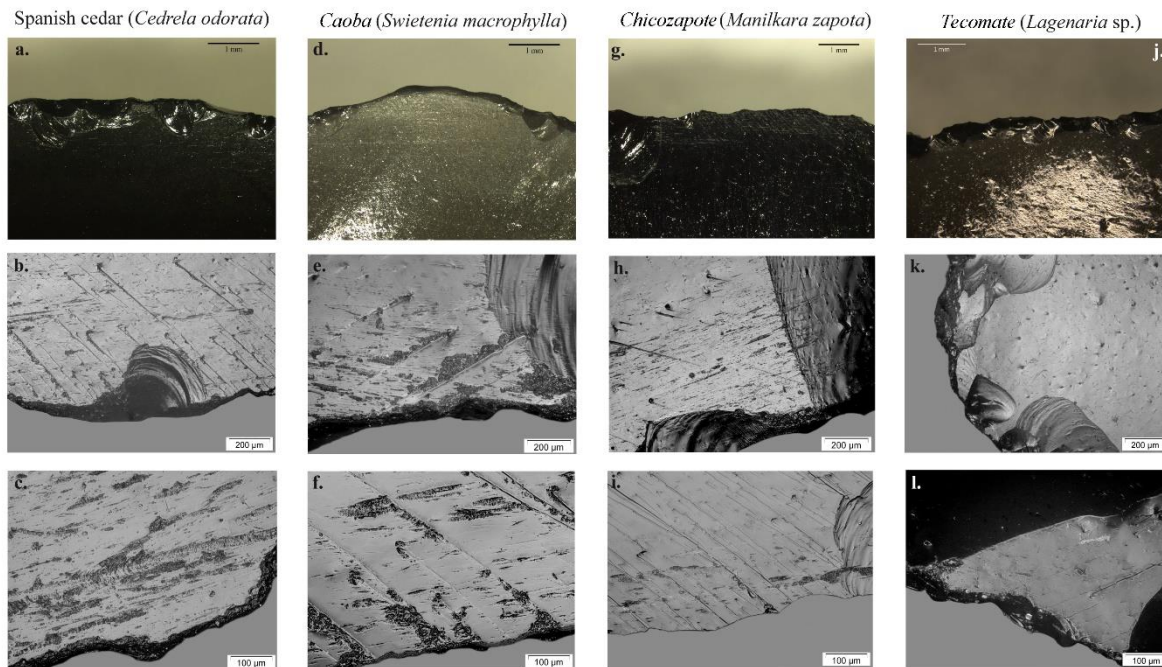


Figure C: Macroscopic and microscopic photographs of various pieces with use-wear characteristic of the work of *cedro* (a: x25; b: x100; c: x200), *caoba* (d: x25; e: x100; f: x200), *chicozapote* (g: x20; h: x100; i: x200) and *Tecomate* (j: x20; k: x100; l: x200)

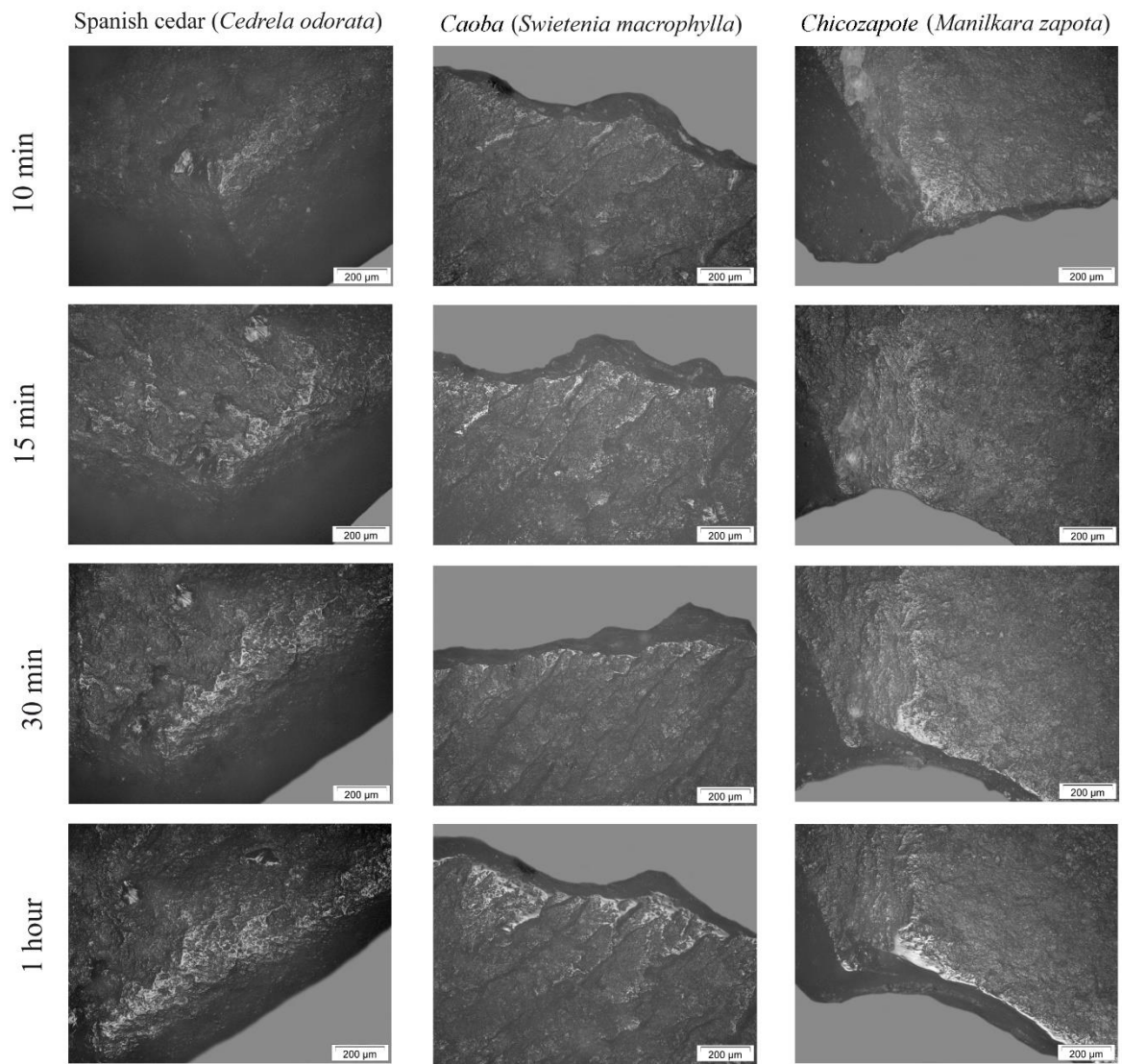


Figure D: Microscopic photographs (x100) of the use-wear traces characteristic of the different wood worked with flint tools, according to the time of use

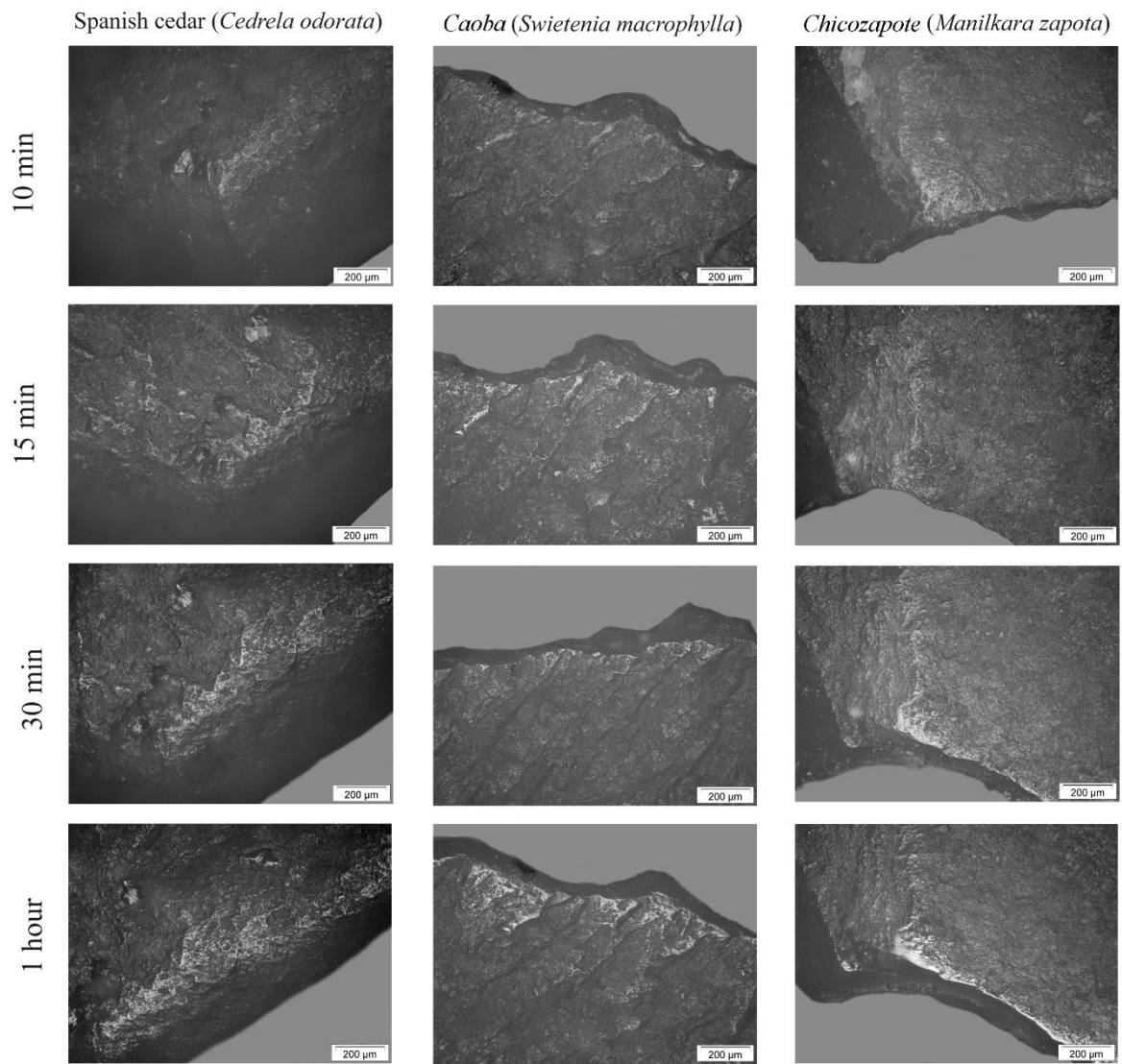


Figure E: Microscopic photographs (x200) of the use-wear traces characteristic of the different wood worked with flint tools, according to the time of use

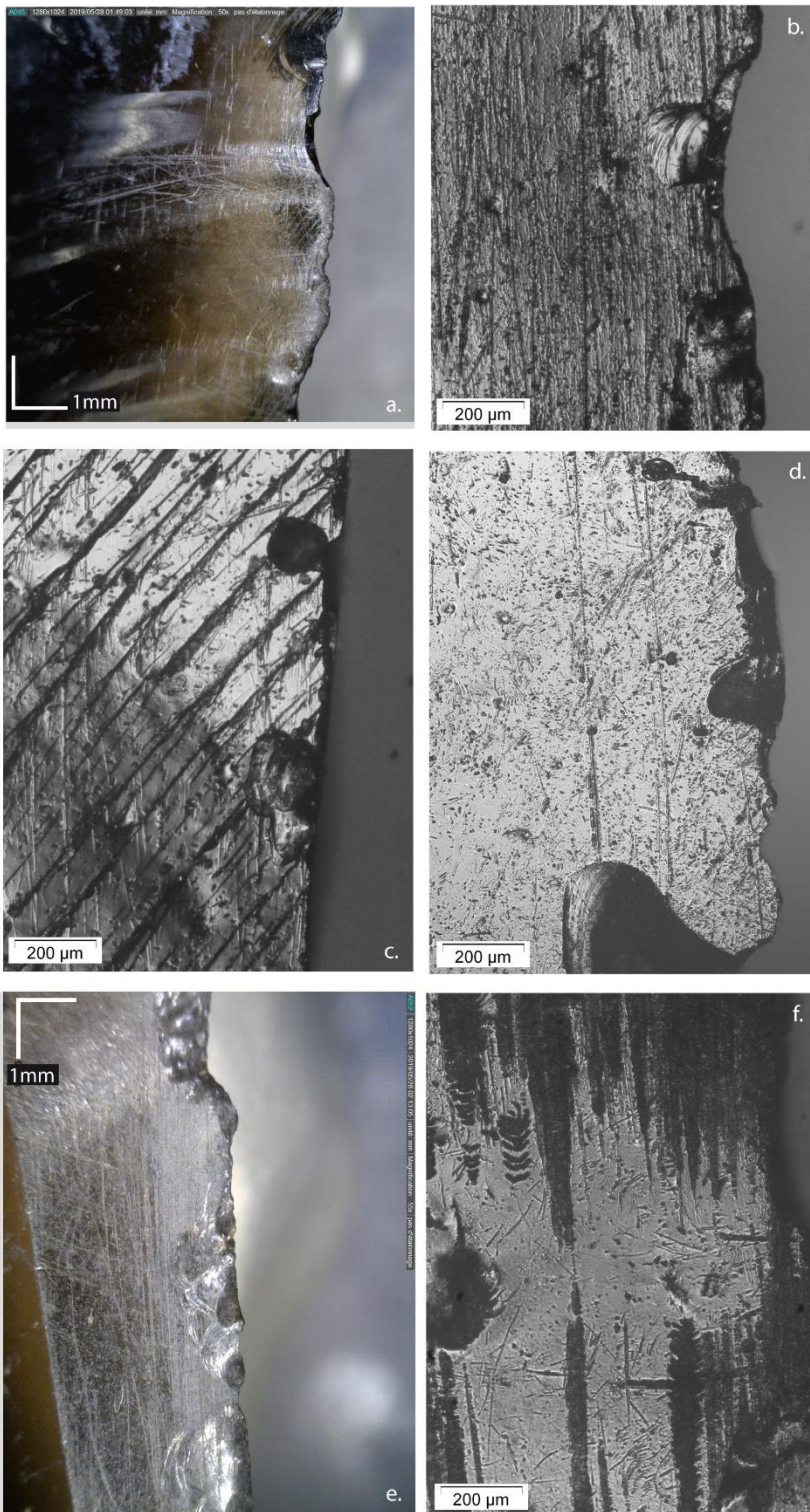


Figure F: examples of obsidian blades that have sawn softwood (a: M10-4 str., b: N10-2 str.), hardwood (c: Palace, d: D Group), and abrasive plant material (e: M9-24 str., f: M10-7 str.)

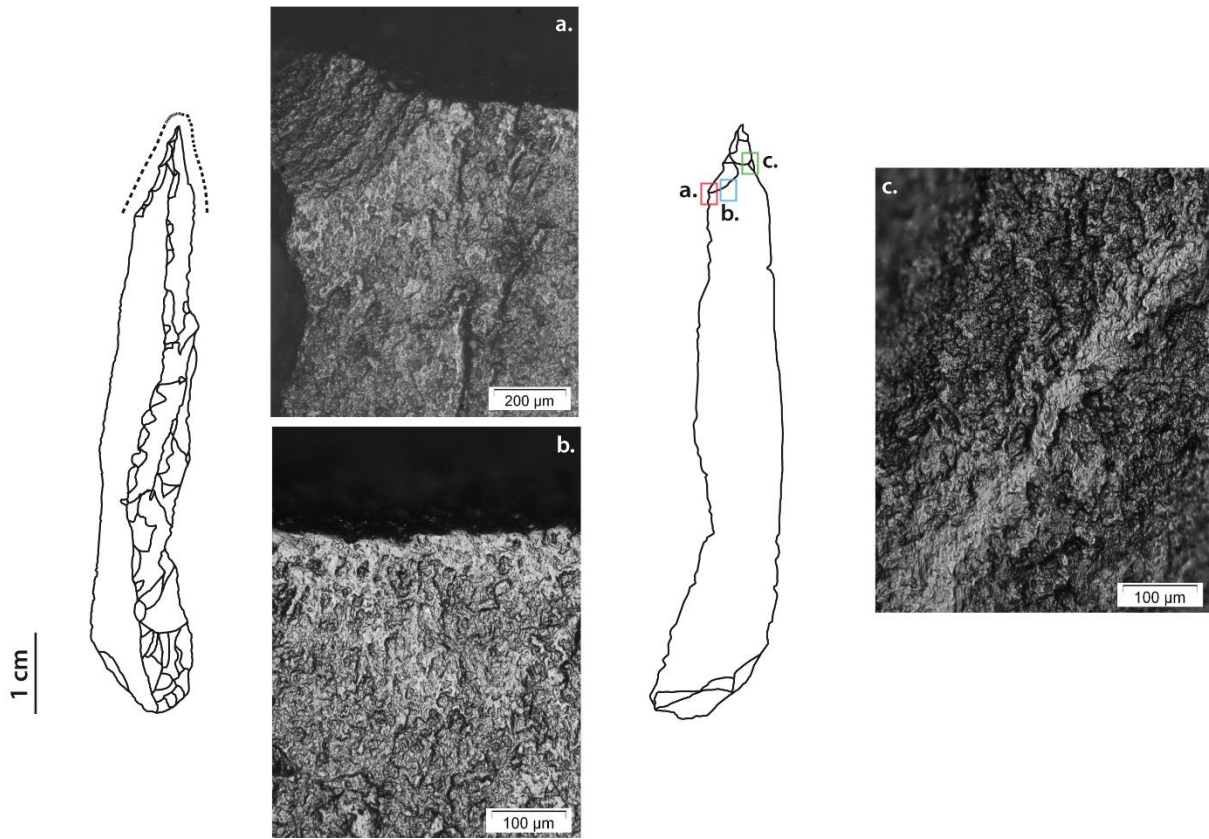


Figure G: drill of the K9-7 structure, with woodworking use-wear traces

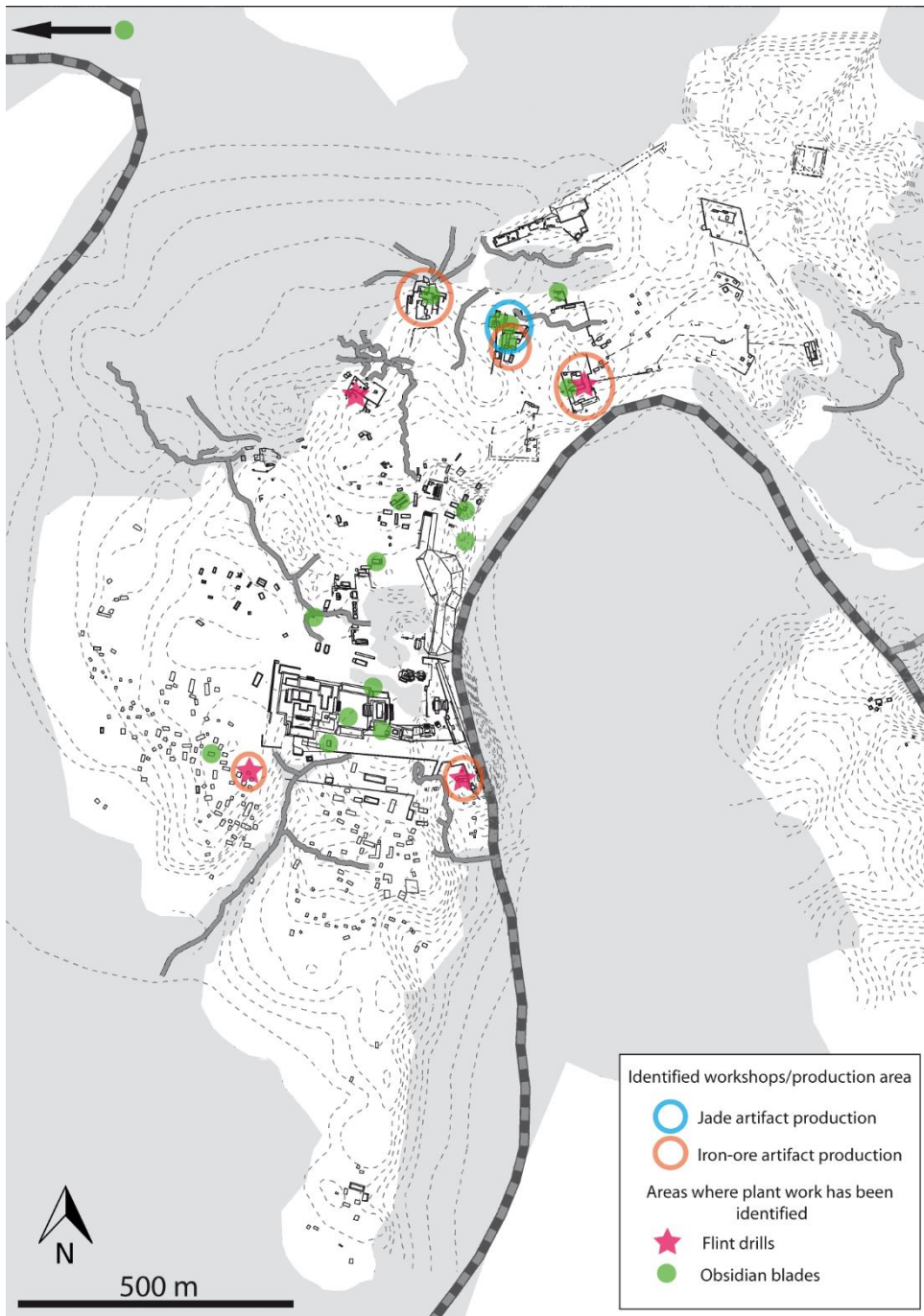


Figure H: location of areas/structures where tools in which the lithic tools that have been used for the plant work were found. The workshops and production areas already identified are mentioned