
Vol 256
4 April 2012
ISSN 1040-6182
ELSEVIER
QUATERNARY INTERNATIONAL
The Journal of the International Union for Quaternary Research
MIDDLE HOLOCENE ARCHAEOLOGY:
DYNAMICS OF ENVIRONMENTAL AND SOCIO-CULTURAL
CHANGE IN SOUTH AMERICA
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Quaternary International 256 (2012) 35–44

Contents lists available at SciVerse ScienceDirect

Quaternary International

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Risk and technological decision-making during the early to mid-Holocene transition: A comparative perspective in the Argentine Puna

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ARTICLE INFO

Article history:
Available online 28 October 2011

ABSTRACT

In this work, the technological changes that took place in the Argentine Puna from the early to mid Holocene are studied, considering settlements at the Alero Cuevas and Alero Hornillos 2 sites. From the perspective of the Human Behavioral Ecology, such changes can be explained considering the risk-minimization in the context of significant environmental fluctuations. Towards the mid Holocene, trends towards technological diversification and an increase in efficiency-related costs are noticeable. These changes are interpreted as new technological variants under different ecological and social circumstances.

1. Introduction

The mid-Holocene is a period of marked climatic and environmental changes that took place throughout the South American ecological mosaic. On a global scale, a process of increasing aridity and rising temperature occurred with local variations. These had repercussions on the dynamics of human populations, influencing on the behavior patterns recorded during the early Holocene.

Within this framework, the present work centers on the study of lithic technology among hunter-gatherers that occupied the Argentine Puna during the early and mid-Holocene. From the perspective of Evolutionary Ecology (Smith and Winterhalder, 1992) the patterns of technological change that took place during the 10,000-6000 BP time-segment will be analyzed, comparing the archaeological record from two sites: Alero Cuevas, in the Santa Rosa de los Pastos Grandes area (Province of Salta), at a height of 4400 m asl, and the Hornillos 2 rockshelter, in the Susques area (Province of Jujuy), at a height of 4020 m asl (Fig. 1). Both rockshelters are located in the transition strip between the Dry and Salt Puna, showing a multicomponent sequence that includes the early Holocene and the mid-Holocene (Table 1).

2. Puna: environmental and Paleoenvironmental issues

The Puna is an elevated desert located at more than 3000 m asl, which causes constraints for human adaptation. Among these are low primary productivity, high variability, both spatial and temporal, in the distribution of critical subsistence resources, and unpredictability in the fluctuations of rainfall, the latter producing lengthy droughts (Yacobaccio, 1994; Muscio, 1998). These constraints allow the Puna to be defined as a risky environment (Yacobaccio, 1994; see below). At the same time, there is a difference between the Dry and Salt Puna (Fig. 1) as regards temperature, aridity, and amount of rainfall (Troll, 1958).

During the early Holocene (*c.* 10,000-8000 BP) the climate was colder and more humid (more rainfall) in relation to the present arid climate, producing a relatively homogeneous environment (Morales, in press). Additionally, the existence of hunter-gatherer populations of low demographic density, and with a high degree of residential mobility has been suggested for this period (Pintar, 1995; Muscio, 1999). As regards hunting-related technology, the presence of stemless triangular projectile points is notable on both slopes of the Andes mountain-range (Fernández Distel, 1986; Pintar, 1995; Hernández Llosas, 2000; Núñez et al., 2005).

Towards the mid-Holocene (*c.* 8000-4500 BP) the climate would have changed to drier and hotter conditions, peaking towards 6000 BP (Núñez and Grosjean, 1994), increasing the environmental heterogeneity (Yacobaccio and Morales, 2005). Resources, particularly camelids, will have been less abundant and predictable than during the early Holocene (Morales, in press), increasing the risk for adaptation. Nevertheless, on a local scale the conditions of humidity would have continued in areas like that of Susques, though with dry events occurring (Yacobaccio and Morales, 2005). In this way, populations will have remained close to the more productive patches, resulting in a decrease in residential mobility, and a growth in the size of the groups (Aschero, 1994; Yacobaccio

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doi:10.1016/j.quaint.2011.10.030

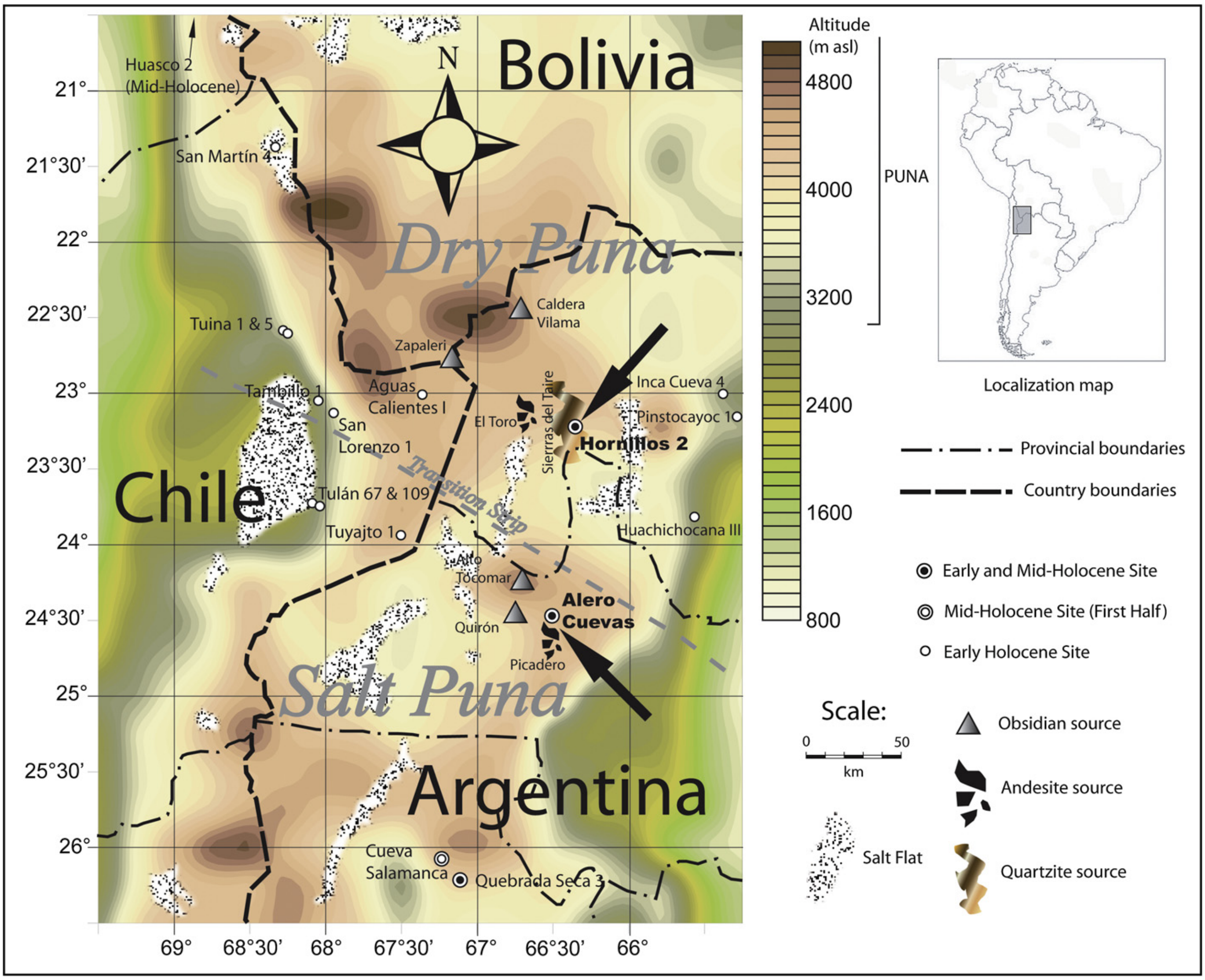

Fig. 1. Location of dated early and mid-Holocene sites in the Puna of South Central Andes.

and Morales, 2005; López, 2008). Archaeologically, during this period hiatuses are noticeable in the occupation sequences, or a decrease in their intensity (Fernández Distel, 1986; Núñez and Grosjean, 1994; Hernández Llosas, 2000). Regarding lithic technology, a diversification in projectile-point morphology has been observed, reflecting new hunting techniques implemented at the same time (Aschero and Martínez, 2001). Lanceolated and heart-shaped heads are particularly to be noticed in the Salt Puna (Martínez, 2003; Pintar, 2004), tetragonal ones in the Puna de Atacama and the river Loa (Yacobaccio et al., in press; Núñez et al., 2005), among others.

Table 1
Radiocarbon dates (uncalibrated).

	Layer	Alero Cuevas	Layer	Hornillos 2
Mid-Holocene			2	6190 ± 70 BP
			2	6340 ± 110 BP
	F3	6.506 ± 58 BP		
	F3	6.510 ± 80 BP		
			3	7430 ± 80 BP
			3	7760 ± 160 BP
Early Holocene			4	8280 ± 100 BP
	F4	8.504 ± 52 BP		
	F4	8.838 ± 52 BP		
			6	9150 ± 50 BP
	F4	9.650 ± 100 BP	6	9590 ± 50 BP
			6d	9710 ± 270 BP
References		López, 2008		Yacobaccio et al., in press

3. Human behavioral ecology and lithic technology

Human Behavioral Ecology studies decision-making, understood as a mechanism of adaptation to different environmental conditions. This mechanism is guided by an optimization criterion (Smith and Winterhalder, 1992). Technological decision-making, as part of a global subsistence strategy, contributes to the adaptation of human populations, and can vary according to changes in the environment (Bousman, 1993; López and Restifo, 2009).

It has been proposed that a key factor conditioning human adaptation is risk, defined as the "unpredictable variation in the outcome of a behavior, with consequences for an organism's fitness or utility" (Winterhalder et al., 1999: 302). Following the logic of the *Z-score* model (Stephen and Krebs, 1986), given a minimum energy requirement for adaptation, at least two strategies can be distinguished: one in which the variation in the outcome of a behavior vis-a-vis unpredictability is reduced, called risk-adverse, and the other in which the minimum requirement for adaptation can be overcome, but with highly variable results, known as risk-prone. Human populations can change from a risk-adverse strategy to a risk-prone one as the availability of resources goes fluctuating with time (Bousman, 1993).

In a context of environmental instability, new technological solutions can arise to minimize risk by means of different mechanisms, such as imitation, or trial and error experimentation, which considerably increases the learning time (Boyd and Richerson, 1985; Fitzhugh, 2001). In the same way, the size of the group, and it consequent mobility – which varies according to the environment (Kelly, 1995) – are factors that condition the decision-making. On the other hand, other possible solutions to minimize risk are the establishment of trade or cooperation networks (Smith and Winterhalder, 1992).

The lithic analyses carried out according to this perspective contemplate efficiency as a variable in guaranteeing the obtainment of resources. Mobility, demography, and energy requirements impinge on the strategies for supplying raw materials and can be expressed as changes in the frequencies of rocks throughout the archaeological sequences and in tool maintenance patterns (Beck et al., 2002). In this sense technological optimization considers that the higher the technical investment (costs), the greater the efficiency (Bousman, 1993). In the framework of this work costs refer to two aspects: 1) production time, including all the stages related to the supply of raw materials and the reduction sequences; and 2) the learning time needed to acquire the skills related to precision, the ability to achieve a certain objective, among others (Roux et al., 1995). Efficiency can be found in: 1) the length of the cutting edge obtained per Kg of knapped raw material (Leroi-Gourhan, 1964); 2) the average length of the cutting edge per artifact; and 3) the standardization (Roux et al., 1995).

Thus, the greater the investment in the learning-process, the greater the expectable technologies, with a higher yield of cutting edge per Kg of raw material, such as in the case of blade technology (Leroi-Gourhan, 1964). In this case the cutting edge average per artifact, as well as the volume of production (number of artifacts from the same volume of raw material) will also turn out to be higher. So, it must be considered that the heavier the investment in the shaping of the cores, the smaller the necessary investment in the final shaping of the blanks.

Fig. 2 compares bifacial technology with that of blades. To arrive at standardization and the functional advantages of the blanks

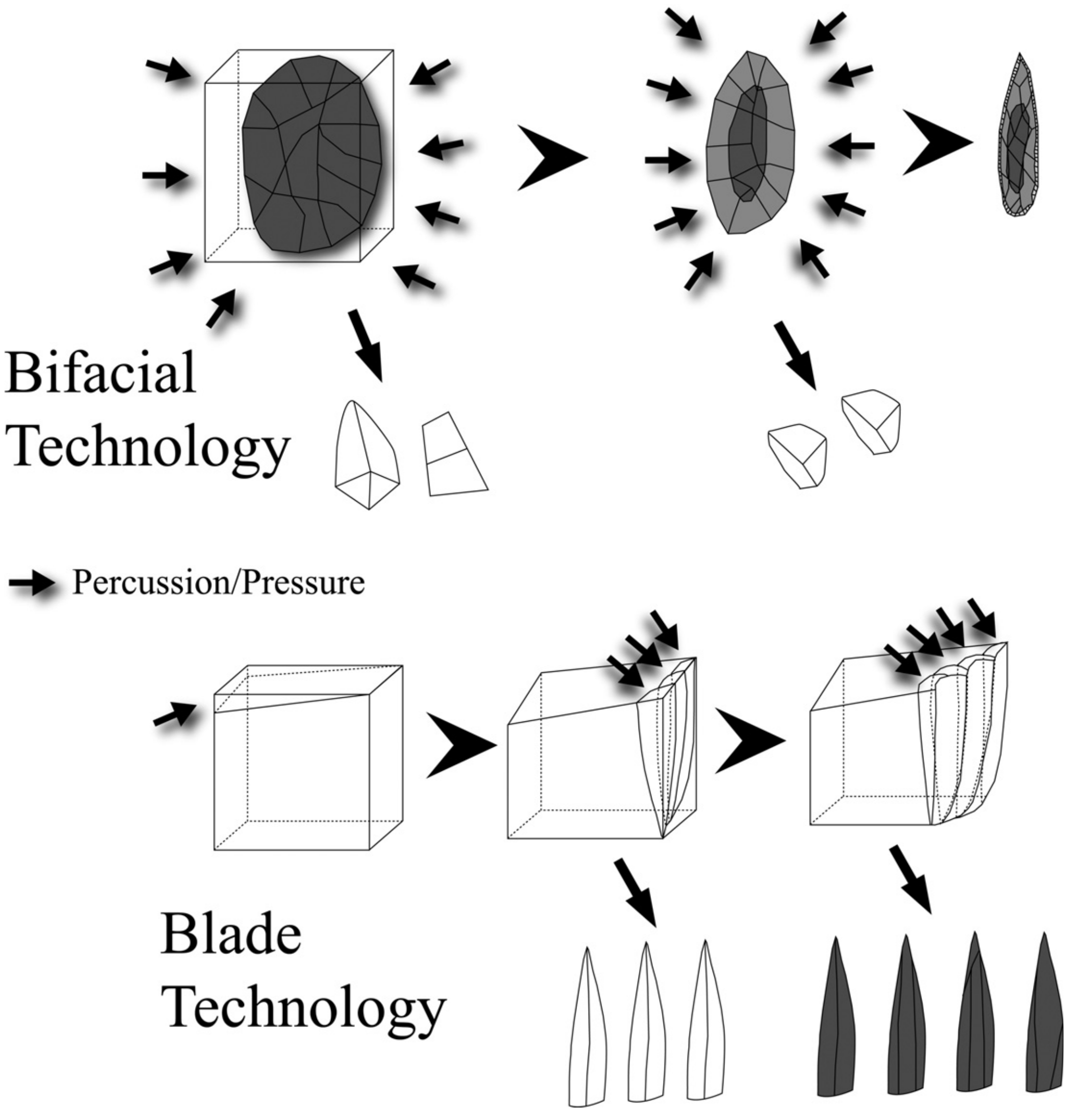

Fig. 2. Economy of blade technology and bifacial technology.

obtained with blade technology, bifacial technology requires more production time and involves greater expenditure in raw materials. These costs increase if the objective of the biface is to obtain a long cutting edge (i.e. of a laminar module), requiring more production sequences. However, bifaces are flexible since they allow the production objective to be reoriented, and they can readily be recycled, enhancing their useful life (Kelly, 1988). The production variability that bifacial knapping enables is not allowed by the little flexible and specialized blade technology, as its elements are interdependent (Boëda, 1997). In both cases the technological investment will permit greater efficiency in functional terms (cutting edge length, standardization), and therefore reliability (*sensu* Nelson, 1991). The concurrent use of both technologies is also possible. High-cost, more reliable, technologies are thus to be expected in the context of high unpredictability in the obtainment of resources (Bousman, 1993; Lanata and Borrero, 1994). In contrast, lower-cost technologies are to be expected in situations of low relative unpredictability as to resources (Bousman, 1993; Lanata and Borrero, 1994).

High learning costs required by technologies with a high technical investment can be maintained in a population by means of biased transmission mechanisms (Boyd and Richerson, 1985). On the other hand, expedient and opportunistic technologies (Nelson, 1991) are more flexible in situations where the biased transmission mechanisms are difficult to maintain, for instance in groups with high residential mobility and low demography. In this last case, if an environmental change takes place leading to lower predictability as regards resources, the investment in production time and learning required by experimentation (Boyd and Richerson, 1985) will be needed to achieve reliable technological solutions (Nelson, 1991) in order to satisfy an average energy requirement. In this case a risk-prone strategy will have to be implemented (Winterhalder et al., 1999) owing to the factor of high unpredictability of the new technological alternatives. It must be stressed that technologies have a slow evolutionary process, and can not arise without prior technical history (Boëda, 1997), particularly in the case of costly ones.

Considering the Puna's palaeoenvironmental history, changes may be expected in lithic technology in response to the long-term environmental fluctuation. Owing to the rise in aridity and temperature, as well as the heterogeneity in the distribution of resources, the early-to-mid Holocene transition will have been one of strong selective pressures and an increase in the adaptative risk (Muscio, 1998; López, 2008).

4. Materials and methods

The sample used for the analysis is shown in Table 2. At the same time, in accordance with the theoretical framework presented, it was considered pertinent to analyze the diverse variables detailed below.

Table 2
Analysed sample.

	Tools	Cores	Debris	Total
Alero Cuevas				
Layer F4	70	0	1602	1672
Layer F3	8	0	125	133
Hornillos 2				
Layers 6	25	3	3472	3500
Layer 4	33	0	2012	2045
Layer 3	16	2	714	732
Layer 2	43	3	2800	2846
Total	195	8	10,725	10,928

Table 3 presents the main characteristics of the lithic raw material sources belonging to the rocks identified at the sites. These characteristics summarize the possible constraints in the use of the rocks. Amongst these factors the distance from the quarry to the sites must be taken into account (Fig. 1). In turn, the cortex was taken as an indicator of the state in which the raw materials reached the site (more than 50%, in debris fragments above 20×20 mm as in tools).

In addition, resharpening was analyzed, taken as an indicator of the maximization of a tool's useful life. In this sense the frequencies of resharpening flakes together with the observation of cutting edge maintenance patterns can be useful in evaluating this characteristic. The said patterns can manifest themselves in the presence of features such as overlaid scars, abundant hinged scars and abrupt edges.

The percentage of laminar modules was also considered. This in itself is not an indicator of blade technology, since other complementary indicators are required, such as the presence of laminar removal cores, crests, and parallel or sub-parallel ridges. Yet the increase in their frequency can be related to rising technological costs. Laminar modules were considered according to the formula:

$$\text{Laminarity : Length/width} \geq 2$$

Finally the analysis of projectile points was carried out. This kind of tool can be an indicator of different hunting-weapon systems, as well as the result of different production processes involving decisions related to the selection of blanks, their extraction from cores, knapping sequence, among others. For these, sizes were considered, according to the formula:

$$\text{Size} = (\text{length} + \text{width})/2$$

The result of this formula refers to the overall size of an artifact regardless of the form (length or width). Higher results indicate larger sizes and vice versa.

5. Results

5.1. Raw materials

Though obsidians are the most distant rocks in the case of both sites, they appear with significant frequency throughout time. The Quirón obsidian deposit is 30 km away from Alero Cuevas, a distance that will have favoured its supply. This is reflected in the high frequencies of this rock through time, though decreasing towards the mid-Holocene, especially the debris (Fig. 3.A). At Hornillos 2, high frequencies of other obsidians (Zapaleri and Caldera Vilama) are observable during mid-Holocene (Fig. 3.B). A pattern of Quirón obsidian presence is noticeable during the early Holocene, and it is absent during the mid-Holocene (Yacobaccio, Pers. Comm.). In addition, the size of the nodules can restrict the extraction of certain blanks, particularly so in the case of small nodules such as those that predominate at the Quirón obsidian deposit.

As for andesites, the sources lie fairly close to the sites (40 km from Hornillos 2 and 10 km from Alero Cuevas). Both Picadero and El Toro have blocks of a considerable size, allowing the extraction of a broad range of sizes. At Alero Cuevas this rock is the second most frequent. Its tendency shows an increase towards the mid-Holocene among the lithic debris, whereas obsidian decreases, though only slightly (Fig. 3.A and C). Hornillos 2 has a higher frequency of debris and tools in the transitional layer 4, despite the fact that the rock is not locally available. It is always among the rocks most frequently represented, together with quartzite and obsidian (Fig. 3.B and D).

Table 3
Characteristics of the sources of raw materials.

Source	Raw material	Shapes	Disponibility	Sizes	References
Zapaleri	Obsidian	Nodules	High	Medium-sized	Yacobaccio et al. (2004)
Quirón	Obsidian	Nodules	High	Small	López Pers. Com.
Tocomar	Obsidian	Nodules	High	Medium-sized	Yacobaccio et al. (2004)
Caldera Vilama	Obsidian	Nodules	High	Small	Yacobaccio et al. (2004)
Ona	Obsidian	Nodules	High	Medium-sized	Yacobaccio et al. (2004)
Sierras del Taire	Quartzite	Blocks	High	Large	Hoguin and Yacobaccio (in preparation)
El Toro	Andesite	Blocks	High	Large	Yacobaccio and Morales Pers. Com.
Picadero	Andesite	Blocks	High	Large	López (2008)
Other 1	Silicified rocks	Lodes	Low	Small	Yacobaccio and Morales Pers. Com.
Other 2	Quartzite	Unknown	Low	Unknown	Vilela (1969)

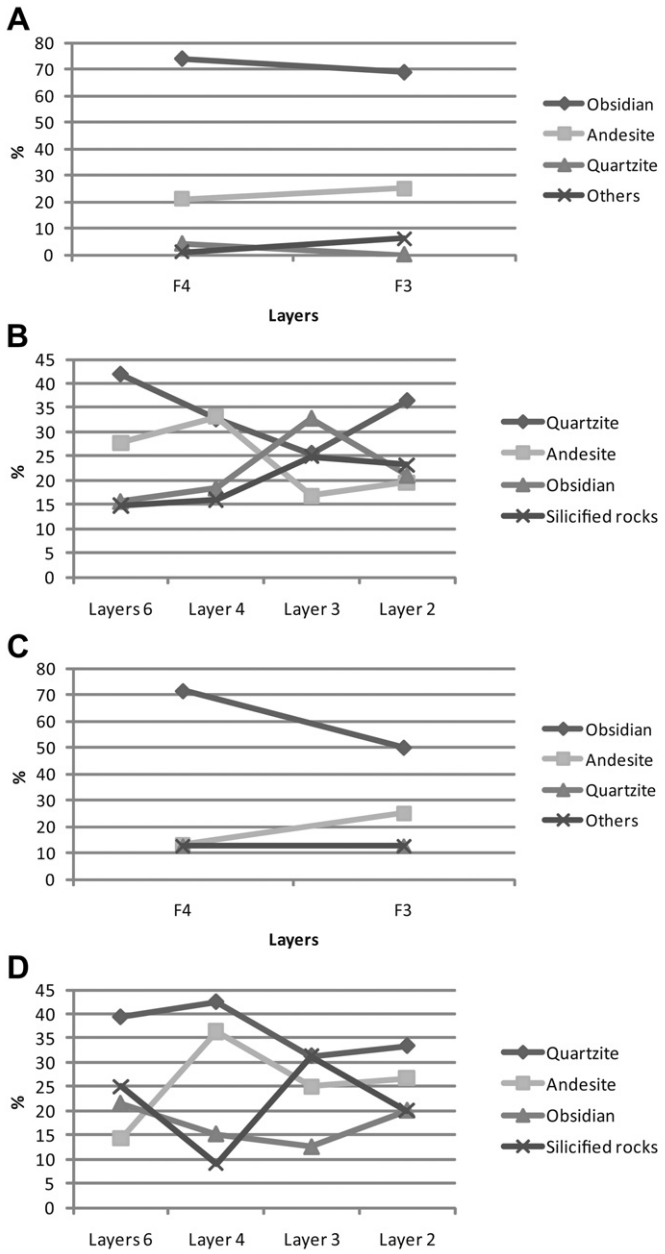

Fig. 3. A. Relative frequency of raw materials (debris) throughout time (Alero Cuevas). B. Relative frequency of raw materials (debris) throughout time (Hornillos 2). C. Relative frequency of raw materials (tools) throughout time (Alero Cuevas). D. Relative frequency of raw materials (tools) throughout time (Hornillos 2).

As for quartzites, at Alero Cuevas it is a rock with low frequencies throughout time (Fig. 3.A). Its distance from the site is around 10 km. Yet it is probable that the deposits of this rock are mainly underground (Vilela, 1969), which would act as a constraint in their exploitation. In contrast, for Hornillos 2 the blocks of quartzite emerging in the Sierras de Taire are very abundant and large in size, which is reflected by their high frequencies throughout the sequence of the site (Fig. 3.B). The size of the block does not condition constrain any sort of removal. Nevertheless, the larger-sized grain than for the other rocks mentioned can be a factor tending to increase the possibility of failure for certain techniques.

Silicified rocks include different varieties: chert, chalcedony, opals, and rhyolites, among others. At Hornillos 2, their greatest frequency is seen in layer 3, towards the beginning of the mid-Holocene (Fig. 3.B and D).

5.2. Cortex

At Alero Cuevas, tools with a cortex represent 8.5% of the total, and Quirón obsidian is the predominant rock, particularly during the early Holocene. This rock will have arrived at the site at least in nodule form. By the mid-Holocene, the frequency of cortex remains low in the lithic debris during the whole time for all classes of rocks (Fig. 4.A). This might indicate that both quartzite and andesite

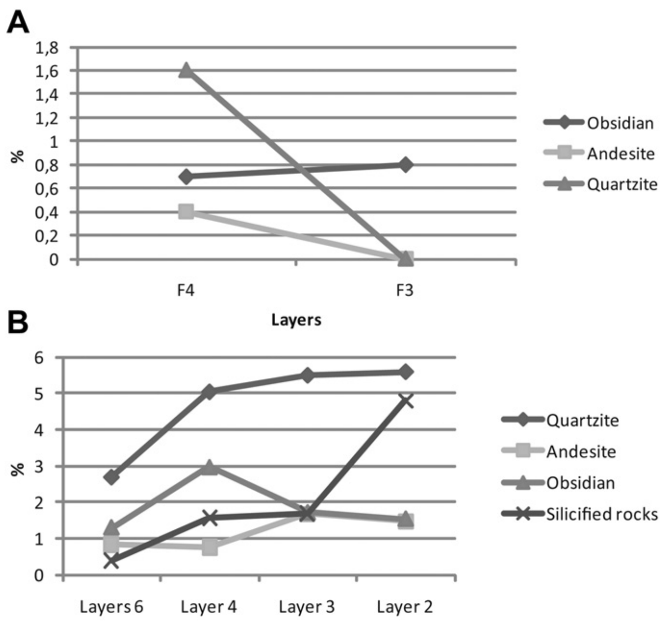

Fig. 4. A. Tendencies in the relative frequencies of tools having cortex through time (Alero Cuevas). B. Tendencies in the relative frequencies of tools having cortex through time (Hornillos 2).

arrived at the site in the form of mostly internal flakes, which is to be expected considering that they appear in the form of large blocks, as in the case of andesite.

At the Hornillos 2 site, it is interesting to point out the increase in the percentage of artifacts having a cortex throughout the sequence, and particularly in the mid-Holocene, for local rocks (Fig. 4.B), whether those of high availability (quartzites) or low (silicified rocks). Throughout the time-sequence, save in layer 3, a relatively high percentage (between 11 and 17%) of tools with cortex is observable.

5.3. Resharpening

At the Alero Cuevas site, low relative frequencies of resharpening flakes can be observed, with stable tendencies (Fig. 5.A). This kind of flake was identified in obsidians most commonly, and secondly in quartzites. In andesites, this kind of flake was not encountered. In the same way, in the early Holocene there appeared two cases of maintenance (Quirón obsidian, and andesite). Two cases of recycling were also observed (Quirón obsidian and quartzite), including two resharpened projectile points recycled as processing artifacts.

In the case of Hornillos 2, a general tendency can be observed for all raw materials in the decrease of the percentage of resharpening flake (Fig. 5.B). Nonetheless, a slight percentage increase for obsidians and silicified rocks in layer 3 can be seen. As at Alero Cuevas, tools showing evidence of maintenance are few. There are five cases of resharpening and one of recycling in layer 6, one of resharpening in layer 4, three and one in layer 3, and four of resharpening in layer 2.

5.4. Laminarity

In both sites a rising tendency in the relative frequency of laminar modules from the early to mid-Holocene can clearly be observed, alongside the presence of tools (projectile points and other tools) fashioned from blanks with crests or parallel ridges (Fig. 6.A and B).

5.5. Projectile points

Regarding the early Holocene, both Alero Cuevas and Hornillos 2 present bifacial projectile points with an unstemmed triangular morphology (Fig. 7). They are fashioned mainly in obsidian, from blanks whose debitage axis is transversal to the morphological axis (Fig. 7: 2, 3 and 5). The presence of these morphologies is restricted to layer F4 at Alero Cuevas, whereas at Hornillos 2 they persist up to layer 2.

At the beginning of the mid-Holocene (layer 3) an occupation with tetragonal points called “San Martín” (Núñez et al., 2005), not found in any other layer, appears at Hornillos 2 (Fig. 8). They are larger, made from predetermined shaped flakes and retouched by pressure with a denticulate. The raw materials used are obsidian, andesite, and quartzite (Hoguin, in press-b).

Towards the middle of the mid-Holocene in both sites a diversification of the morphologies of projectile points can be seen (Fig. 8), as well as a medium tendency towards an increase in size (Fig. 9.A and B). The appearance of bifacial lanceolated points, most of them laminar, is especially noticeable (Fig. 8: 9–15; López, 2008: Fig. 9.11). These present different patterns of manufacture. At Hornillos 2 different technical modalities and blanks were used, including bifacial rough out, and crest (blade technology) (Fig. 8: 11, 14 and 12 respectively). The raw materials used for this kind of artifact are varied (Hoguin, in press-a). In the case of Alero Cuevas a larger-sized point was observed, carved from a laminar blank, in which sub-parallel ridges are to be seen, which coincide with the technical axis (Fig. 8: 16). This sort of blank for projectile points is not found in the previous layer. Then a heart-shaped point was recorded and rough out stem shaped on a flake. Additionally, bifacial roughouts of projectile points are to be seen. A relevant aspect is that, both in the points and the roughouts, obsidian ceases to be the predominant rock, giving way to others such as andesite and quartzite.

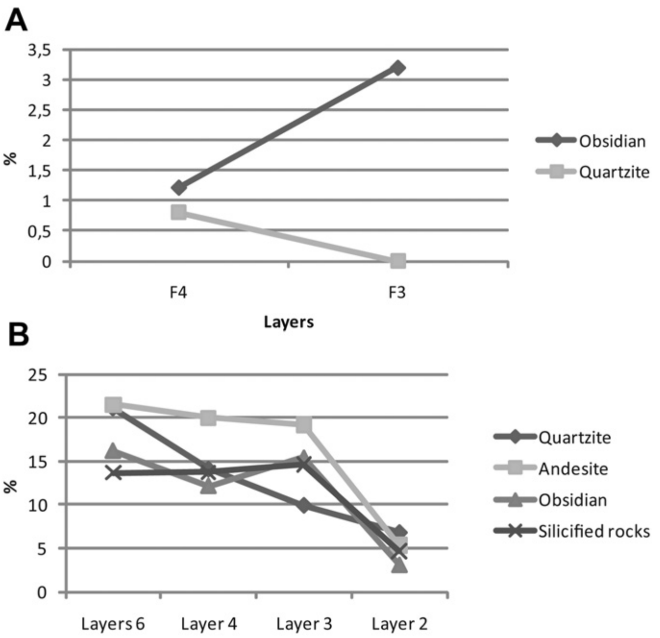

Fig. 5. A. Tendencies in relative frequencies of resharpening flakes through time (Alero Cuevas). B. Tendencies in relative frequencies of resharpening flakes through time (Hornillos 2).

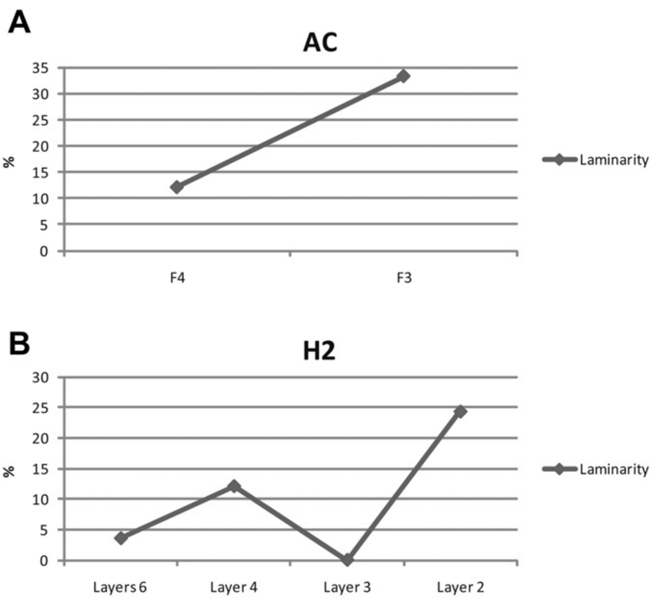

Fig. 6. A. Tendencies in relative frequencies of laminar modules through time (Alero Cuevas). B. Tendencies in relative frequencies of laminar modules through time (Hornillos 2).

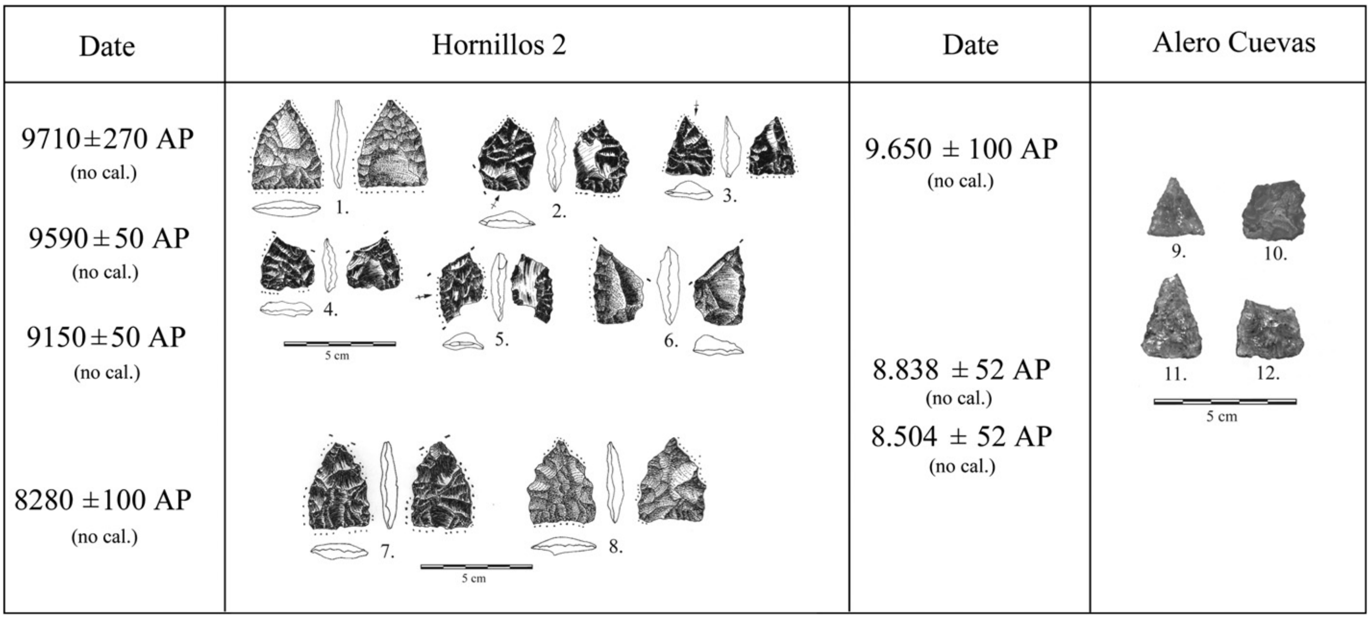

Fig. 7. Early Holocene projectile points.

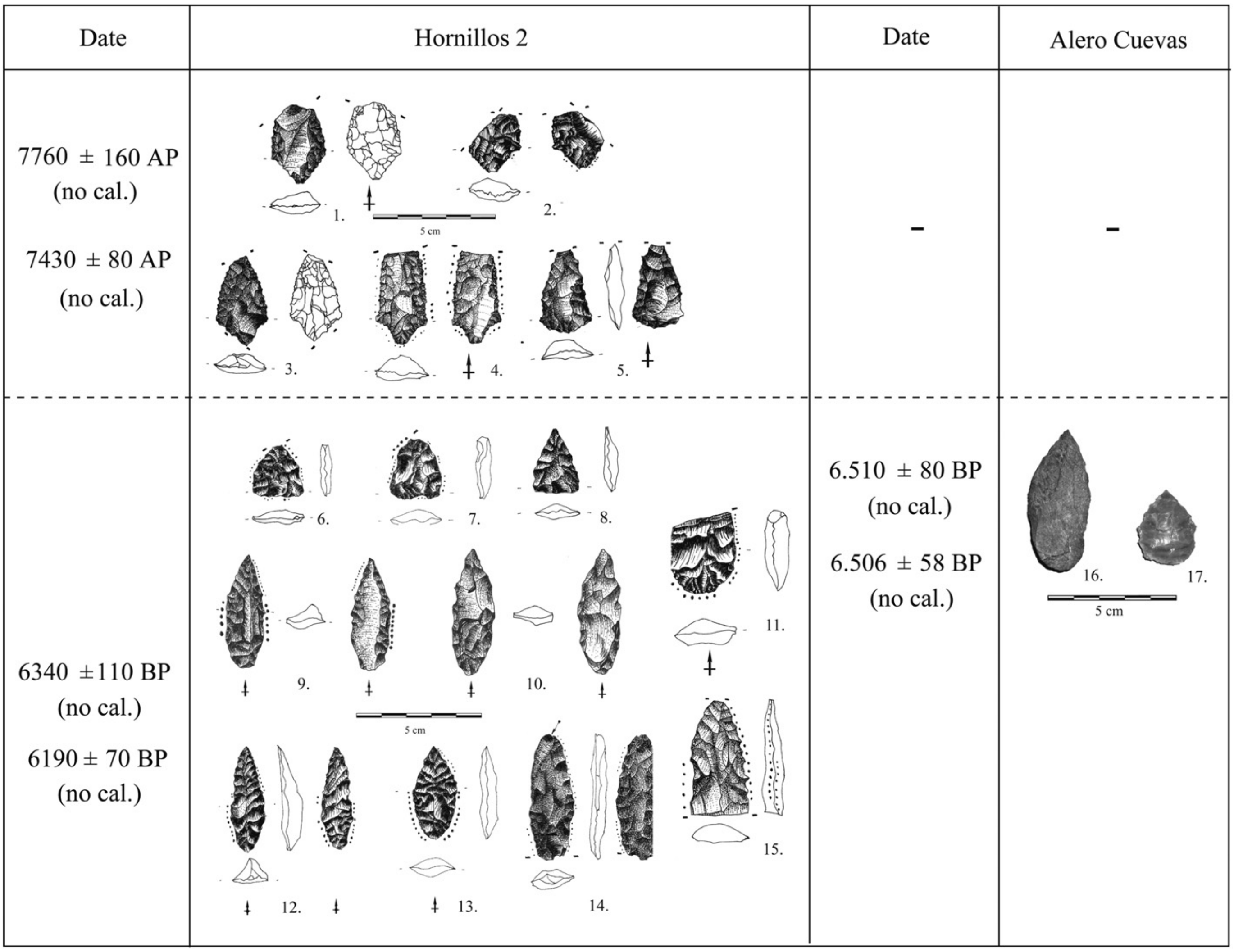

Fig. 8. Mid-Holocene projectile points.

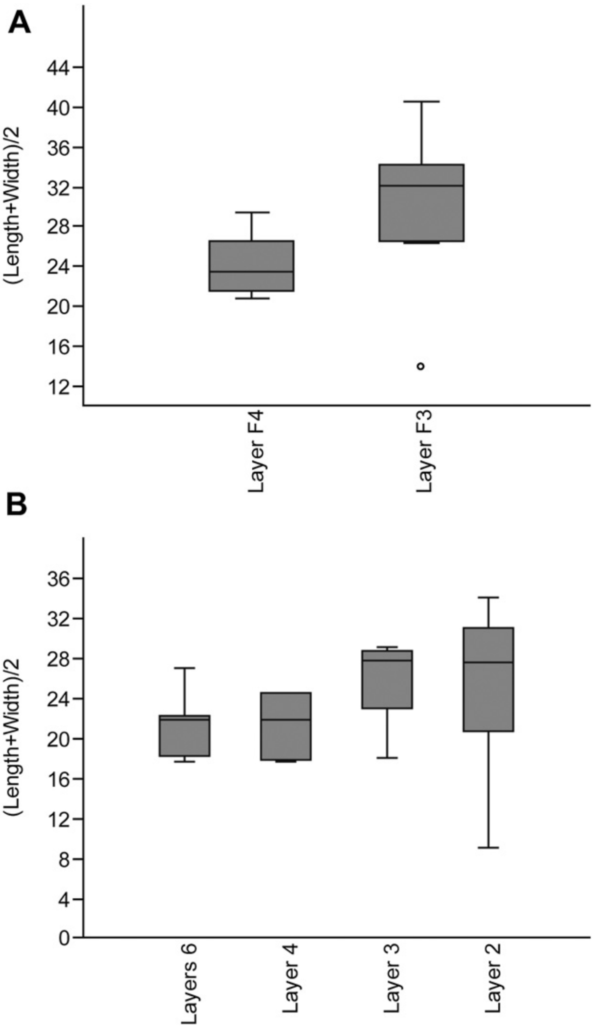

Fig. 9. A. Comparative sizes of early and mid-Holocene projectile points (Alero Cuevas). B. Comparative sizes of early and mid-Holocene projectile points (Hornillos 2).

6. Discussion

6.1. Raw materials and mobility

Considering the hypothesis of a decrease in residential mobility towards the mid-Holocene (Aschero, 1994; Pintar, 1995; Yacobaccio and Morales, 2005; López, 2008), the use of certain kinds of rocks does not seem to have been greatly affected by those changes as regards frequencies. At Alero Cuevas obsidian, especially that from Quirón, is the most frequent rock in layer F4, followed by andesite. Towards the mid-Holocene the same tendency is observed, though with a slight decrease in obsidian and rise in andesite. At Hornillos 2 quartzite – immediately available, though it varies in time, is always the rock with the highest frequencies.

In contrast, other rocks would seem to have been sensitive to changes in mobility. Andesite from Toro, of which the source is 40 km away from Hornillos 2, decreases towards the mid-Holocene as regards debris, but rises as regards tools together with the increase of closer-by silicified rocks, with a low frequency during the early Holocene. Instead, at Hornillos 2 obsidian, a far-off rock, increases its frequencies of lithic debris towards the mid-Holocene referred to layer 3. This pattern could be explained by a logistical pattern of mobility along a South–North axis (Hoguin and Yacobaccio, in preparation). In this sense it should be pointed out that the obsidian from southerly Quirón at Hornillos 2, is found during the early Holocene but is absent during the mid-Holocene (Yacobaccio Pers. Comm.).

In addition to the frequencies, it is also possible the patterns of provision and transport of the rocks may have varied. It has already been pointed out that the reduction stages carried out at both rockshelters are mainly to do with the shaping of tools. Nonetheless, some preliminary stages of shaping were also carried out. At Hornillos 2 this can be the case of the silicified rocks, whose frequency of cortex increases towards layer 2, and also of quartzite, though with gentler tendencies. This pattern could be related to higher-intensity occupations. In the case of Alero Cuevas, cortex frequencies throughout time remain very low for all rocks. In the case of andesite this would be related to the presentation of the rocks, in the shape of blocks, which necessitates the extraction of blanks to be transported.

Finally, resharpening tools can vary through time in terms of restrictions in obtaining raw materials, maximizing the usefulness of the resource. At Hornillos 2 a falling tendency is to be noticed in the frequency of resharpening flakes with time, as well as a small number of cases of resharpened tools. Considering the growth in intensity of the settlements around the resource patches towards the mid-Holocene (Aschero, 1994; Yacobaccio and Morales, 2005), this is an expectable pattern for the case of nearby rocks such as quartzites or silicificates, since finding them is safer, or less unpredictable, in the case of groups with less residential mobility. In the case of Alero Cuevas, resharpening flakes show low frequencies through time for quartzite and obsidian, and are absent in the case of andesites. It is considered that the size of the sample could be influencing the observed patterns. As an alternative it may be posited that the relative availability of these rocks was not sensitive to the changes in mobility, so that it was not necessary to resharpen tools to maximize the utility of lithic resources. Just as at Hornillos 2, at Alero Cuevas the cases of resharpened or maintained tools are scanty, and are mainly recycled projectile points or standardized artifacts (Restifo, 2011). In this case the determining factor in resharpening would not be to maximize the utility of the lithic resource but to maximize the useful life of a tool (whether its function changes or not) because of its high production cost.

Mobility is a key factor in evaluating changes in the use of rocks, a prominent fact in the Argentine Puna (Pintar, 1995). All the same it is not the only factor to consider, as the selection of rocks can also vary due to new technological requirements and restrictions as to raw materials. As regards Alero Cuevas, a change in the use of rocks stands out together with the appearance of lanceolate morphology. Though obsidian is the most usual rock in the lithic sample, in projectile points it predominates during the early Holocene and recedes during the mid-Holocene, with an increase in andesite. It is probable that this change is due to the size of the nodules of Quirón obsidian being insufficient to obtain a blank for large-sized points, which necessitates the choice of another rock for their shaping.

6.2. Laminarity and projectile points: new technological trends

One of the expectations pointed out the need of reliable technological features as part of a strategy to minimize risk, specially towards the mid-Holocene. In this sense towards *c.* 6000 BP greater percentages of laminar module tools were detected, reflecting a greater technical investment and efficiency (length of cutting edge per artifact). Likewise, the presence of blade technology features such as the scars of parallel ridges and crests was noticeable. In the context in question, it is to be expected that the decision to be made should tend towards blade technology, in view of its cost-benefit relationship in terms of production time and raw material economy. In a single nodule, the extraction of blades, which allows several specimens to be obtained, is more profitable than the bifacial, the aim of which is to obtain just one product. In turn, it allows standardized blanks to be obtained with less production time.

What can be seen in the study area, at both sites, is the appearance of a predetermined blade technology, allowing a recurrent serial production, standardized and not just casual (Boëda, 1997), in answer to increased production needs. These needs might be related to a growth in the size of the groups (López, 2008). This is different from what was observed towards the south, at the mid-Holocene sites of the Salt Puna, where no evidence was found of this technology. Although the rise of a predetermined blade technology is suggested for around 6000 BP, its generalization is observed around 5000-4000 BP in the provinces of Jujuy and Salta (Fernández Distel, 1978; López, 2008). This process of gradual development and transmission of information must be studied in the light of new evidence.

As for projectile points, changing tendencies can be seen in agreement with variations in risk. In accordance with expectations, during the early Holocene lower production costs are to be expected, in relation to smaller selective pressures. The evidence from the early Holocene layers at both sites upholds this expectation. In projectile points, a class of artifacts with a higher production cost in their shaping, it was observed that the debitage axis is always shifted in relation to the morphological, which might be related to an opportunist selection of flakes as blanks. In contrast, mid-Holocene projectile points show a heavier technical investment both in the shaping stages of these tools and the removal of blanks such as blades around 6000 BP. Concurrently, the use of bifacial technology for shaping these points can also be observed. This investment can be related to the search for standardization, such as was seen at Hornillos 2 (Hoguin, in press-a,b), which is a feature of reliability (*sensu* Nelson, 1991). In turn, in the case of Hornillos 2, continuities in the shaping pattern of points were observed between layers 2 and 3, which can be related to the biased transmission of information in the long term (Hoguin, in press-b).

Another remarkable aspect at both sites is the morphological diversification of projectile points around 6000 BP. Also noteworthy is the diversification of the technologies employed, not only among tools, but also within the same kind of point (e.g. small lanceolate) (Hoguin, in press-a). This diversification, technical as well as functional, could reflect an enrichment of the cultural pool owed to the association of different groups to participate in collective hunts (Aschero and Martínez, 2001; Hoguin, in press-a; Yacobaccio and Morales, 2005; López, 2008). These events will have been indispensable for adaptation, since cooperation is crucial in order to minimize risk (López, 2008; Morales, in press). In turn, these events influenced technology.

7. Conclusions

In this work the lithic technology in the Argentine Puna during the early-to-mid Holocene transition has been studied. This period signaled a new ecological and social scenario that had an impact on the cultural dynamics of human populations, as the growing of the group sizes and the resources competition (López, 2008). In this sense stone technology, as part of a global adaptative strategy, underwent changes. Both technological diversification (concurrent use of blade and bifacial technology, new projectile points morphologies) and the rise in the costs involved (more complex technologies) will have been responses directed to raising efficiency in the face of an increase in risk. The demands of larger groups may have influenced technological organization so as to respond to the need of enhanced production. In this context, experiment will have been a necessary mechanism to generate new technological alternatives during times when the available options proved insufficient to reach a minimum adaptation threshold. The changes referred to can be understood as variations from a risk-adverse strategy to a risk-prone one in fluctuating environmental situations. Though this paper has focused on the study of rock-shelters, the hypotheses set forth will need future examination by integrating the surface archaeological record, which will allow the scale of the analysis to be broadened.

Acknowledgements

We thank Hernán J. Muscio for his review of preliminary manuscripts of this paper and to Hugo D. Yacobaccio for his advice. Thanks to Alasdair Lean for the translation. This paper was realized in the frame of the project PIP 3173-CONICET and two post-graduation grants of CONICET. We acknowledge the reviewers for their useful comments.

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