
Technological change during final Mid-Holocene and early Late Holocene (ca. 5000-2000 years BP) in Barrancas (Jujuy province, Argentina)

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Abstract:

The archaeological evidence from the end of the Middle Holocene and the beginning of the Late Holocene (ca. 5000-2000 years BP) shows a period of great changes. These appear to be the main result of low residential mobility occupations and subsistence strategies based in the specialized hunting of camelids, their domestication and further herding. Even though there is no consensus over the relative importance of each adopted strategy (hunting vs. herding) during this temporal sequence, several and relevant changes can be observed, related to many social spheres. In this paper, we present the particular changes over lithic technology during the temporal sequence proposed through two sites analysed from Barrancas: Laguna Media 7 and Morro Blanco. First, we will clarify the concept of technical system and describe the operative chains observed in both sites. This context is suitable for the topic addressed in this paper, since the chronological difference between both sites (ca. 3400-3200 years BP) is almost contemporary with the appearance in the region of the domesticated camelid *Lama glama*. Thus, we explain the changes in lithic technology and their relation with the other raw materials used in different technologies from a qualitative characterization. Afterwards this change is characterized by performing separate Chi square analysis from the quantification between both sites of: transformative and prehensile techno-units, shaping and knapping methods. We detect some continuities related to the operative chains, but some changes as well, with the disappearance of blade knapping. Finally, we conclude that the changes during this time period are mainly related with the prehensile and hafting system, associated to a broader regional technological change, influenced by the circulation and exchange of goods, knowledge and people.

Keywords: lithic technology; Puna; Mid-Late Holocene; prehensile system; hafting system; innovations

1. Introduction

In Andean archaeology, the period between the end of the Mid-Holocene and the beginning of the Late-Holocene (ca. 5000-2000 ¹⁴C years BP; 5500-2000 cal. BP), possesses



numerous changes and technological innovations. Sites such as Caral or Tiahuanaco are two great examples to take into account, as they represent the beginning of the Andean civilizations (in terms of landscape urbanization) and the relevance of these changes. The Argentine Puna, was not an exception to these processes involving, among others, the sedentarization of human groups and the handling of domestic species -this representing one of the key aspects in the changes from the hunting-gathering strategies towards agro-pastoral ones- being contemporary or even older than in the northern part of this region (Yacobaccio 2001).

In this context, there were some important changes happening in the social, cultural and technological spheres. This dynamic contextualized the technological evolution, in particular, with the lithic instruments. The current paper presents the results of the lithic technology from two sites located in Barrancas (Province of Jujuy, Argentina): Laguna Media 7 and Morro Blanco (Figure 1), showing the processes occurred during the transition between the Middle and Late Holocene (ca. 3500-3000 ^{14}C years BP). Technological changes were discussed in the context of major ones in subsistence strategies, with hunting-gathering strategies no longer dominating (or at least, ceasing to be the only strategies used) with the rise of herding and agriculture in the highlands. As developed below, the lithic operating chains were related to other raw materials in several stages. This framework allowed us to understand technical changes occurred during this key-period in terms of cognitive, techno-economic and cultural aspects (Geneste 2010; Inizan *et al.* 1995; Lemonnier 1986) and from a “techno-logical” perspective (Boëda 2013).

2. The concept of technical system

The technical system is a conceptual tool initially formulated in anthropology to analyze techniques, how they function in human societies (Mauss 1950) and was later applied in archeology (Leroi-Gourhan 1971). This concept proposes ordering the different technical actions of the groups and their relationships. They are treated as interconnected subsystems in action, involving people, tools, gestures, raw materials, know-how and knowledge. Different variables are taken into account, such as cultural expressions, idiosyncrasies, restrictions, as well as economic, geographical and ecological aspects, among others. A given technical system works well in its environmental, cultural and social context (Geneste 2010; Lemonnier 1986; Leroi-Gourhan 1971). They usually involve different quality materials from different sources and therefore, several operating chains. Thus, lithic materials are privileged in archeology due to their durability, as it allows to rebuild almost completely their operational chains from the technical systems in which they operated (Geneste 2010; Inizan *et al.* 1995).

The operative chains (*chaînes opératoires*) consist of all the processes and stages, from the supply of raw materials to the abandonment, going through all the modifications and uses of the raw material. The use of this conceptual tool in archeology and anthropology is useful and adequate to distinguish between different degrees of events (*degrés des faits*). This means, to separate the cultural aspects (information transmission) from the economic ones or those more directly related to subsistence (Lemonnier 1986; Leroi-Gourhan 1971).

It is a greatly used tool in archeology, allowing to rebuild the knappers' objectives for the proper functionality of the lithic tools and their cultural aspects, the kind of raw materials used, their economy, and the knowledge and know-how involved (Geneste 2010; Inizan *et al.* 1995; Pelegrin 1995). The know-how (developed by practice) is an important concept to distinguish pragmatic and flexible decisions taken by knappers and its relation with the mental operating scheme (Boëda 2013; Pelegrin 1995).

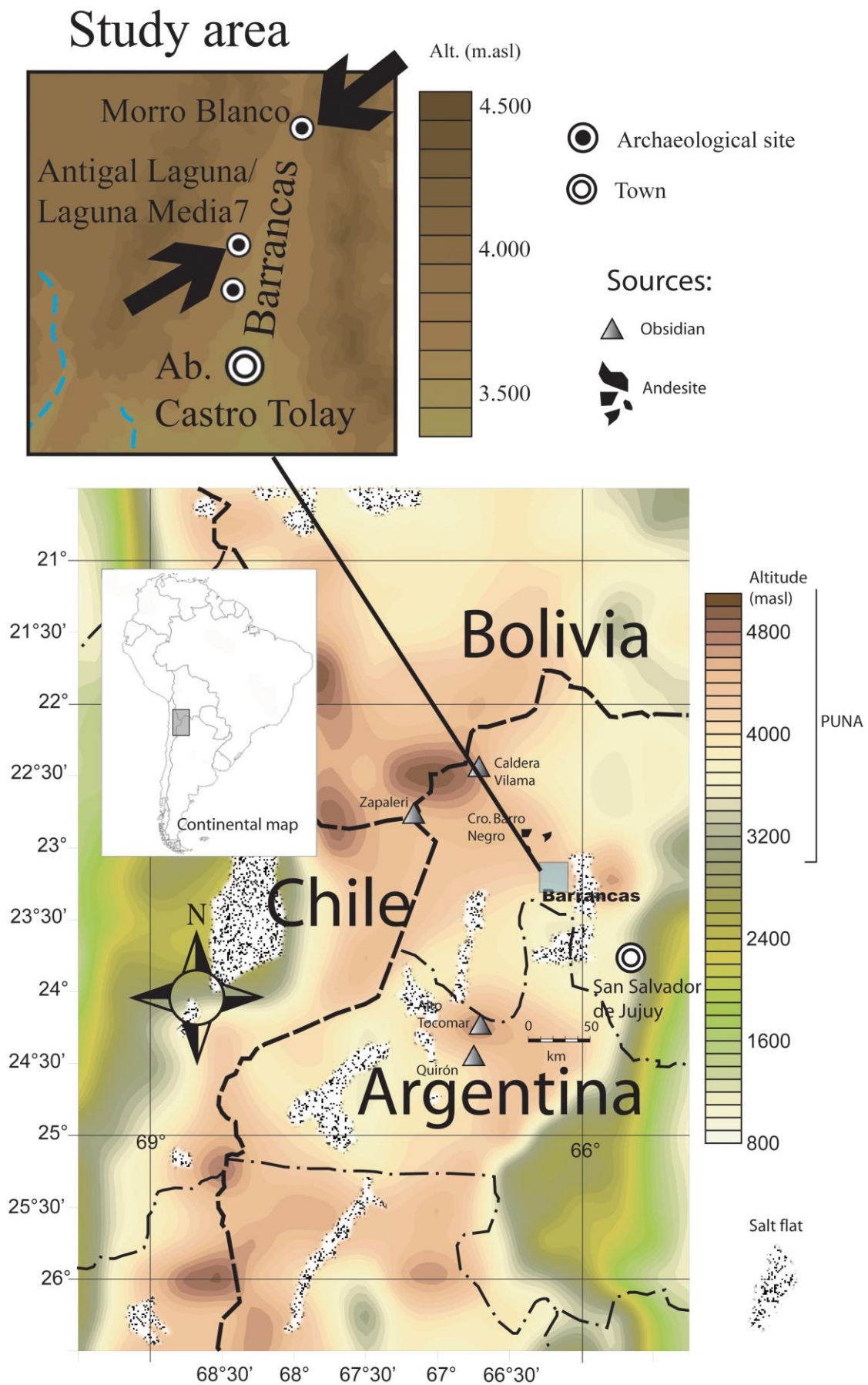


Figure 1. Localization map of archaeological sites.

Likewise, these studies on a larger scale would allow us to distinguish the local or non-local innovations, inventions, and processes resulting from a logical evolution or a breakthrough in the technical lineages, which may be the product of profound changes in societies (Boëda 2013; Roux 2010).

3. Palaeoenvironmental context and innovations in the South-Central Andes

Before delving into technical systems and technology from the aforementioned geographical region, it is necessary to describe the known social and palaeoenvironmental context and framework, since, as previously stated, a contextual approach is necessary to properly interpret technical systems and lithic technology.

Palaeoenvironmentally speaking, in a regional scale, after the aridization process observed during the Mid- Holocene, an overall increase in humidity was noted in the Andean area records between 4500 and 2500 ¹⁴C years BP. Subsequently, this period was followed by a decrease in humid conditions between 2500 and 1500 ¹⁴C years BP, after which the current climate conditions settled. Locally, palaeoenvironmental studies showed a rather wet phase between ca. 4500 and 2000 ¹⁴C years BP, although it was interrupted by repeated dryness events (Pirola *et al.* 2018). These dryness events were represented in the PCC2 profile around 2100 ¹⁴C years BP (2100 cal. BP) and 2400 ¹⁴C years BP (2500 cal. BP) (Morales *et al.* 2014), but also in other nearby locations, such as Pastos Chicos at 2900 ¹⁴C years BP (3000 cal. BP) and 3070 ¹⁴C years BP (3260 cal. BP) (Tchilinguirían *et al.* 2014). The different proxies (palaeomagnetism, diatoms, pollens, *etc.*) supported the existence of a relatively stable wetland and grassland (*vega*) in the region, though torrential events alternate regularly with the mentioned peaks of dryness (Pirola *et al.* 2018). More specifically, regarding the human impact on the landscape, the pollen studies in Barrancas suggested a remarkable anthropogenic change in the *vegas* after ca. 3600 ¹⁴C years BP, probably related to the use of camelid herds (Oxman 2015).

The aforementioned period corresponds to the last fully hunter-gatherer occupation and the beginning of the first agro-pastoral occupation. Likewise, during the period covered in this paper, a great number of occupations were detected, and the study of the dates from these sites were consistent with a demographic growth (Muscio & López 2017). The zooarchaeological studies showed evidence of an intensification and domestication process of camelids towards ca. 5000 ¹⁴C years BP (Cartagena *et al.* 2007; López & Orsi 2017; López & Restifo 2014; Núñez *et al.* 2013; Yacobaccio 2001; 2012; among others). Towards the end of the mentioned period in this work, archaeofaunal studies made it possible to show a consolidation of herding practices, without abandoning hunting as a subsistence strategy (Escola 2000; 2002; López 2008; Yacobaccio *et al.* 1998). Intensification processes were also evident in the processing and consumption of plant resources towards the end of the Middle Holocene (Babot 2011).

These population dynamics and changes in subsistence strategies had a remarkable impact on the landscape, with the appearance of structures (in particular corrals used to handle herds in captivity) and the first human groups' congregation, in the end of the Middle Holocene in the Chilean slope (Núñez *et al.* 2006; 2013) and in the beginning of the Late Holocene in the Argentine slope (Muscio 2011; Olivera 2012). However, the first pastoral occupations did not underestimate the use of rock shelters (Aschero 2007; López 2008; López & Orsi 2017; Yacobaccio *et al.* 2011). From ca. 2500 ¹⁴C years BP, a period characterized in an integrated way by a productive economy, sedentary lifestyle and technological innovations began. The sedentary lifestyle in this case did not necessarily involve low mobility, as there might already be a high logistical mobility with residential bases agglutinated, stable enough and permanent in time, as well as other semi-permanent bases for isolated families, to access

other resources (Olivera 2012). Over time, a greater concentration of the constructions, a hierarchy over spaces, and a size increase of the sites were observed (Delfino *et al.* 2007; Korstanje 2007; Olivera 2012).

Ceramics were one of the most characteristic innovations which marked the beginning of the Late Holocene. It is also relevant to mention the presence of isolated findings well before this date, as in PCh1.5, dated ca. 3800 years BP (Aschero & Hocsman 2011), or in Ramadas in ca. 3600 years BP (Muscio 2011), but they have only begun to appear conspicuously in the archaeological contexts of the region from ca. 3200 ¹⁴C years BP onwards. Likewise, metallurgy was another technological innovation which appeared ca. 2900 years BP (Angiorama & Taboada 2008; Fernández Distel 1998; González 2004; among others). It is important to mention that these processes must have influenced greatly the social organization as well as the technological systems (in particular the lithic one) of the human groups who occupied the area of study between ca. 5000-2000 ¹⁴C years BP.

In the Dry Puna (“*Puna Seca*” in Spanish), the aforementioned processes of intensification towards the end of the Middle Holocene (ca. 5500-4000 ¹⁴C years BP) were related to the production and use of blades as blanks for tools (Huguin 2014a; López & Restifo 2012; Loyola *et al.* 2016; Núñez *et al.* 2006; Restifo 2015). This type of tool was accompanied by bifacial lanceolate projectile arrowheads associated with a spear-thrower system, which exceeded the geographical distribution of blades and its date of appearance ca. 6000 ¹⁴C years BP in its early phase, disappearing around ca. 2000 ¹⁴C years BP in its late phase (Aschero *et al.* 2011; Huguin 2014b; Lavallée *et al.* 1995; Núñez *et al.* 2006; de Souza *et al.* 2010; Yacobaccio *et al.* 2011). Only then, during the late Holocene (ca. 3000 ¹⁴C years BP), small triangular arrowheads with barbed shoulders and stems appeared, mostly associated with the bow and arrow propulsion system in different areas of the Salt and Dry Puna (Escola 2002; Fernández Distel 1998; Mercuri 2014). Towards the end of this temporal sequence, the provenance studies of the obsidians allowed to demonstrate the existence of a distribution sphere whose main source was Zapaleri in the northern zone of the Argentine Puna (Yacobaccio *et al.* 2004). This sphere would have been active for the Barrancas basin, as shown by the XRF studies on obsidian from Morro Blanco and Laguna Media 7 (Yacobaccio *et al.* 2017), as well as being related to caravan traffic. Indeed, the access to certain resources from other ecological levels, and the circulation of goods, knowledge and people, were secured by llama caravans in a regular exchange system, even though, it was not very intense (Yacobaccio 2012).

4. Presentation of the sites

4.1. Antigal Laguna and Laguna Media 7

West from the Barrancas River, there is a large terrace associated with several small rock shelters, mounds (Figure 2) and housing structures. The mounds are artificial structures, mostly made from local quartzites and ignimbrite, but we still do not know their exact functionality. They are associated with part of the lithic material here presented (Table 1). Several test pits were carried out in the rock shelters and on the slope, as well as inside and outside the housing structures, in which bone and lithic materials were found, including ceramics and glass beads in the Antigal. Only in the lower sector of the site (in the Antigal part) were ceramics found on the surface. The date obtained (220 ± 30 ¹⁴C years BP, Gif#A17281) from a charcoal coming from the ash lenses (layer 2) matched the dates of the occupation from layer 1 (Colonial Period). In the third test pit from the rock shelter, two layers were also found, but with a much lower sedimentation rate. One burned bone was dated, and it appeared to belong to the transition between the Middle and Late Holocene (Figure 2). As the lithic material (apparently with a late Middle Holocene chronology due to

the presence of blades and Saladillo related tools), appears in all the sectors previously mentioned, an extensive occupation from the late Middle Holocene could have occupied the entire area.

It was thus possible to distinguish two main occupations, an older one from the Middle Holocene -extending towards the late Holocene by the radiocarbon date obtained (Table 2)-, and a more recent one from the historical period (although the architectural and ceramic traits appear from the Inca period).

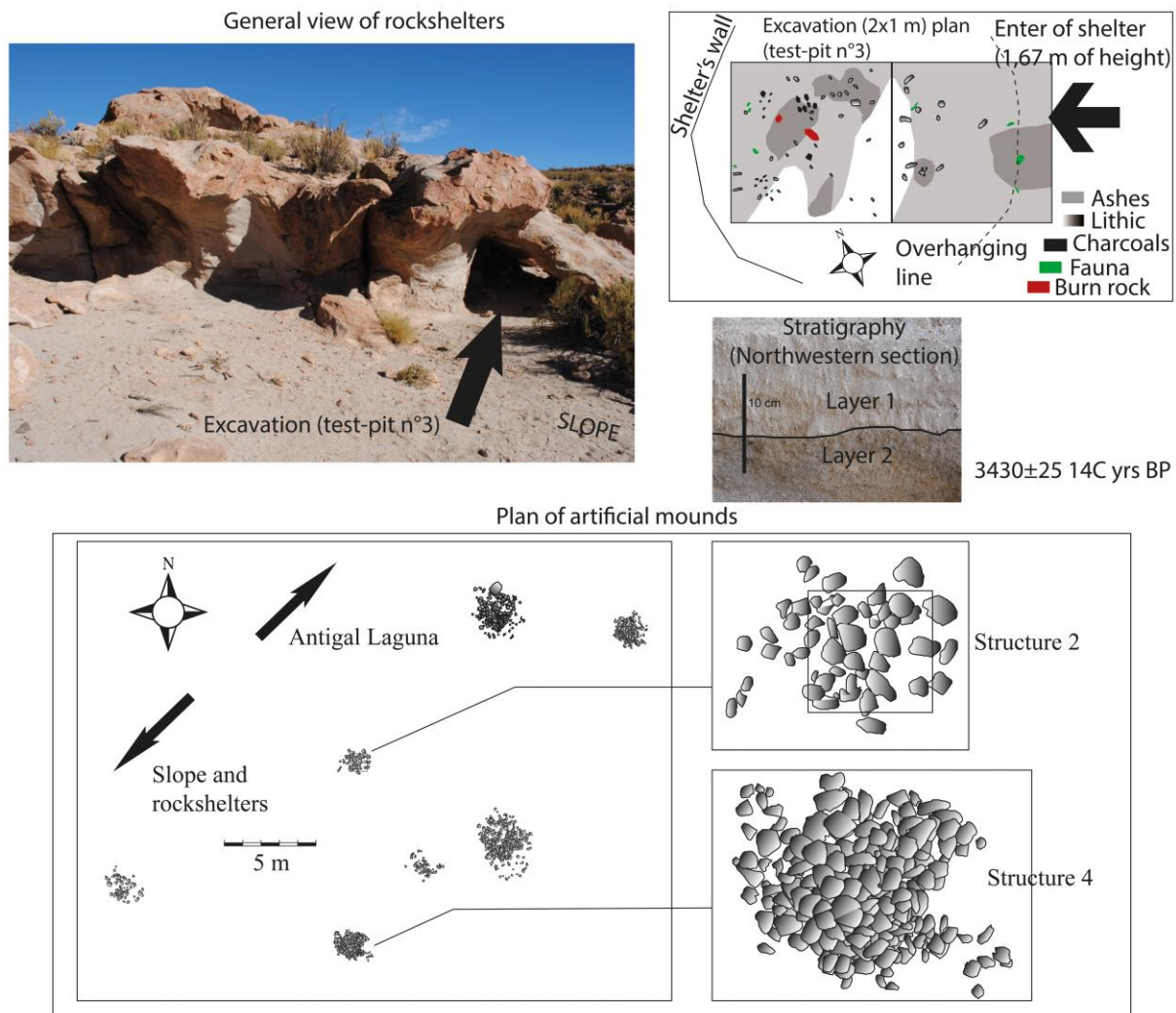


Figure 2. Laguna Media 7. General view of rock shelter, Excavation plan, stratigraphic column and artificial mounds sector map.

4.2. Morro Blanco

In this site, it was possible to distinguish two main sectors: the rock shelter with its drip line, and a terrace bounded by a fallen block and two badlands (Figure 3). Several panels of engravings and painted rock art are associated with the site. Six dates (three in each sector) were made on charcoals for each level and extraction, allowing to date the site to the beginning of the late Holocene (Figure 3). A great variety of materials were found: bones, lithics (Table 3), vegetables, animal leather and fibres, shell beads, and ceramic sherds, whose characteristics (such as stemmed and barbed shoulders arrowheads, bifacial lanceolate arrowheads and Los Morros ceramic) are coherent with the dates, suggesting a continuous occupation overall, except the latest one (Table 2).

Table 1. Lithic materials of Laguna Media 7 classified following raw material and *chaîne opératoire* by-products.

| | Materials | Knapping | | | | Tools | | | | Total | % |
|-----------|--------------|-----------|----------|------------|------------|-----------|------------|----------|-----------|-------------|-----|
| | | Cores | Cortical | Flakes | Confection | Retouched | Shaped | Others | Ind. | | |
| Local | Quartzite | 24 | 1 | 318 | 798 | 70 | 97 | 2 | 10 | 1320 | 85 |
| | Opal | 0 | 0 | 2 | 11 | 1 | 0 | 0 | 0 | 14 | 1 |
| | Quartz | 2 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 7 | 0.5 |
| | Quartzite v2 | 0 | 0 | 2 | 7 | 1 | 1 | 0 | 0 | 11 | 1 |
| Non-local | Andesite | 3 | 0 | 57 | 54 | 20 | 25 | 0 | 5 | 164 | 11 |
| | Obsidian | 0 | 0 | 2 | 25 | 0 | 1 | 0 | 0 | 28 | 2 |
| | Others | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0.1 |
| | Total | 29 | 1 | 381 | 902 | 92 | 124 | 2 | 15 | 1546 | |
| | % | 2 | 0.1 | 25 | 58 | 6 | 8 | 0.1 | 1 | | |

Table 2. Radiocarbon dating from both sites (Morro Blanco dates taken from Yacobaccio *et al.* 2018)

| Site | Localisation | Layer | Dates (14C years BP) | Calibrated dates (2 σ range) | Method | Material | Laboratory code |
|----------------|----------------|-------|----------------------|-------------------------------------|--------|----------|-----------------|
| Laguna Media 7 | Test-pit n°3 | 2 | 3430±25 | 3562-3703 | AMS | Bone | GifA#17286 |
| Morro Blanco | C1 (Shelter B) | 1(2°) | 3190±80 | 3159-3567 | 14C | Charcoal | LP-3299 |
| | C1 (Shelter B) | 2 | 3075±25 | 3144-3349 | AMS | Charcoal | GifA#17283 |
| | C1 (Shelter B) | 1(1°) | 2830±70 | 2781-3083 | 14C | Charcoal | LP-3296 |
| | Terrace A | 1 | 2255±25 | 2676-2742 | AMS | Bone | GifA#16252 |
| | Terrace A | 1 | 2560±20 | 2489-2644 | AMS | Charcoal | GifA#17284 |
| | Terrace A | 2 | 640±25 | 588-646 | AMS | Charcoal | GifA#17285 |

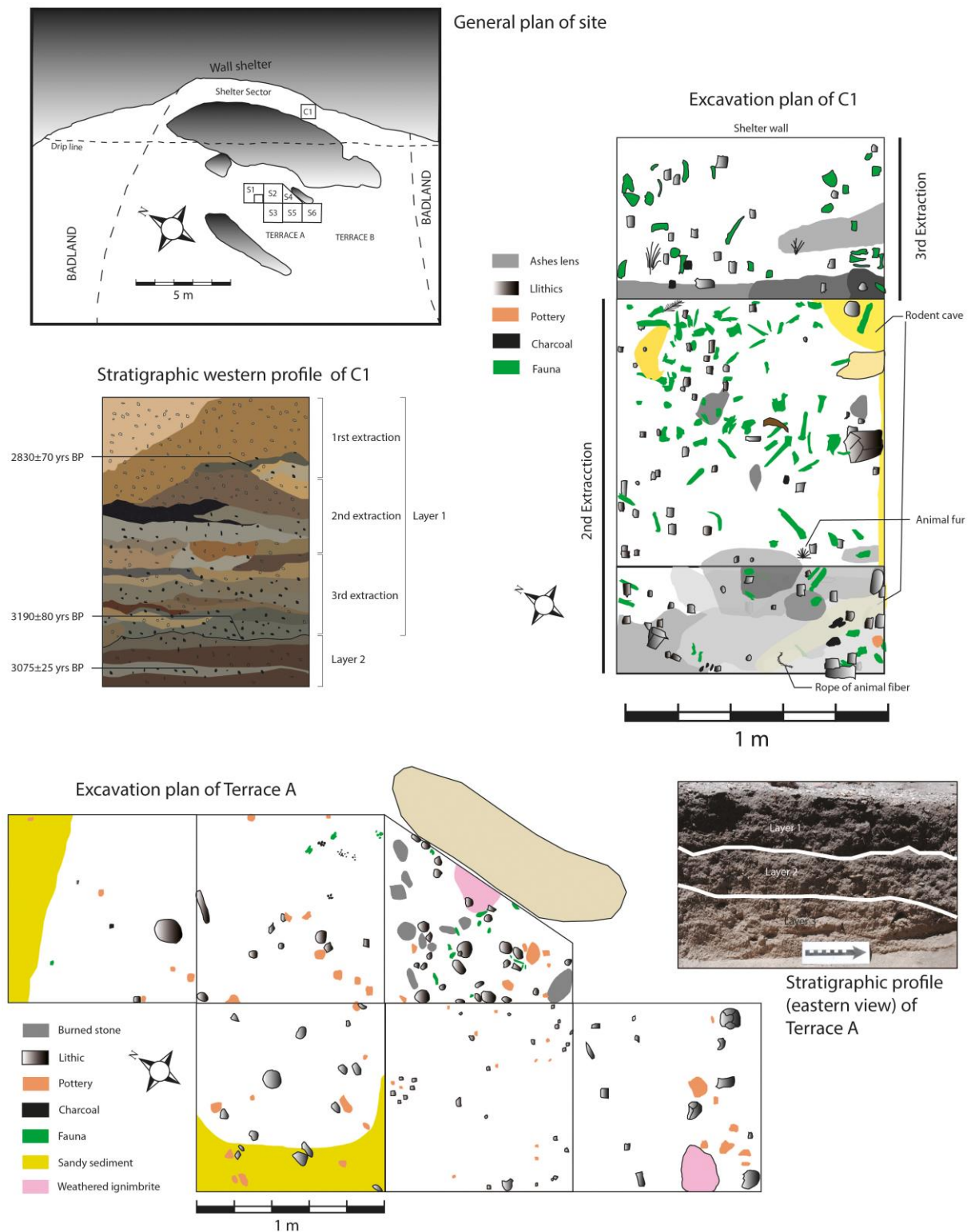


Figure 3. Morro Blanco. General view of rock shelter. Excavation plans and stratigraphic columns.

This chronological continuity, as much in the site as in comparison with Laguna Media 7, may be suitable for the study of technological change. For the purpose of this work, technological analysis was carried out separately by site. The methodological decision to study the sites separately was given by the context: the presence or the absence of certain diagnostic materials revealing a marked change, such as ceramics, blades and stemmed projectile points with barbed shoulders.

Table 3. Lithic materials of Morro Blanco classified following raw material and *chaîne opératoire* by-products.

| | Material | Knapping | | | | Tools | | | | Total | % |
|-----------|--------------|-----------|-----------|------------|------------|-----------|-----------|-----------|-----------|------------|-----|
| | | Cores | Cortical | Flakes | Confection | Retouched | Shaped | Others | Ind. | | |
| Local | Quartzite | 13 | 22 | 177 | 124 | 34 | 6 | 0 | 0 | 376 | 51 |
| | Opal | 3 | 0 | 5 | 27 | 1 | 0 | 2 | 3 | 41 | 6 |
| | Quartz | 3 | 8 | 48 | 65 | 4 | 3 | 19 | 22 | 172 | 23 |
| | Quartzite v2 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 0,3 |
| Non-local | Andesite | 0 | 0 | 2 | 16 | 1 | 3 | 0 | 0 | 22 | 3 |
| | Obsidian | 1 | 0 | 3 | 103 | 7 | 4 | 2 | 0 | 120 | 16 |
| | Others | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 | 0,4 |
| | Total | 20 | 30 | 235 | 339 | 47 | 17 | 23 | 25 | 736 | |
| | % | 3 | 4 | 32 | 46 | 6 | 2 | 3 | 3 | | |

5. Materials and methods

From the pit tests and excavations previously presented, 1546 artefacts were collected and analyzed from Laguna Media 7 (955 from the excavations and 591 from the surface) and 736 in Morro Blanco (554 from the excavation and 182 from the surface). For the aforementioned reasons, the analysis was performed by separating the sites from each other.

The techno-functional units (TFU) of the tools were identified (Boëda 2013). These were divided into two large classes: transformative (TFU_t) and prehensile (TFU_p). The techno-functional units answer to certain criteria that the instruments have in order to be functional in action (accompanied by a gesture), and obtained by knapping and retouching or by shaping, answering to a certain objective the knapper has (Boëda 2013). They were then identified from the morphological features in the plan and section of the artefact, as well as from its technological aspects, that is to say, by the study of the organization of the scars and removals on the tool. Then these traits are studied in relation to each other to determine which is transformative and which is prehensile or hafted.

The lithic operational chains were reconstituted by physical and mental (Geneste 2010; Pelegrin 1995) refittings. The latter were carried through the classification of the different artefactual classes: cores, initialization flakes, knapping flakes, confection flakes, blanks and tools. For each type of artefact the removals, their direction and the position of the negative bulbs were identified. In this way, illustrations were made following the codings of Inizan *et al.* (1995). An analytical cut was made between knapping and *façonnage* (shaping). The first consists of knapping a block to remove a flake consisting of the blank sought by the knapper to be the support of a tool. A subsequent confection (*façonnage* or retouching) is possible in order to give the tool its final functionality and eventually customize it from a cultural point of view (an event that can also occur during the knapping). On the contrary, the shaping (*façonnage*) consists of formatting a block or a blank that consists of the matrix sought to make the tool (Inizan *et al.* 1995). In this way the removed flakes are not the desired products, although they can function later as blank for tools. It is important to estimate the importance of knapping and shaping in the artefacts' functional criteria for the study of change and technical evolution (Boëda 2013).

Sketches were also made from the operational chains of knapping and classified according to their degree of integration. This consists of defining how much volume is integrated into artefactual production relatively with the remaining volume (Boëda 2013). Thus, different types were defined, of which 3 (C, D and E) were identified in this work. The first two were considered "additional" structures. This means that the different surfaces, platforms and faces of the knapping process were independent from each other. The last one (type E) is an "integrated" structure, and in this case, all the surfaces had a role and a dependence to carry out the knapping. More specifically, Type C was a volume selected due to its convexities and natural angles that would allow the removal of a predetermined blank; in the case of a Type D, the surfaces (platform and surface of the knapping) must have been prepared, which would allow to obtain another series from the same surfaces. Finally, Type E was knapped to obtain blanks in a systematized and recurrent manner, requiring a close relationship between its worked surfaces. Examples of this were the pyramidal (blades) and discoidal cores (Boëda 2013).

Separately by site, the cores and blanks (unmodified and tools) were quantified by the aforementioned classes, identifying the method and the degree of integration. For each instrument, the shaping was characterized by two main variables: the position (bifacial, unifacial, alternate methods) and extension (partially extended, invasive, and covering). From this perspective, retouching is always marginal and its use corresponds to a slight modification because the blank was obtained in order to already have the TFU. The TFU_t

(burin, sinuous edges, denticulate, side-scraper, knife, scraper, *rostrum*, perforators, arrowheads and notches) and the TFUp (peduncle, notch, back obtained by knapping, back obtained by shaping, natural, sinuous edge and thinning) of the tools and blanks were quantified by the whole assemblage.

In all the analyses, the undetermined classes were not taken into account in statistical analysis, thus avoiding noises on diversity interpretation. Likewise, only knapped (that is to say knapped and shaped) materials were analyzed here. This present work did not take into account polished, grounded and percussion classes.

Finally, the data analysis was then presented according to the following categories: transformative TFU, prehensile TFU, knapping method and shaping. For each particular case, the χ^2 test was used to compare the distributions between the two sites in order to test the null hypothesis of no correlation between the different levels of the categorical variables. When faced with frequencies less than 5, as observed for some of the registered characteristics (especially regarding prehensile TFU) the probability associated with the χ^2 test was estimated by the Monte Carlo approximation (n=9999 permutations), which provides a more precise and conservative context.

6. Results

6.1. The transformative techno functional units

Over ten classes of TFU_t were identified: burin, sinuous edges, denticulate, side-scraper, knife, scraper, *rostrum*, perforators, arrowheads and notches.

The transformative TFU representing projectile points were identified in both sites, but more specifically in Morro Blanco. They are mostly made from immediately local quartzite in Laguna Media 7 (67%) and a diversity of rocks in Morro Blanco (non-local obsidian, local fine-grained quartzite, quartz, and intermediate andesite). The burins also show an interesting relation between Laguna Media 7 and Morro Blanco, where they are better represented. While in the latter, they are associated with rock art engravings, showing traces of being used against hard materials (such as the ignimbrite in which said engravings were made), in Laguna Media 7 there was a complete absence of engravings or any form of rock art. These artefacts are mostly manufactured in quartzite (91%). The size as well as use wear traces seem to show that while the burins in Morro Blanco were mainly used to perform activities over hard materials, in Laguna Media 7, they were related to processing animal or vegetable resources.

The different distribution observed between both sites (Figure 4) in activities does not mean that functional activities were different because of a technological change through time, but could be linked with the spatial location of sites and their specific activities.

Comparing the transformative TFU from both sites, the result of χ^2 was significant (Table 4), rejecting the null hypothesis of similarity in the distributions (χ^2 , $p < 0,001$ $p = 1,94E-07$), which was also consistent with the approximation of Monte Carlo ($p = 0,0001$). The normalized residuals also suggest that burins and projectile points were the categories with the greatest weight in the samples. The weight of the notches and the knives was equally remarkable in the sample (Table 4). These classes reflected the greatest difference in activities between both sites.

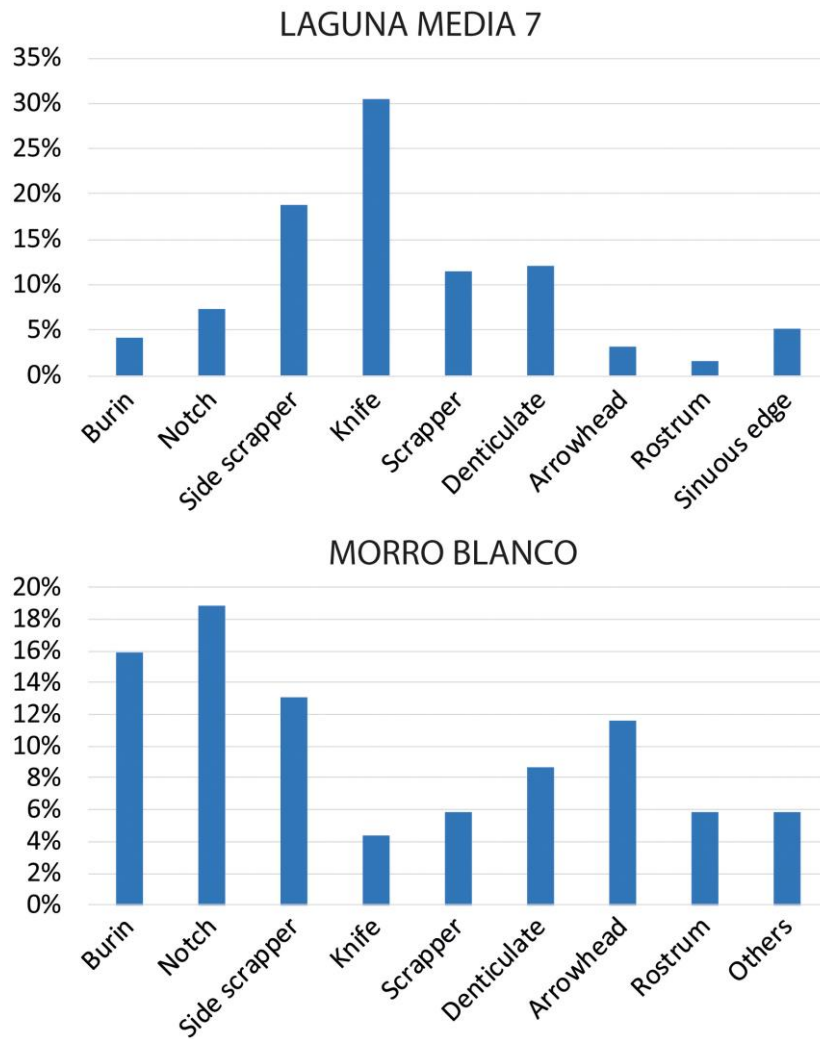


Figure 4. Distribution (percentages) of TFU_t on Laguna Media 7 and Morro Blanco.

Table 4. Frequencies and normalized residuals for the Transformative TFU from Laguna Media 7 and Morro Blanco - χ^2 and Monte Carlo results.

| TFUt | Frequency | | Residuals | |
|-----------------|----------------|--------------|------------------|--------------|
| | Laguna Media 7 | Morro Blanco | Laguna Media 7 | Morro Blanco |
| Burin | 8 | 11 | -6.2697 | 6.2697 |
| Notches | 14 | 13 | -6.278 | 6.278 |
| Side-scrapers | 36 | 9 | 2.2033 | -2.2033 |
| Knives | 58 | 3 | 12.187 | -12.187 |
| Scrapers | 22 | 2 | 3.9751 | -3.9751 |
| Denticulate | 23 | 6 | 1.2199 | -1.2199 |
| Arrowhead | 6 | 8 | -4.5145 | 4.5145 |
| Rostrum | 3 | 4 | -2.2573 | 2.2573 |
| Perforator | 1 | 1 | -0.50207 | 0.50207 |
| Sinuous edge | 10 | 3 | 0.23651 | -0.23651 |
| Total | 181 | 60 | | |
| Chi squared | | | | |
| Rows, columns: | 10, 2 | | Degrees freedom: | 9 |
| χ^2 : | 48.641 | | p (no assoc.): | 1.94E-07 |
| Monte Carlo p : | 0.0001 | | | |

6.2. The prehensile techno functional units

Six large classes of prehensile techno-functional units (TFU_p) were identified: notches, peduncle, back (obtained by extended or partially extended retouching), back (already present from the blank), sinuous edge, and thinning (proximal). These TFU_p involved different ways of prehension: axial hafting for the peduncles and the bulb thinning of the proximal parts (Figure 5: 1 to 6, Figure 6: 11 to 19), lateral manual or axial-lateral grasping for the backs (either shaped or previously present in the blank) and sinuous edges (Figure 5: 7 to 10; Figure 7: 20 to 22, 24), oblique or lateral hafting for notches (Figure 7: 23). The presence of two simultaneous TFU_p such as proximal thinning and back was remarkable, as observed with tools of the Saladillo technical tradition (Figure 5: 2). These artefacts (N=32) are mostly made of quartzite (78%) and andesite (22%).

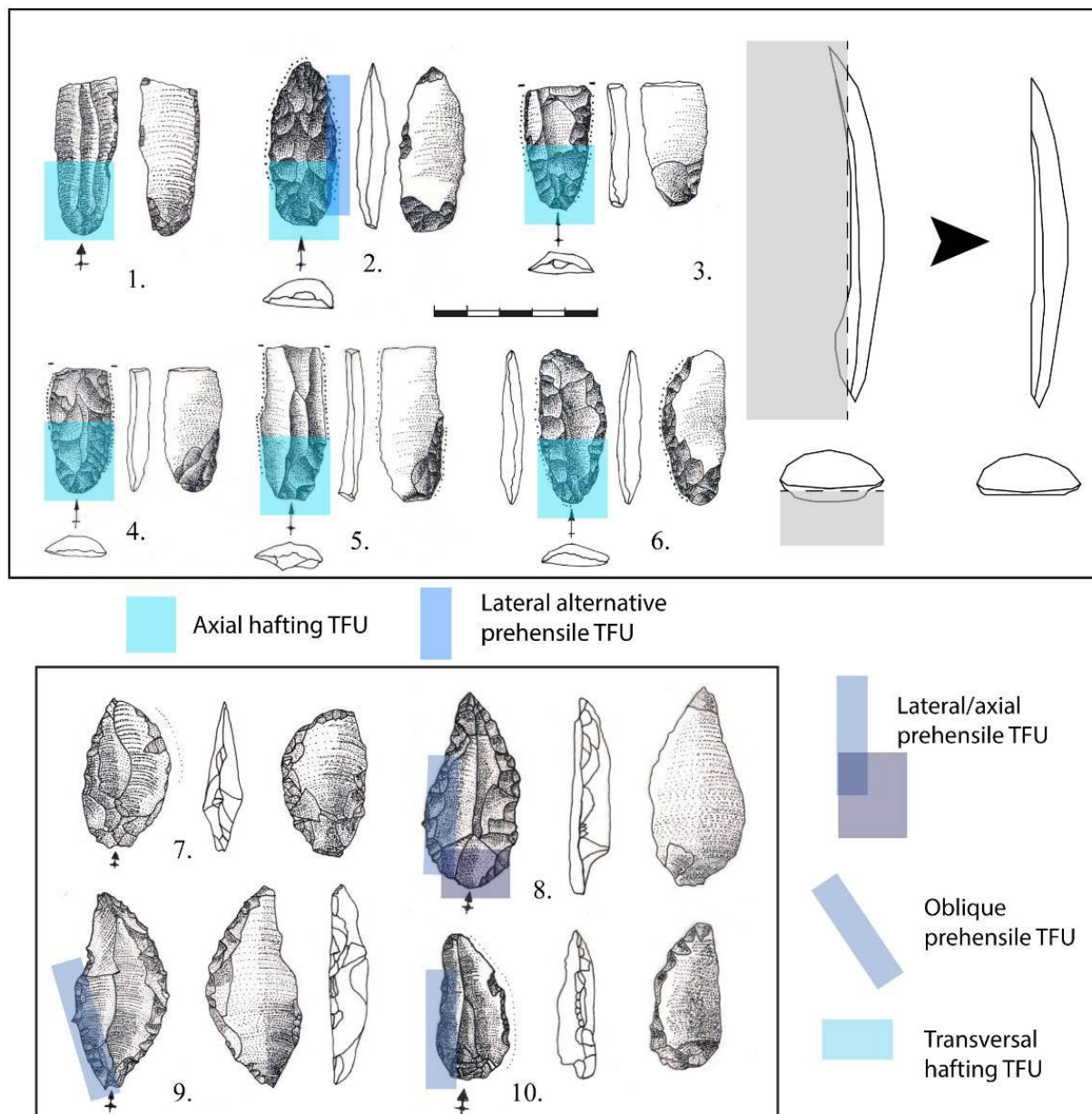


Figure 5. Different tool classes and their prehensile modes in Laguna Media 7.

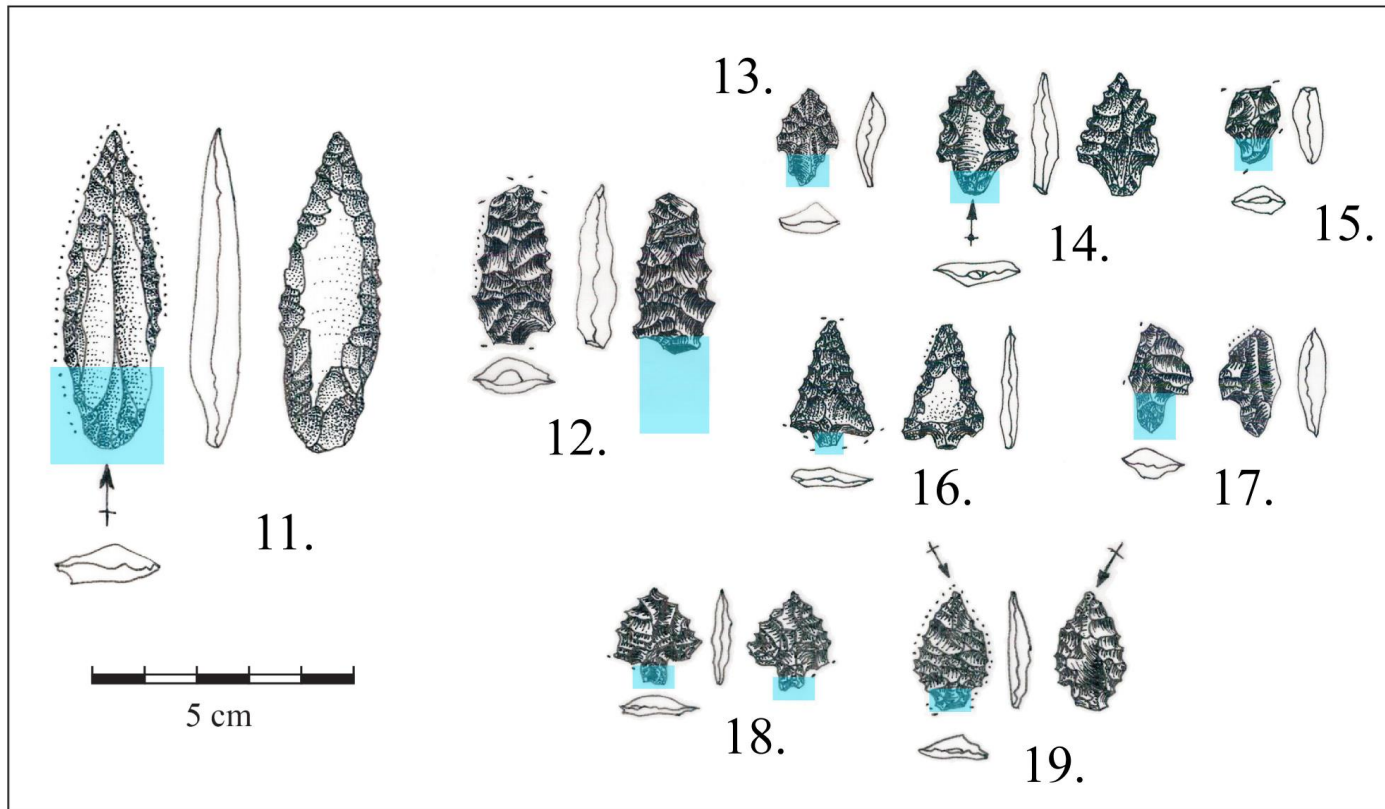


Figure 6. Arrowhead and their prehensile modes in Morro Blanco.

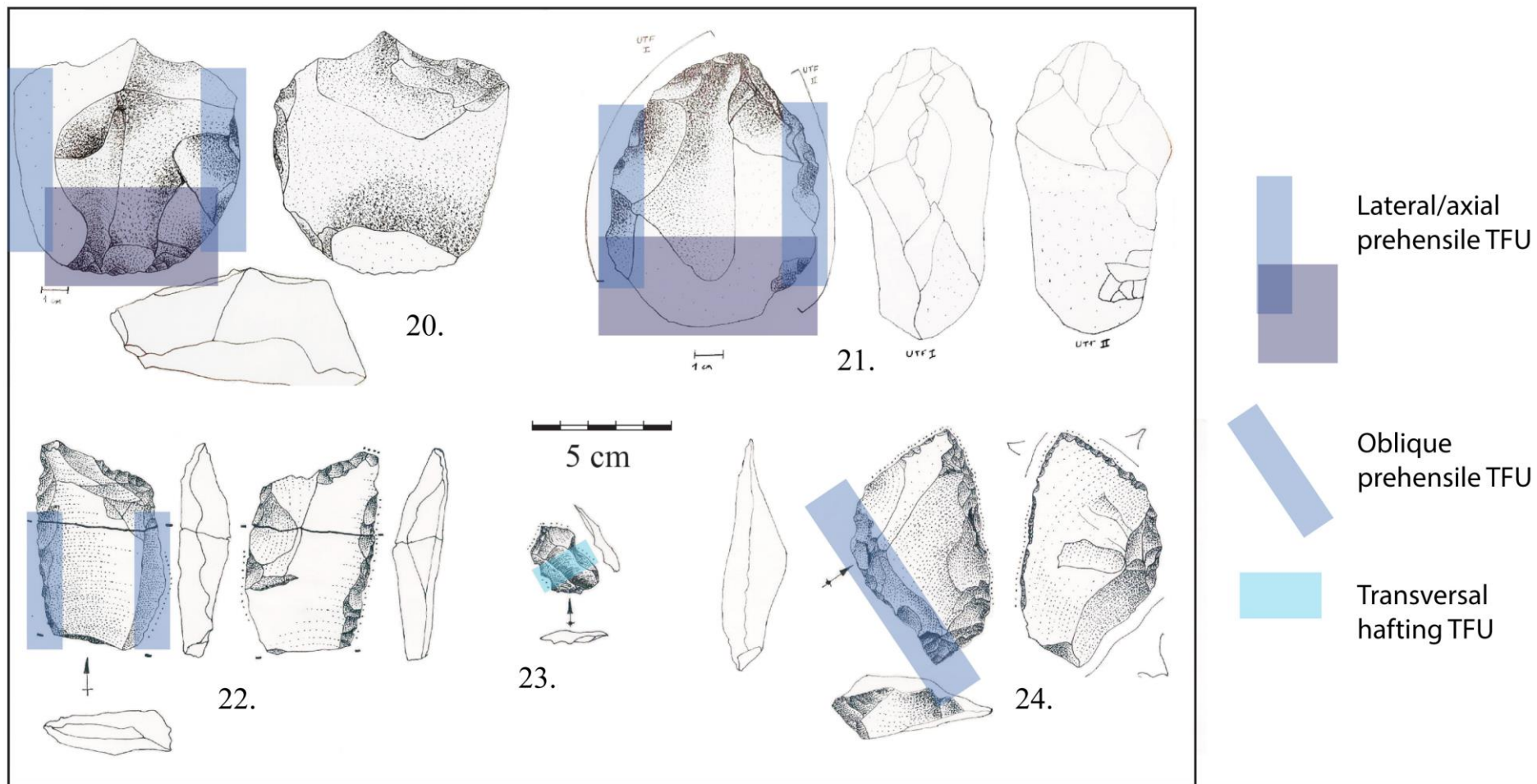


Figure 7. Different tools and their prehensile modes in Morro Blanco.

Similar tendencies were highlighted in terms of the hafting axis and the axial or lateral prehension between both sites, with a stronger tendency towards the axial handling in Morro Blanco (Figure 8). The thinning of the proximal parts was a TFU_p dominant trait in Laguna Media 7 while in Morro Blanco the peduncles dominated (Figure 8). Although it was low, the exclusive presence of the shaped backs was notable in Laguna Media 7. The sinuous edges and the back (knapping) were more used as TFUp in Morro Blanco than in Laguna Media 7 (Figure 8).

In the case of the Prehensile TFU, the results should be taken with certain precaution, even though the results (as in this case) were significant (Table 5). In effect, the null hypothesis of association between the two distributions was rejected (χ^2 , $p < 0.001$). The normalized residuals suggested that the frequencies of peduncles in Morro Blanco and bulb thinning in Laguna Media 7 showed the greatest differences between the observed and expected frequencies between both sites.

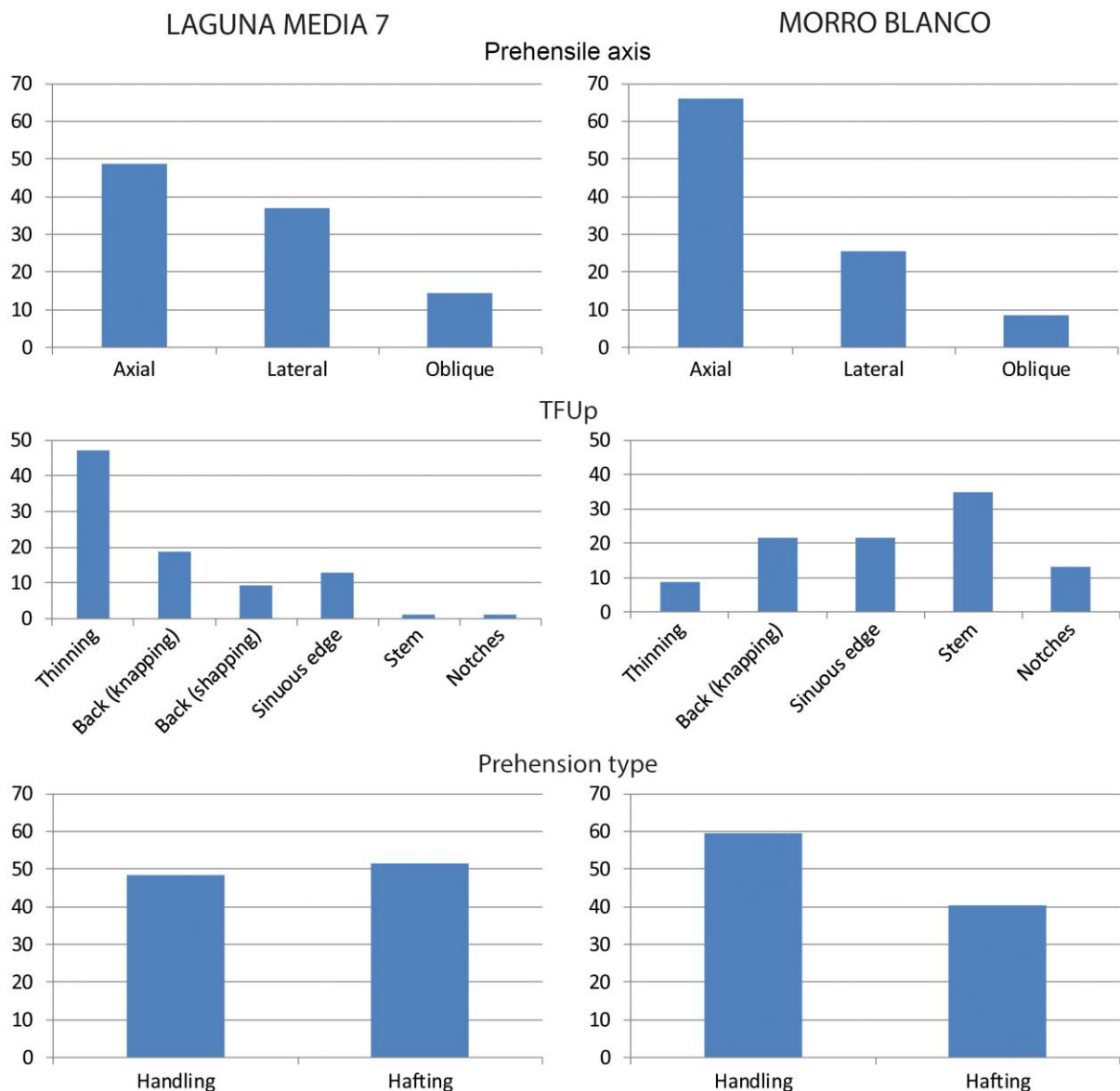


Figure 8. Distribution (percentages) of prehensile axis, prehension type and TFU_p at Laguna Media 7 and Morro Blanco.

Table 5. Frequencies and normalized residuals for the Prehensile TFU from Laguna Media 7 and Morro Blanco - χ^2 and Monte Carlo results.

| TFUp | Frequency | | Residuals | |
|-----------------|----------------|--------------|------------------|--------------|
| | Laguna Media 7 | Morro Blanco | Laguna Media 7 | Morro Blanco |
| Sinuous edge | 11 | 5 | -1.3478 | 1.3478 |
| Back (knapping) | 17 | 3 | 1.5652 | -1.5652 |
| Back (shaping) | 8 | 0 | 1.8261 | -1.8261 |
| Thinning | 33 | 2 | 5.9891 | -5.9891 |
| Stem | 1 | 8 | -5.9457 | 5.9457 |
| Notches | 1 | 3 | -2.087 | 2.087 |
| Total | 71 | 21 | | |
| Chi squared | | | | |
| Rows, columns: | 6, 2 | | Degrees freedom: | 5 |
| x2: | 38.002 | | p (no assoc.): | 3.77E-07 |
| Monte Carlo p : | 0.0001 | | | |

6.3. The shaping methods

In general, in Laguna Media 7, an even percentage was observed between the instruments whose TFU were mainly obtained by shaping (50%) after knapping. On the other hand, the blanks were only marginally retouched (50%) (Figure 9). In Morro Blanco, it was observed that the TFU of most tools were obtained only by knapping and retouching methods (73%) while the tools in which TFUs were made through shaping were lower (27%).

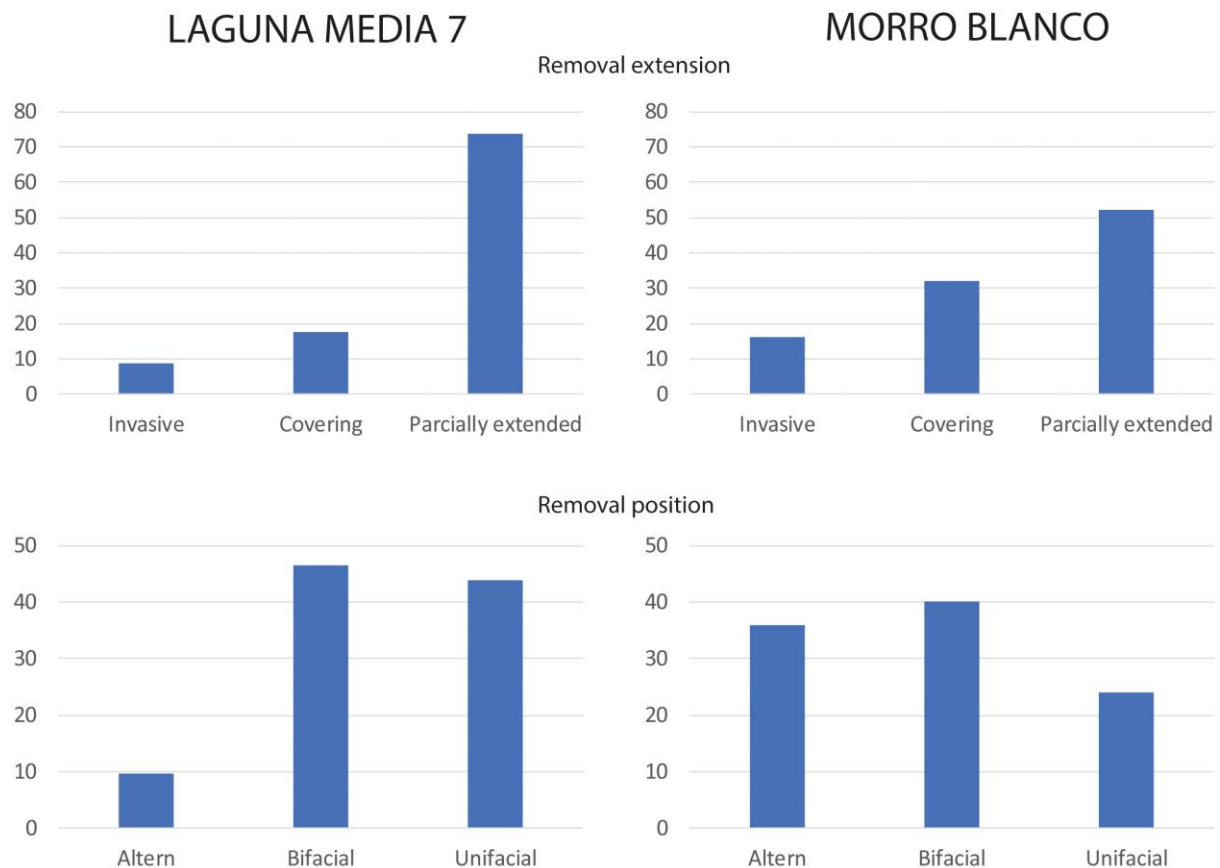


Figure 9. Distribution (percentages) of shaping methods on Laguna Media 7 and Morro Blanco.

In both sites, the extent of the flaking over the instruments was mostly partially extended, and to a lesser extent, covering and invasive (Figure 9). However, in Laguna Media 7, the partial extension was more distinguished in relation to Morro Blanco. The alternate shaping was better represented in Morro Blanco, at the expense of unifacial shaping, which is better represented in Laguna Media 7 (Figure 9).

Some artefact classes deserve a more detailed description of their manufacturing sequence. In the case of the Saladillo technical tradition, the bulb was thinned and confection usually provided a lanceolate-shaped morphology and a flat-convex section (Figure 5: 1 to 6). According to each case, the confection involved more or less extended flaking on the dorsal side and a final bifacial or unifacial retouching. This variability was possibly the product of the different characteristics of the initial (unmodified) blades, and with the aim of obtaining a flat-convex section. However, the cultural weight (that is to say the last degrees of the events) of some aspects, such as the bulb thinning, was possible, since in some cases, as mentioned in Susques, it did not significantly diminish the proximal part of the piece, nor did the perimeter retouching rectify the curvature of the profile (Huguin 2014a).

The bifacial lanceolate projectile points were present in both sites and were present during the Middle and Late Holocene at an important geographic scale (Aschero *et al.* 2011; Huguin 2014b; Lavallée *et al.* 1995; 1997; Núñez *et al.* 2005; 2006; de Souza *et al.* 2010). These presented a variability of methods as shaping at least in two sequences with direct percussion and pressure (Huguin 2014a). In some cases, the blanks seemed to be obtained to avoid an invasive confection (Figure 6: 11).

The test did not reject the null hypothesis regarding the shaping extension (χ^2 , $p > 0.05$) (Table 6). According to the normalized residuals, the category that would most mark differences were the partially extended flaking (Table 6). On the contrary, regarding the flake position, the results of the χ^2 were significant (Table 7), therefore rejecting the null hypothesis (χ^2 , $p = 0.005$). The normalized residuals suggest that alternate and, to a lesser extent, the unifacial shaping contributed substantially to the difference between the two sites, being the alternate less frequent than what would be expected by hazard in Laguna Media 7, where unifacial is more frequent (unlike Morro Blanco) (Table 7).

Table 6. Frequencies and normalized residuals for the shaping extension in the tools from Laguna Media 7 and Morro Blanco - χ^2 and Monte Carlo results.

| Shaping Extension | Frequency | | Residuals | |
|--------------------|----------------|--------------|---------------------|--------------|
| | Laguna Media 7 | Morro Blanco | Laguna Media 7 | Morro Blanco |
| Invasive | 10 | 4 | -1.482 | 1.482 |
| Complete | 20 | 8 | -2.964 | 2.964 |
| Partially extended | 84 | 13 | 4.446 | -4.446 |
| Total | 114 | 25 | | |
| Chi squared | | | | |
| Rows, columns: | 3, 2 | | Degrees freedom: | 2 |
| χ^2 : | 4.5722 | | p (no association): | 0.10166 |
| Monte Carlo p : | 0.1009 | | | |

6.4. The knapping methods

Four principal core classes were identified at the sites: discoidal (and centripetal), SASP (system alternating surface and platform), blade and others (unidirectional and multidirectional type C and D). In both sites, a certain diversity was observed and quartzite is the dominant rock in cores in both sites (80% in LM7 and 73% in AMB). The centripetal method usually involved a single extraction surface, while the discoidal method alternated

two sides and produced a greater number of blanks (Figure 10). The blanks showed centripetal removals, dihedral or faceted platforms in the advanced phases, and in turn an overshot and flow side back (Figures 10 and 11). Let us make that clear: this kind of back is a facet that results from the percussion in a platform near the intersection of two removal surfaces following a sharp angle. The SASP method alternated platform and flaking surfaces, thus producing flakes with dihedral platforms from the second sequence onwards. In its most advanced phase, it could have produced a core flank flake with its typical back (Figure 10). Thus, this back is the remnant of the intersected neighbour surface and is more linked with the ventral than the dorsal face. Two methods of blade knapping, one unidirectional and the other bidirectional (Figure 12), were recognized here. They produced blades, with a module length/width equal or greater to 2, which served as blanks for the Saladillo tradition tools, present exclusively in Laguna Media 7. In Morro Blanco, unidirectional C-type flakes allowed the production of blanks of a certain size as those used for the burins (Figure 7: 20, 22). A multidirectional type D obsidian core was also found and could have been used as the blanks for the pedunculated projectile tips observed (Figure 11).

Table 7. Frequencies and normalized residuals for the shaping position in the tools from Laguna Media 7 and Morro Blanco - χ^2 and Monte Carlo results.

| Shaping Position | Frequency | | Residuals | |
|------------------|----------------|--------------|------------------|--------------|
| | Laguna Media 7 | Morro Blanco | Laguna Media 7 | Morro Blanco |
| Unifacial | 50 | 6 | 4.0719 | -4.0719 |
| Altern | 11 | 9 | -5.4029 | 5.4029 |
| Bifacial | 53 | 10 | 1.3309 | -1.3309 |
| Total | 114 | 25 | | |
| Chi squared | | | | |
| Rows, columns: | 3, 2 | | Degrees freedom: | 2 |
| χ^2 : | 12.093 | | p (no assoc.): | 0.0023666 |
| Monte Carlo p : | 0.0016 | | | |

Although the different products resulting from the centripetal methods (including discoidal knapping) were present in both sites, in Morro Blanco they had a greater importance (Figure 13). Likewise, the knapping products obtained by the SASP method and the cores in Morro Blanco had greater importance in relation to Laguna Media 7, even though there, the blanks of the tools were better represented (Figure 13). It is necessary to clarify that the blanks produced by the SASP and discoidal methods were not always clearly identifiable, and had a marked equifinality in relation to other methods. Finally, the most marked trend in the site was regarding the blade production. The different products obtained by blade knapping were better represented in Laguna Media 7 than in Morro Blanco (Figure 13). Also, the difference in type C knapping was clear between both sites, but it is necessary to clarify that these types of products had an important equifinality with the flakes produced by other knapping methods, particularly in the initial stages (Figure 13). This could have been related to a greater integration of these products in the initial stages of the tool kit, and to a higher production in Morro Blanco.

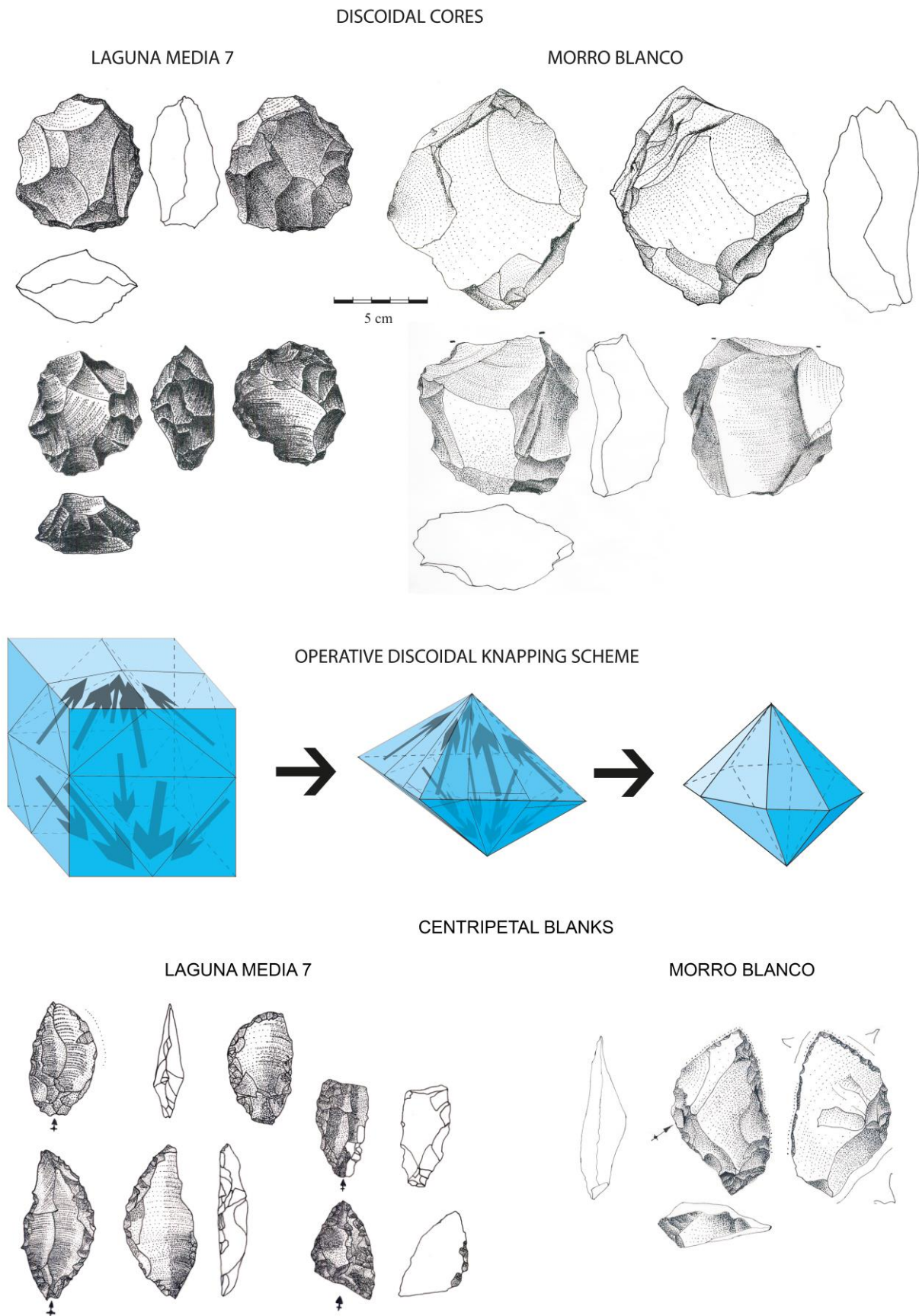


Figure 10. Discoidal operative schemes and centripetal by-products.

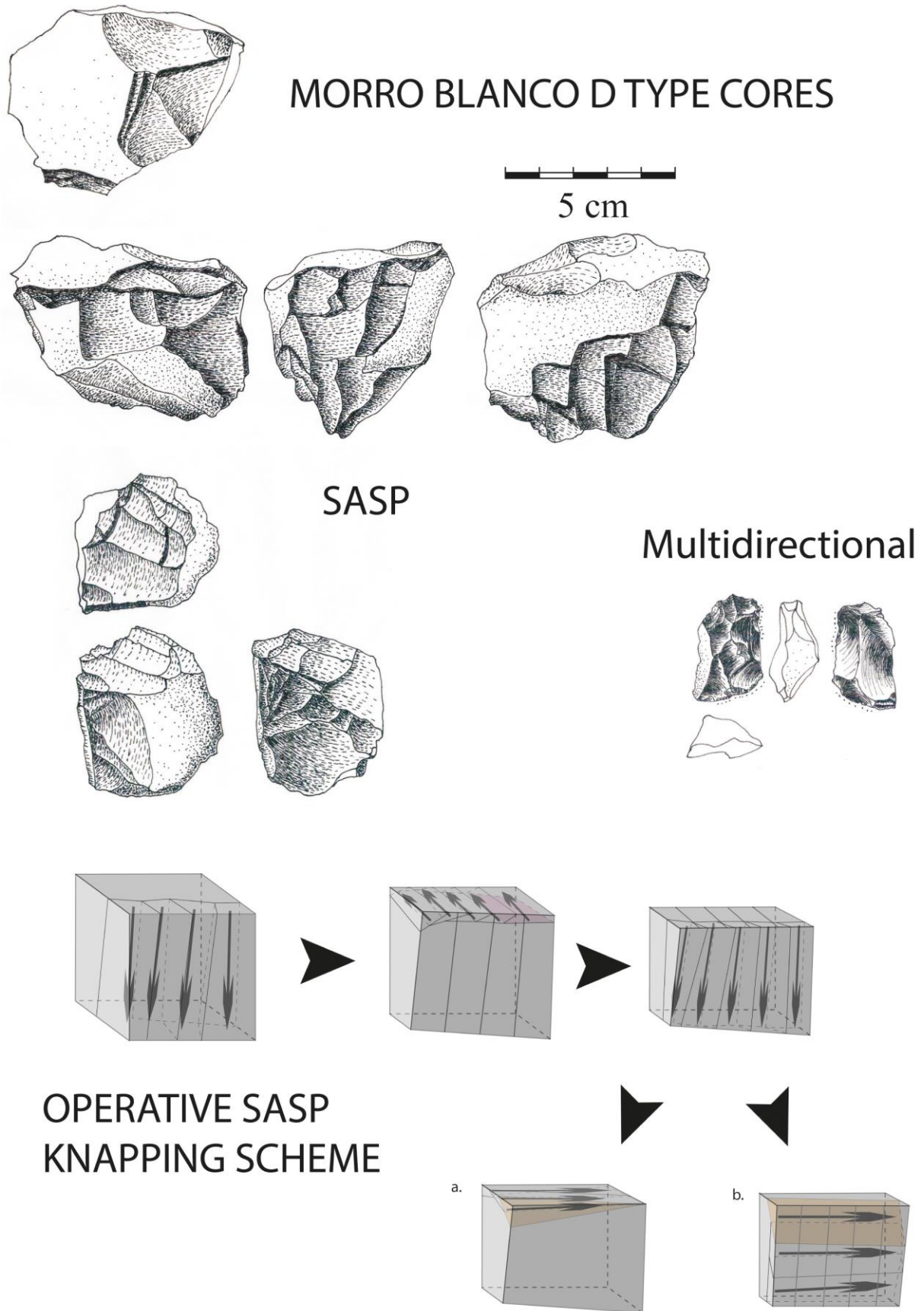


Figure 11. Other D type operative schemes and cores. Pink: Flow side back flake. Orange: Core flank flake.

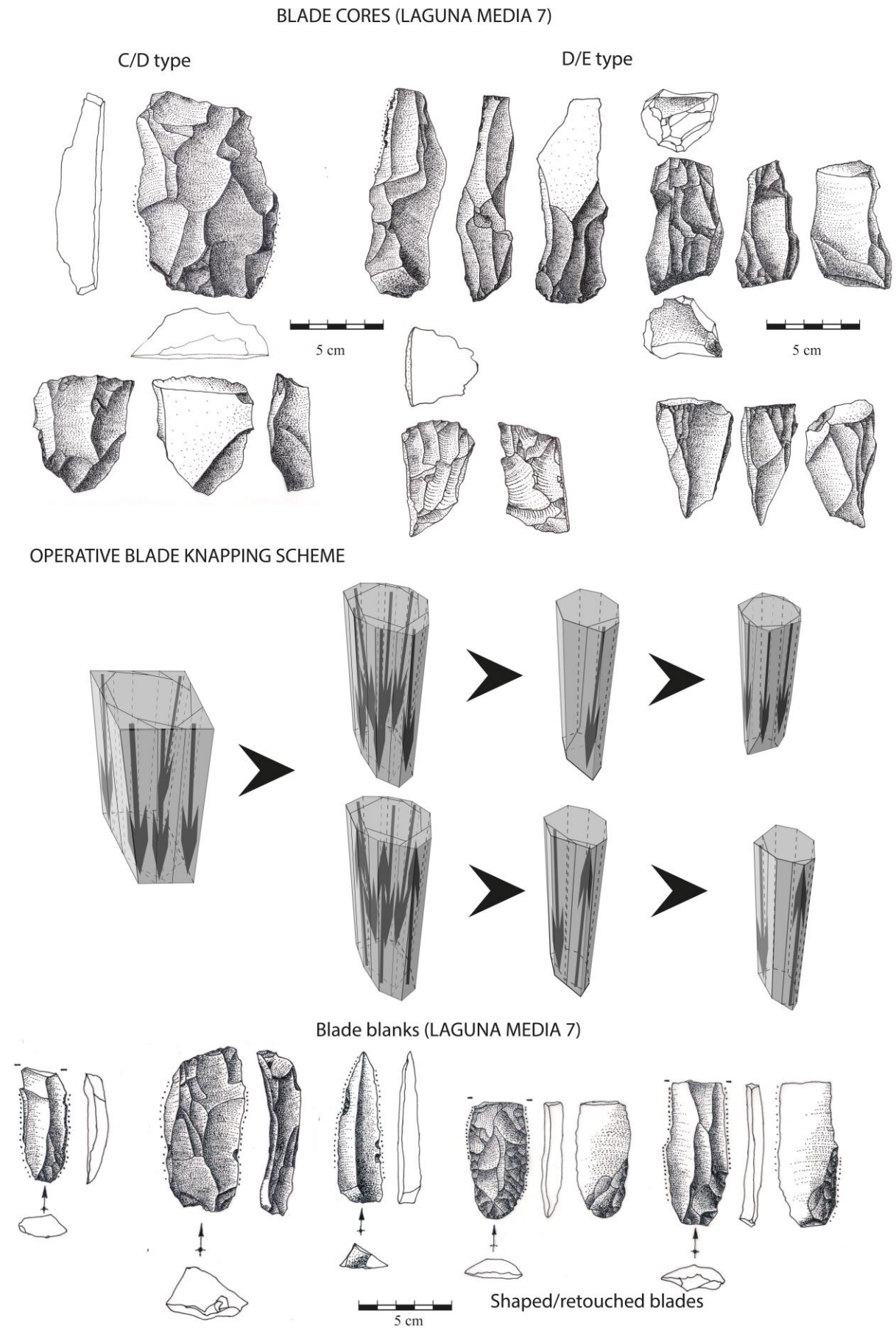


Figure 12. Blade operative schemes and by-products.

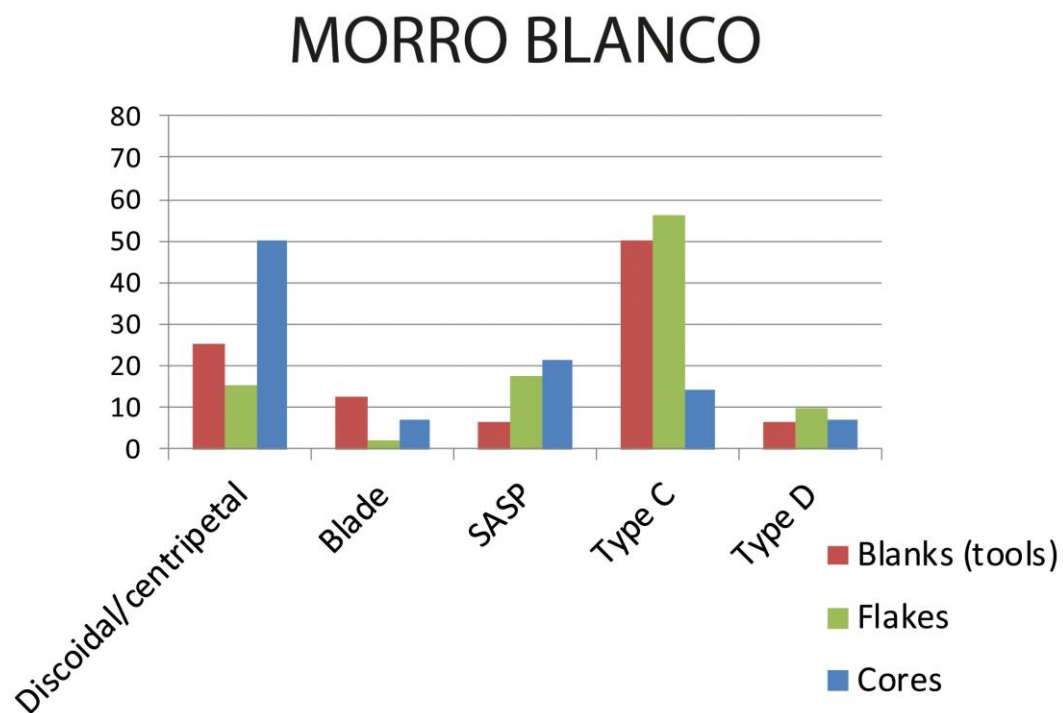
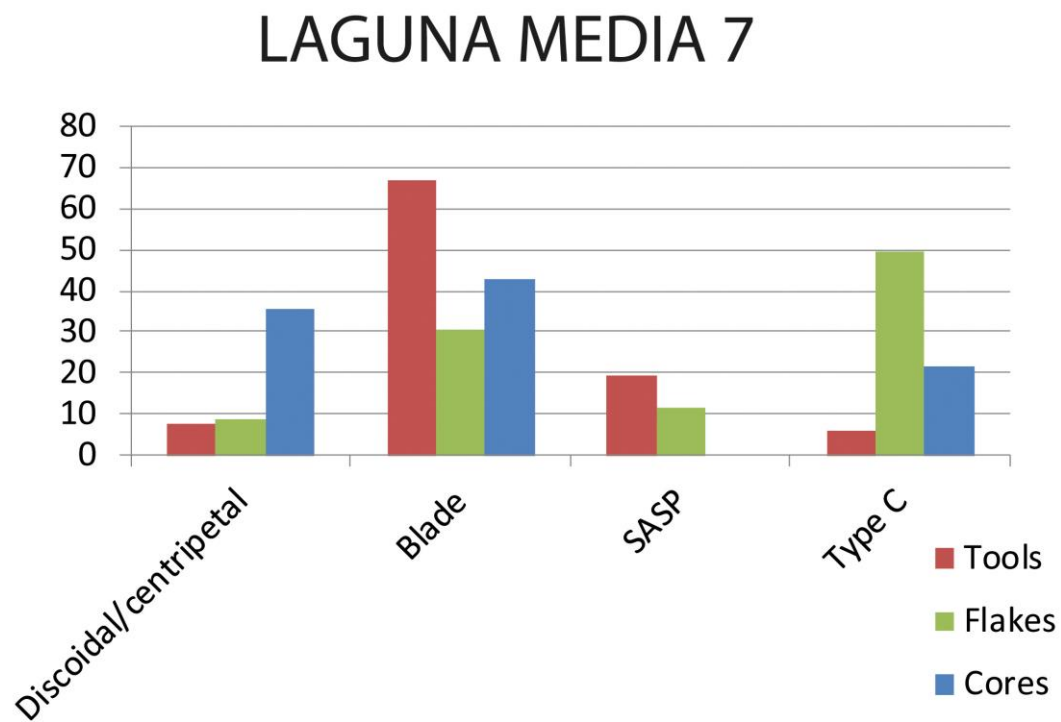


Figure 13. Distribution (percentages) of knapping by-products on Laguna Media 7 and Morro Blanco.

Finally, comparing the knapping methods from both sites, the χ^2 result (Table 8) was particularly relevant, therefore rejecting the null hypothesis of association between both distributions (χ^2 , $p < 0,001$ $p = 3,68E-26$), which also supported the Monte Carlo approximation ($p = 0,0001$). The normalized residuals confirmed the previous observations, as blade knapping represented a weight class in this analysis, being much more represented in Laguna Media 7 than in Morro Blanco. On the other hand, D type cores, were significant and relevant in Morro Blanco, while completely absent in Laguna Media 7.

Table 8. Frequencies and normalized residuals for the knapping methods from Laguna Media 7 and Morro Blanco - χ^2 and Monte Carlo results.

| Knapping method | Frequency | | Residuals | |
|---------------------------|----------------|--------------|------------------|--------------|
| | Laguna Media 7 | Morro Blanco | Laguna Media 7 | Morro Blanco |
| Discoidal and centripetal | 37 | 39 | -3.1591 | 3.1591 |
| Blade | 161 | 7 | 9.859 | -9.859 |
| SASP | 52 | 36 | -1.2286 | 1.2286 |
| Type C | 149 | 114 | -3.6931 | 3.6931 |
| Type D | 0 | 20 | -6.1795 | 6.1795 |
| Total | 399 | 216 | | |
| Chi squared | | | | |
| Rows, columns: | 5, 2 | | Degrees freedom: | 4 |
| χ^2 : | 125.44 | | p (no assoc.): | 3.68E-26 |
| Monte Carlo p : | 0.0001 | | | |

7. Discussion

The period strictly addressed in this paper ranged from ca. 3400 to 2200 years BP. Theoretically, the chronology extended to ca. 5000 years BP thanks to the archaeological context of Antigal Laguna and Laguna Media 7, in particular due to the presence or the absence of certain technological features, such as ceramics, blades and stemmed projectile heads with barbed notches. At a regional scale, the Central-South Andes were the scene of several changes of various intensity in the different spheres of human occupations: social, cultural, economic and technological. One of the major changes of the societies during this period was regarding the domestication strategies of the camelids, and the consolidation of the herding strategies after them (López 2008; López & Orsi 2017; López & Restifo 2012; Olivera 2012; Yacobaccio 2001; among others). One can undoubtedly discuss about the fact that it was a social and economic context crossed by profound changes, possibly gradual and imperceptible on a smaller scale, but marked and notorious on an archaeological scale. The sedentarization process and the groups' growth accompanied these processes, concomitant with notable technological innovations (Muscio 2012; Muscio & López 2017).

The palaeoenvironmental evidence showed a relatively wet phase at a regional level between ca. 4500 and 2500 ^{14}C years BP, although interrupted by dry and torrential events at the local level. In Barrancas, a relatively stable *vega* was detected, suitable for herding (Pirola *et al.* 2018). Also, a possible signal of pastoral activities in these *vegas* was detected from ca. 3600 ^{14}C years BP (Oxman 2015).

Particularly, in the basin of the Barrancas river, a marked chronological cut has been detected between ca. 3400 and 3200 ^{14}C years BP where ceramics (although in very low frequency in the beginning) and the bow and arrow hunting system appeared (reflected by the presence of pedunculated tips with fins), while certain technological features such as blade knapping disappeared. This change does not seem to be related to raw materials supplying the area, as local quartzite of medium quality is dominant in both sites, specifically related to blade technology and discoidal (and centripetal) knapping. Non-local obsidians with a very good knapping quality, and local quartz and opal outcrops presented as small nodules, mostly under ca. 12-20 cm (see also Yacobaccio *et al.* 2004 for obsidian sources), do not allow to produce blanks for different kind of tools discarded at both sites. On the contrary, local quartzite and non-local andesite blocks reach up to 40 cm. Indeed, all the blade and discoidal (and centripetal) production is made on quartzite and andesite, in order to respect the size of blanks. Unlike this, the SASP and other Type D obsidian and quartz production consists of small blanks intended for projectile arrowheads in Morro Blanco. Particularly, we must

highlight the changes occurring in all technical aspects: functional, prehensile and also production.

However, functional aspects may also be the result of different activities that take place at both sites. Burins used for art rock graving activities (Kohan 2018) and small projectile arrowheads used with bows made the difference in Morro Blanco. Only side-scrapers are common at both locations. In these cases, blanks are significantly different between the sites: blades on Laguna Media 7, and discoidal (and centripetal) or Type C flakes on Morro Blanco.

Despite these important changes, a certain continuity could be observed on a regional scale, as in the case of the presence of bifacial lanceolate arrowheads present before and after this chronological break (Aschero *et al.* 2011; Huguin 2014a; Lavallée *et al.* 1995; 1997; Núñez *et al.* 2006; de Souza *et al.* 2010). The stem, in spite of being an almost exclusive technological hafting feature from Morro Blanco, could have been introduced progressively as it is shown in the following sketches of the lanceolate points, and some specimen of the triangular arrowheads (Figure 5B: 11, 12, 13, 15, 17, 19). This was also an observed phenomenon in other regions of the Puna (Hocsman 2010). In effect, the stem was not an exclusive hafting feature of the bow and arrow and was detected at the beginning of the Middle Holocene in a spear throwing system (Huguin & Yacobaccio 2012; Núñez *et al.* 2005; Restifo 2013a; 2013b). The technical sphere was not the only one involved here as funeral practices seem to also reflect some continuity and stabilization of hunter-gatherers in specific territories, as part of a “cult of ancestors” (Aschero 2007; Gonzalez Baroni *et al.* 2017). However, in the case of lithic technology, it is necessary to take necessary precautions with the continuity hypothesis as activities such as reactivation and the individual decisions of the knappers could introduce a certain variability that would correspond to the observed one.

Indeed, statistical data showed relevant changes beyond the differences linked to the function of each site (with burins and arrowheads more representative in Morro Blanco). Hafting modes showed clear differences with the stems in Morro Blanco and the bulb thinning of Saladillo tradition in Laguna Media 7. Shaping methods showed the weight of unifacial formatization as more typical at Laguna Media 7 and alternate methods were more common at Morro Blanco.

On the contrary, continuity was observed in the knapping methods from their qualitative study, except in the case of blade knapping which clearly decreased, if not entirely disappearing, between *ca.* 3400 and 3200 years BP in the area, at least as a type D and E core. Only D type methods, other than blade and discoid production, showed some difference between the sites. Further, discoidal knapping was present in both sites and in similar proportions. No new shaping techniques or modalities were detected at the level of instrument confection over blanks, but the pressure technique should have taken a greater importance during the Late Holocene, given the more systematized use of obsidian at Morro Blanco and its better aptitude for smaller and thinner arrowhead, and the preparation of certain features such as the highlighted stemmed and barbed notches. It was also important to point out that unifacial shaping was more typical in Laguna Media 7, particularly associated with Saladillo type tools. As it was stated, the bulb thinning of these artefacts could have been related to a cultural aspect of the technical tradition and not only functional (Huguin 2014a).

As for the backs UTF_p, those obtained by knapping were more common in Morro Blanco and the backs shaped after obtaining the blank were exclusively present in Laguna Media 7. Likewise, in a general way, the shaping was a more intense activity in Laguna Media 7 than in Morro Blanco. It is a logical phenomenon of technical evolution, since the changes tend to affect the instruments and the final operational chain stages first (that is to say the shaping of the blank), and only then the knapping methods, which are later arranged in a way to obtain the features sought in the blank without the need to further shaping (Boëda 2013). Obviously, it is not an intransigent rule, but an evolutionary trend. In this case, the ruptures caused would

be related to deep cultural and social changes (Boëda 2013). In the case presented in this paper, we could observe clear technical change events, although some notable continuities were observed. That is to say: there were some marked changes but not a total disruption.

Functional, prehensile and production changes are linked to broad technical changes, as seen in a local and regional scale with the appearance of ceramics and architecture among others. In lithics, *chaînes opératoires* and related technical systems' changes may be mostly linked to subsistence strategies, and animal and vegetal raw material supply and processing. The beginning of herding in the region would make the difference between both sites, and could have possibly happened during this time in the Puna of Jujuy, identified by the presence of the taxa *Lama glama* (Yacobaccio 2001). In fact, it is the herding strategy which has greater impact in by-products supplying as milk and wool, among others (Ghesquière 2018). Butchering and other processing activities, and related technical systems might have been affected by domestication and then herding strategies. However, technical systems and subsistence economies may be a concomitant phenomenon, whose changes would be due to a root cause, as social and ecological structuration of populations. New activities, territories and social relationship networks during Late Holocene should have affected resources supplying, gestures and associated technical systems. Blades, for instance could have become obsolete in a context with differential supplying of allochthon resources, as *chusquea lorentziana* being used as shafts (Mondini *et al.* 2013; Pintar & Rodriguez 2015). These seem have only been used to haft projectile arrowheads with peduncle with the introduction of the bow and arrow propulsion system, whereas butchering, collection and processing activities used manual prehension. Pre-existent Type E (integrated) production structures as discoid knapping could have substituted blade ones, offering the same degree of integration, but possibly better adapted to new requirements.

8. Conclusions

During the end of the Middle Holocene and the beginning of the Late Holocene, several ecological, social and economic changes affected the technical systems, which probably underwent modifications on a regional scale, from its techno-economic and economic aspects. On the other hand, in spite of notable discontinuities, it was observed that the operational chains remained unaltered at a local level. The main changes seem to have mainly affected both the hafting and prehensile methods, and also led to a more systematized supply of obsidian nodules. In this way, the adoption of the bow and arrow propulsion system, as well as the caravan traffic in the beginning of the Late Holocene (as a form of procurement of valuable resources such as obsidian and even knowledge) could have had an influence on technical systems. New knowledge, goods and people should have circulated in such contexts. The human group kept mainly flexible technical systems (C and D ones), and the innovations previously mentioned could have arisen in the context of bigger exchange processes and steadier networks. The technical production systems were adapted to the new changes affecting the technical systems, through original solutions of the local knappers adapting their know-how.

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