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Palaeoenvironmental scenarios and lithic technology of the first human occupations in the Argentine Dry Puna

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ABSTRACT

The aim of this research is to contribute to the discussion of environmental scenarios and evaluate in this context lithic technical strategies developed by hunter–gatherer groups during the process of settlement of the area. The Andean paleoenvironmental knowledge supports the view that during the early Holocene (10,500–8000 ^{14}C BP, uncal.) the environmental conditions were more humid than at present, which would have produced both an extension of wetlands and an expansion of Andean grassland. However, the results of pollen analysis in this locality show that these changes were not synchronous. Certain localities may have retained humid conditions *ca.* 7000 ^{14}C B.P according to the Pastos Chicos record and 7600 ^{14}C B.P in the Lapao record. Thus, the reduction of the distance between the productive patches would have favored a strategy of highly mobile small groups of hunter–gatherers, allowing the supply of raw materials from long distances, and favoring individual learning, a flexible operational chain, and low technical investment. The Early Holocene is very heterogeneous with numerous environmental and technological changes.

1. Introduction

Due to the recent development of paleoenvironmental investigations in the area, the tendency has been to make broad generalizations from a small number of study cases (Oxman and Yacobaccio, 2014). Nevertheless, recent studies in the Andean zone indicate environmental variability resulting from the different response of particular localities to climate changes on a wider scale (Tchilinguirian and Morales, 2013). Owing to this, it is necessary to advance the palaeoenvironmental study of the area and evaluate with precision this differential impact on ancient populations.

This investigation seeks to advance the palaeoenvironmental studies already performed in the locality (Morales, 2011; Tchilinguirian et al., 2014a; Oxman and Yacobaccio, 2014; Tchilinguirian et al., 2014b; among others) by means of new pollen analyses in the Quebrada de Lapao and Pastos Chicos localities in the Department of Susques, Province of Jujuy, Argentina. In this way, it will be possible to put in their proper context the first evidence of human occupations in the area, and to generate a concept concerning the subsistence strategies of hunter–gatherer groups. More specifically, the question of the technical behavior of these populations during the first settlement period will be approached.

Secondly, the concept will be contrasted with the results obtained from lithic technology in two sites of the Susques area: Hornillos 2 and Lapao 9. More specifically, this work proposes to reconstruct operative chains in order to be able to infer technical and economic behaviors regarding the raw material supply and lithic technology in a first settlement context.

1.1. *Background research*

Traditionally, the advance of the first human settlement towards the late Pleistocene, on a macro-regional scale, is associated with megafaunal hunting (Lynch, 1983; Dillehay et al. 1992; Yacobaccio, 2010, among others). However, in the Central-Southern Andes, no associations exist between megafauna and materials of anthropic origin. Chronologically coinciding evidences of megafauna and human occupation in the area have been discovered, but not at the same site (e.g. *Hippidion sp*. at Barro Negro and the archaeological site Inca Cueva IV) (Yacobaccio and Morales, 2011). No evidences of Fish-tail type points (Oxman and Yacobaccio, 2014), usually associated with the hunting of megafauna, have been found, except one surface example discovered at the Salar Punta Negra 1 site (Grosjean et al. 2005).

Apparently, in these latitudes, the higher areas (more than 3800 m asl) were colonized later in time, with the retreat of the glaciers.

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It is only from *ca.* 10,500 ^{14}C BP when the Puna began to be used with greater frequency by hunter–gatherer groups (Yacobaccio and Morales, 2011). It has been proposed that the discovered occupations may be the result of a process of dispersion and subsequent colonization of the area (Yacobaccio, 2010). Then, towards 9500 ^{14}C BP, the evidence suggests that density-dependent mechanisms will have come into play: demarcation of the space, recurrent circuits, standardization in the use of lithic resources, which would have increased notably at 8500 ^{14}C BP (Yacobaccio and Morales, 2011). In general terms, most early Holocene archaeological sites (Table 1) are located in caves and rockshelters in gorges and valleys close to permanent water sources. These settlements would have low demographic density and high mobility, as shown by the presence of goods from other ecological zones on both sides of the cordillera (Núñez and Santoro, 1988; Aschero, 1994), and the circulation of obsidian (Yacobaccio et al. 2008). With regards to the archaeofaunal record, whereas in some sites camelids are an ample majority, elsewhere it is chinchillids that dominate, the result of opportunistic hunting on locally available prey (Oxman and Yacobaccio, 2014).

Table 1
Early Holocene sites in the South-Central Andes.

Site	Radiocarbon date (yrs non cal. BP)	Reference
Tuyajto-1	8130 ± 110	Núñez et al. 2005
Tulan-67	8190 ± 120	Núñez et al. 2005
Tuyajto-1	8210 ± 110	Núñez et al. 2005
Hornillos 2 layer 4	8280 ± 100	Yacobaccio et al. 2013
Cueva Yavi layer E, F	8320 ± 260	Kulemeyer et al. 1999
Cueva Yavi layer G	8420 ± 70	Kulemeyer et al. 1999
Alero Cuevas layer F4	8504 ± 52	López 2008
Tambillo 1	8590 ± 130	Núñez et al. 2005
Aguas Calientes I-1	8720 ± 100	Núñez et al. 2005
Alero Cuevas layer F4	8838 ± 52	López 2008
Tambillo-2	8870 ± 70	Núñez et al. 2005
Hornillos 2 layer ensemble Early Holocene	9150 ± 50	Yacobaccio et al. 2013
Pintoscayoc 1 Upper layer 6	9180 ± 230	Hernández Llosas 2005
Salar Punta Negra-1	9180 ± 50	Grosjean et al. 2005
Pintoscayoc 1 Upper layer 6	9190 ± 110	Hernández Llosas 2005
Salar Punta Negra-1	9230 ± 50	Grosjean et al. 2005
Inca Cueva 4	9230 ± 70	Aschero 2010
Salar Punta Negra-1	9450 ± 50	Grosjean et al. 2005
Cueva Yavi	9480 ± 220	Krapovickas 1987–88
Tambillo-2	9590 ± 110	Núñez et al. 2005
Hornillos 2 layer ensemble Early Holocene	9590 ± 50	Yacobaccio et al. 2013
Alero Cuevas layer F4	9650 ± 100	López 2008
Inca Cueva 4	9650 ± 110	Aschero 2010
Hornillos 2 layer ensemble Early Holocene	9710 ± 270	Yacobaccio et al. 2013
Cueva Yavi	9760 ± 160	Krapovickas 1987–88
Cueva Yavi layer C	9790 ± 100	Kulemeyer et al. 1999
Tuina-5	9840 ± 110	Núñez et al. 2005
Inca Cueva 4	9900 ± 200	Aschero 2010
San Lorenzo-1	9960 ± 125	Núñez et al. 2005
Tuina-5	10060 ± 70	Núñez et al. 2005
Huachichocana III	10200 ± 420	Fernández Distel 1986
San Lorenzo-1	10280 ± 120	Núñez et al. 2005
Pintoscayoc 1 Lower layer 6	10340 ± 70	Hernández Llosas 2005
Salar Punta Negra-1	10350 ± 60	Grosjean et al. 2005
San Lorenzo-1	10400 ± 130	Núñez et al. 2005
Salar Punta Negra-1	10440 ± 50	Grosjean et al. 2005
Cueva Yavi layer B	10450 ± 55	Kulemeyer et al. 1999
Salar Punta Negra-1	10460 ± 50	Grosjean et al. 2005
Salar Punta Negra-1	10470 ± 50	Grosjean et al. 2005
Leon Huasi	10550 ± 300	Fernández Distel 1989
Tulán 109	10590 ± 150	Núñez et al. 2005
Inca Cueva 4	10620 ± 140	Aschero 2010
Pintoscayoc 1 Lower layer 6	10720 ± 150	Hernández Llosas 2005
Tuina-1	10820 ± 630	Núñez et al. 2005

This paper thus begins from the supposition that the effects of climatic and environmental changes establish the structure of subsistence resources, which are the bases of decision-making in hunter–gatherers groups (Kelly, 1992). The way in which the resource structure varies can be understood in terms of predictability, distribution, periodicity, productivity, and the mobility of the resources, among other factors. In this way it is assumed that environmental conditions can influence demographic processes, which can also restrict or encourage mobility (Binford, 2001). In turn, changes in mobility and demography can have repercussions on the networks of information transmission. These networks can be altered in low demography and population dispersal contexts, increasing the difficulty in the transmission of more complex techniques (Henrich, 2004). The size of the group composing the transmission network is important in establishing innovations, and also the population dispersion and association (Henrich, 2004; Richerson et al. 2009). On the other hand, social structures encompass individuals' technical innovations (Roux, 2007). In this way, it is to be expected that individual learning will predominate when populations are in a dispersed context in new spaces, not fully resident, as the first settlers in the Puna (see Dillehay, 2000; Meltzer, 2003; Yacobaccio and Morales, 2011). In a process of population dispersal, new habitats and raw materials are factors which the groups must adapt to. In this context, the techniques must be simple and flexible enough to adapt to different situations. These technical behaviors are to be expected in foraging groups with high residential mobility and exploratory conducts.

Ultimately, so as to deal with lithic evidence in this work, we might distinguish two kinds of structure: *additional structures* and *integrated structures* (Boëda, 2013). The additional structures possess elements that are independent, in opposition to integrated structures in which the elements function synergically (Boëda, 2013). Additional structures, due to the independence of the diverse elements, both productive as well as functional aspects of the techniques, are flexible. Thus, this kind of system is to be expected in a context of initial occupation by small groups with high residential mobility. Therefore, as the ancient populations must have had to face the ignorance about properties of rocks (block size, fracture quality, abundance, and so on) found in the region, the partial transmission of operative chains must have been preferred as a simple solution.

2. Study area

The study area corresponds to the region of the Dry Puna of Argentina, between 22° and 24°S and between 3000 and 4500 m asl (Fig. 1). The locality of Susques is located among several mountains NE–SW oriented mountain chains. The Puna is defined as a high desert biome, characterized by high solar radiation due to its high altitude, wide daily thermal amplitude, marked seasonality in rainfall, and low atmospheric pressure. The vegetation is xerophytic and distributed along an altitudinal gradient, with two main floristic compositions: tolar vegetation (shrub steppe) and grassland (herbaceous steppe), as well as "vegas" (wetlands) whose distribution is azonal (Cabrera, 1976). Several basins with permanent freshwater streams, salt marshes, pans, and beaches (barreales) constitute the drainage system. There are few streams and watercourses annually available, a critical resource for human populations in the semi-arid zone (Yacobaccio et al. 2008). The rainfall (200 mm/year in the region of Susques) occurs mainly in summer, representing 80% of annual precipitation (Vuille et al. 1998). Altogether, these conditions determine a heterogeneous distribution of plant and animal resources. Some patches defined as 'nutrient concentration zones' contain most of the regional biomass

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available (Yacobaccio, 1994). The most important animal food sources for humans in the Puna include several mammals (e.g., the vicuña *Vicugna vicuña* and guanaco *Lama guanicoe*), rodents (eg vizcachas and chinchillas *Chinchilla L. viscacia* and *brevicaudata*), and cervid (taruca, *Hippocamelus antisensis*).

At the regional level, it has been argued that environmental evolution consisted in the passage from more humid and cold final Pleistocene conditions to the arid and warm Holocene conditions, an equivalent to the Younger Dryas (Morales 2010: 102). In the early Holocene (11,000–8000 ^{14}C BP), moisture conditions prevailed in the high Puna with rainfall 400 mm/year, double the current 200 mm/year (Grosjean et al., 1997). In the Dry Puna, Argentina, the pollen results presented by Markgraf (1985) from El Aguilar and Quebrada de Humahuaca suggest a cold and wet environment between 10000 and 7500 B.P ^{14}C BP, dominated by Poaceae and herbaceous plants. Although the pre 11,000 B.P ^{14}C and early Holocene records are similar, in Barro Negro receding herbaceous steppe begins around 11,000 B.P ^{14}C, and in Aguilar (200 m from Barro Negro) remained until 7500 B.P ^{14}C. The middle Holocene was characterized by a decrease in rainfall. Several lakes between 20 and 23°S including Titicaca, Salar de Uyuni and the Salar de Atacama (Bradbury et al., 2001) decreased in level. About 8500 ^{14}C BP, the climate became dry, and between 6000 and 5000 B.P extreme arid conditions developed. Tchilinguirian (2009) in the sequence of Laguna Colorada, Catamarca, Argentina, found low levels of the lake between 7900 and 6300 ^{14}C B.P and between 5800 and 4500 ^{14}C B.P. However, these conditions were not homogeneous and moist events have been detected in the area. For example, in the La Hoyada, Catamarca, peat deposits were dated at 8830, 8410 and 8230 ^{14}C B.P. (Ratto et al., 2008).

3. Materials and methodology

3.1. Pollen analyses

The pollen analyses consisted of the study of the samples obtained from the profiles Lapao 5 and Pastos Chicos, which have already been analyzed for diatoms, geomorphology and sediment (Morales, 2011; Tchilinguirian et al., 2014a; Oxman and Yacobaccio, 2014; Tchilinguirian et al., 2014b). From the sedimentary record of Pastos Chicos (23° 40′ 29″ S; 66° 25′ 32″ W; 3781 m asl), 6 m in height, 4 samples were taken for dating the profile and 28 samples for pollen analysis. The bulk organic matter of two of these samples, PCH2-M2 and PCH1-M3, were dated to 7900 ± 100 ^{14}C BP and 8900 ± 130 ^{14}C BP using conventional ^{14}C dating (Table 2). Another date was obtained from a bird bone included in sample PCH2-M15, dated to 6935 ± 69 ^{14}C BP (Fig. 2). Finally in the top of the profile, PCH2-M17 was dated to 4203 ± 58 ^{14}C BP. According to the radiocarbon dates and the age-depth model (Bennett, 1994) carried out, they indicate that the profile ranges within a chronology from *ca.* 9300 to post-4200 ^{14}C BP (Table 3).

Table 2
Sample origin, date and laboratory code.

Sample origin	14C date (Yrs. B.P)	Lab code	Method
Lapao 5 D4	7770 ± 80	LP 981	Regular
Lapao 5 D3	8380 ± 100	LP 1518	Regular
Lapao 5 D2	8560 ± 90	LP 1763	Regular
Lapao 5 D1	9380 ± 110	n/a	Regular
PCH4 M2	4203 ± 58	AA79835	Regular
PCH1 M3	8900 ± 130	LP 1841	Regular
PCH2 M2	7900 ± 100	LP 1836	Regular
PCH2 M15	6935 ± 69	AA94570	Regular

Table 3
Radiocarbon dating and estimated ages, from age-depth model for each of the samples of Pastos Chicos.

Sample	Depth	Chronology
PCH2 M20	402	
PCH2 M19	362	
PCH2 M18	331	**Post 4200**
PCH2 M17 Bis	311	
PCH2 M17	308	
PCH2 M16	280	6319
PCH2 M15	270	**6935 ± 69**
PCH2 M14	260	6998
PCH2 M13	250	7062
PCH2 M12	240	7125
PCH2 M11	230	7189
PCH2 M10	220	7252
PCH2 M9	210	7316
PCH2 M8	200	7379
PCH2 M7	190	7443
PCH2 M6	180	7506
PCH2 M5	170	7570
PCH2 M4	168	7583
PCH2 M3	142	7748
PCH2 M2	118	**7900 ± 100**
PCH1 M8	118	7900
PCH1 M7	108	8015
PCH1 M6	91	8210
PCH1 M5	63	8532
PCH1 M4	33	8877
PCH1 M3	31	**8900 ± 130**
PCH1 M2	20	9130
PCH1 M1	0	9256

In the case of profile Lapao 5 (23° 22′ 01″ S, 66° 21′ 52,8″ W; 3650 m asl), 3 m thigh, 4 samples were taken, three of them ^{14}C dated (L5_M22 9380 ± 100 ^{14}C BP, L5_M15 8560 ± 90 ^{14}C BP, L5_M13 8380 ± 100 ^{14}C BP and L5_M8 7770 ± 80 ^{14}C BP) and one by ^{14}C AMS (L5), to date the archive which, according to the age-depth model (Bennett, 1994) used covers a chronology from *ca.* 9400 to 7600 ^{14}C BP (Fig. 3). In this case, a total of 22 samples have been processed for pollen analyses (Table 4).

Table 4
Radiocarbon dating and estimated ages, from age-depth model for each of the samples of Lapao 5. Dates in gray correspond to radiocarbon dating.

Sample	Depth	Chronology
L5M1	15	7375
L5M2	30	7447
L5M3	80	7483
L5M4	85	7519
L5M5	120	7591
L5M6	140	7627
L5M7	150	7734
L5M8	185	**7770 ± 80**
L5M9	210	7878
L5M10	220	7949
L5M11	240	8164
L5M12	260	8236
L5M13	270	**8380 ± 100**
L5M14	300	8500
L5M15	310	**8560 ± 90**
L5M16	325	8660
L5M17	330	8800
L5M18	345	8840
L5M19	350	8920
L5M20	360	9060
L5M21	365	9080
L5M22	370	**9380 ± 110**
L5M23	380	9340

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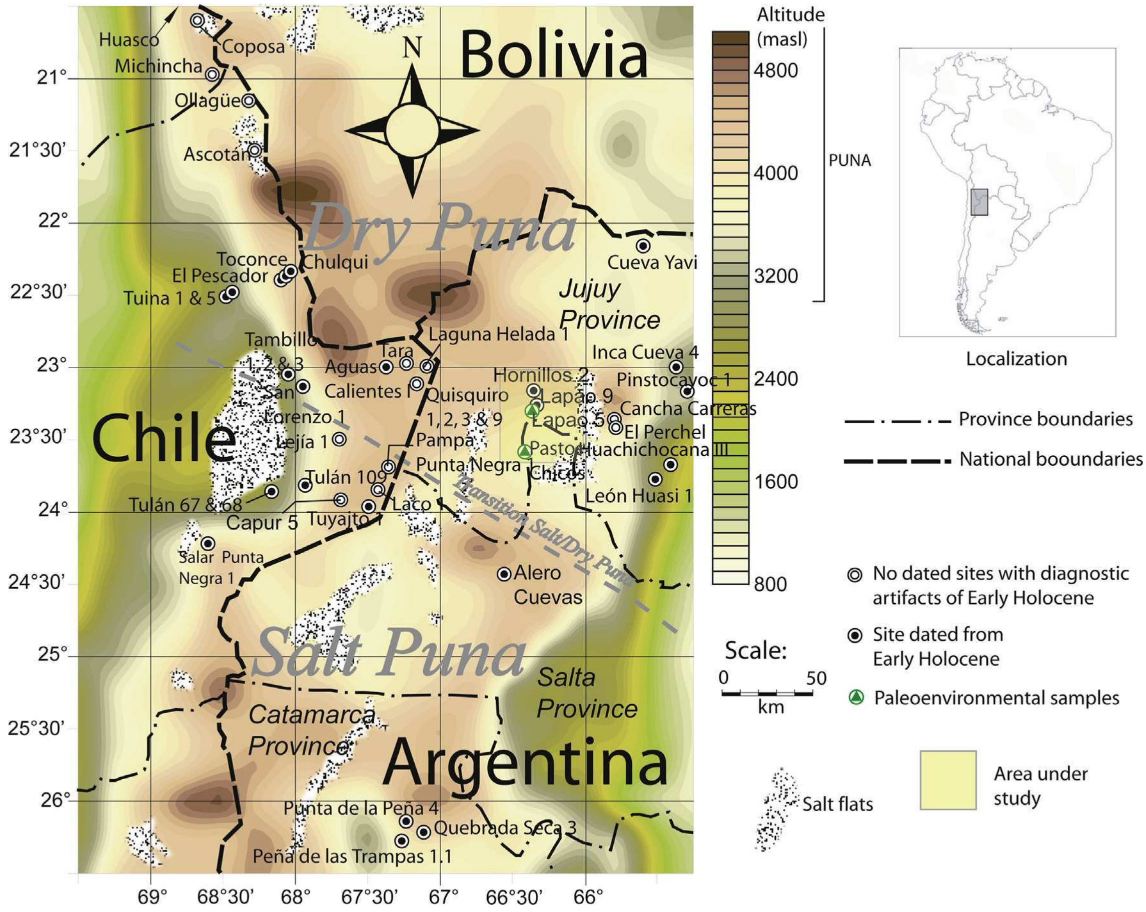

Fig. 1. Map of localization of early Holocene sites and study area.

The methodology in the pollen analyses adhered to the standard protocol for Quaternary pollen (Faegri and Iversen, 1989). The laboratory stage consisted in the observation of the samples under a Zeiss-Axiolab biological microscope, counting at least 200 grains per sample whenever possible.

Identification of the pollen types has been performed using the bibliography and available atlases for the area under study (Heusser, 1971; Markgraf and D'Antoni 1978) and the reference catalog of the Palynology laboratory of the Faculty of Agricultural Sciences UNJu/Conicet. For the statistical analysis of the data, the TILIA program (Grimm, 1987, 2004), was used, with an analysis of main components (CONISS) which allowed the discrimination of two principal palynological zones.

The palynological interpretation is based on ecological criteria of actualism and uniformitarianism. Therefore, in this case it is possible to use the information of current vegetation for making palaeoenvironmental interpretations. In this sense, descriptions of vegetation belts and ecologically related matters in the Puna, carried out by different scholars, among them Cabrera (1976), Ruthsatz and Movia, 1975 were used.

On the other hand, several paleoecological studies from the Altiplano have suggested that increases in Poaceae and decreases in Asteraceae indicate wetter conditions (and vice versa) (Liu et al. 2005). The Poaceae/Asteraceae proxy follows a precipitation-driven vegetation gradient on the Altiplano, in which grasses dominate in the northern (wetter) sections of the region, while Asteraceae shrubs dominate in the drier southern sections. This ecological relationship forms the basis for our interpretation of the pollen record. Therefore, we can use the logarithmic P/A ratio as a humidity index for the Altiplano. Accordingly, the P/A ratio would be 0 if the Poaceae and Asteraceae pollen percentages are equal. Positive numbers show the dominance of grasses and therefore wetter conditions. Negative values suggest the dominance of the Asteraceae over grasses, and therefore drier conditions (Liu et al. 2005).

3.2. *Lithic technology*

Operative chains are reconstructed in the framework of lithic technology. One operative chain is defined as the logical and organized concatenation of technical steps, from the supply of raw materials to the discarding of artifacts, including all stages of production and use of the tools (Inizan et al. 1995). This methodology allows choices, possibilities, and concepts of volumetric reduction to be put in evidence (Boëda, 2013). In this way, after determining operative schedules, hypotheses can be drawn regarding the conducts, knowledge, know-how, and skills of the stone-knappers (Inizan et al. 1995), and consequently the mechanisms of cultural transmission (Roux, 2007).

In lithic technology, at least two aspects can be considered with regard to the level of integration (to determine whether a structure is additional or integrated): production and function (or rather techno-function). In production, the level of integration depends on the relation between the volume of the exploited raw material and the remaining (unused) volume. The larger the exploited volume in relation to the remaining one, the greater is the level of integration in production (Boëda, 2013). Concerning the techno-functional aspect, a tool will be considered integrated in which both techno-

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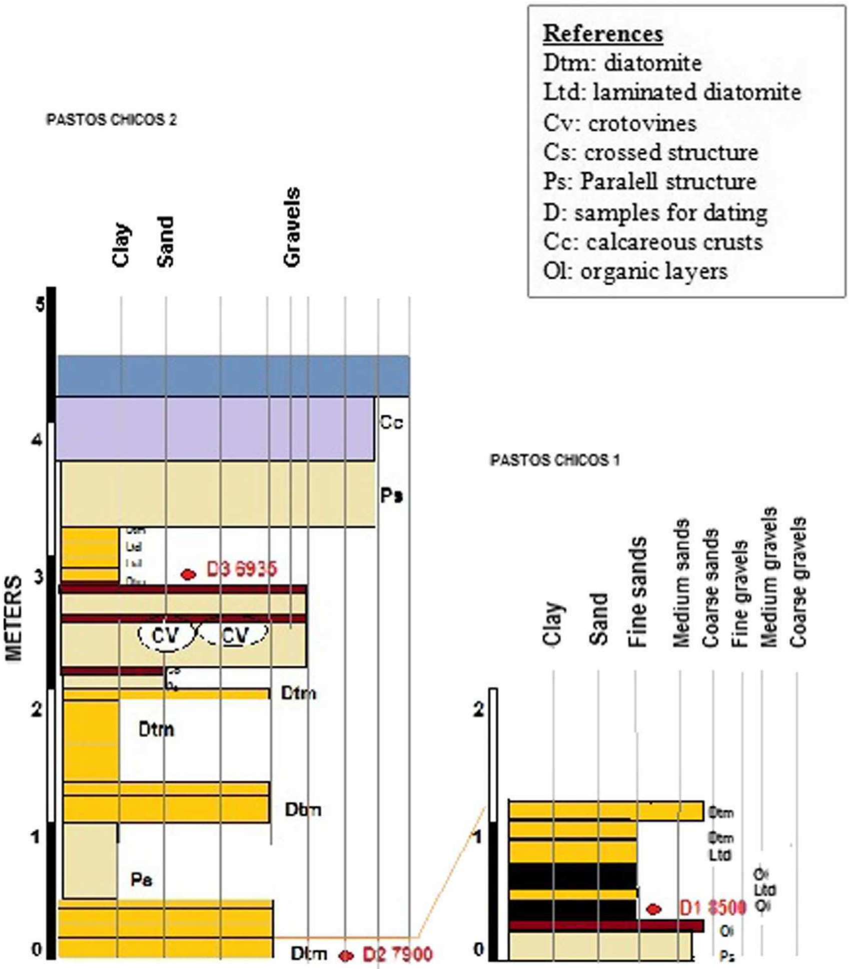

Fig. 2. Sediment reconstruction of Pastos Chicos profile. Pastos Chicos was the sequence studied by pollen analysis.

functional units (prehensile, transformative, and energy-transmitting TFUs) and their shaping (Boëda, 2013). It is important to evaluate the level of integration and technical investment in the production of blanks (i.e. knapping), in the shaping of the tools, and the degree of integration between them.

The first step in any lithic analysis, particularly the technological, consists in analyzing the separate assemblages' raw materials. Three categories will be taken into account: 1) the flakes from the debitage; 2) the debris of the shaping; and 3) the tools themselves. From this classification, it will be possible to have an idea of the activities carried out at the sites, as well as strategies of supply and transport of raw materials, which can also hint at the mobility of the groups.

Subsequently, knapping procedures will be analyzed by producing diacritical diagrams of the cores, showing order and direction in the extractions, and of the blanks, as much in their extraction as in their dimensions. Diacritical diagrams of the tools will be made in order to determine their shaping procedures, showing the series that allowed the Techno-functional Units to be established. The interdependence among the different stages of the operative chains, determined by the carrying out of preliminary stages (preparation) and by the identification of the different series of blanks and flakes from cores and tools reduction, will allow the knapping-procedures to be characterized as additional or integrated.

The sample analyzed comes from the assemblage of the initial early Holocene layers at Hornillos 2 (layers 6, 6A, B, C, and D), from layers 5 and 4 of the same site (final early Holocene), and from a small above-surface assemblage at the Lapao 9 profile, possibly corresponding to final early Holocene occupation (Table 5). Layer 5, a clay silt sandy lens layer, has an intermediate situation in the stratigraphy, and is without dating (Yacobaccio et al., 2013). It contains some similar artifacts to those of layer 4. For this reason, it probably corresponds to a final early Holocene occupation. In this work, only tools from this level were analyzed.

Table 5
Sample per site.

	Layers 6, 6A, B, C & D Hornillos 2	Layer 5 Hornillos 2	Layer 4 Hornillos 2	Lapao 9
Tools	31	3	32	3
Non retouched artifacts	3771	46	2488	0
Cores	3	0	0	0

4. Results

4.1. Pollen analyses

In the case of Pastos Chicos, 17 samples were subjected to pollen analysis. Fifteen taxa have been identified, grouped into large

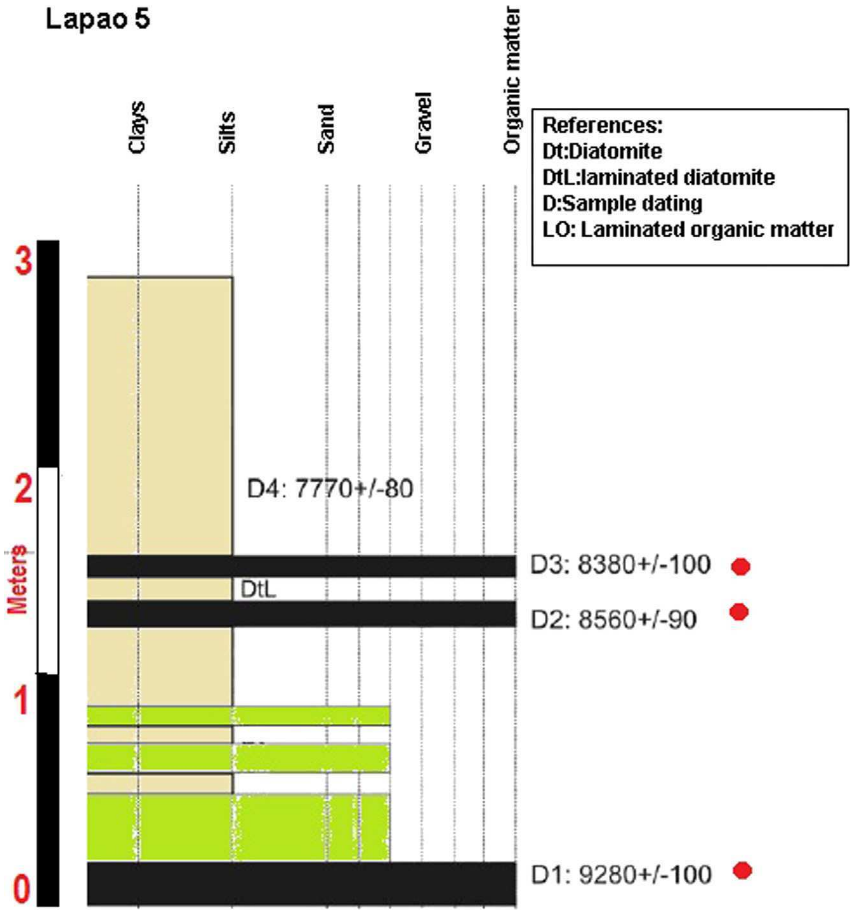

Fig. 3. Sediment reconstruction of Lapao 5 profile. Lapao5 was the sequence studied by pollen analysis.

categories that agree with the present composition of Puna vegetation: the herbaceous steppe represented by Poaceae and Ephedrae; and the shrub steppe represented by the Asteraceae, Fabaceae, Rosaceae, Solanaceae and Mimosaceae taxa. Chenopodiaceae-Amaranthaceae, and Urticaceae were identified as disturbance indicators. Finally, the indicators of local humidity were also determined, including Cyperaceae, Pteridophytes, Halorgaceae and *Carex sp*. The fern spores, fungal spores, and algae colonies are excluded from the pollen sum.

From the analysis it has been possible to detect two different intervals on the basis of the composition of the vegetation: 1) between 9300 and 7000 ^{14}C BP, when a stable steppe grassland was recorded (represented mainly by the Poaceae family between 80 and 100%), with pollen elements defined as indicators of local humidity (v.s.); and 2) after 7000 to 4200 ^{14}C BP, a clear change in plant composition is evident, in which a decrease in the herbaceous steppe is observed (Poaceae family) accompanied by a gradual increase of the shrub steppe (mainly the Asteraceae family). Isolated humidity events have also been recorded around 6300 ^{14}C BP (Fig. 4). From the humidity index applied, only towards the period after 6300 ^{14}C BP (sample P2 M17) did it show a negative value, which is interpreted as the most arid interval in the whole sequence (Fig. 5).

In the case of Lapao 5, 15 samples were subjected to pollen analysis. A total of 15 taxa have been identified. Representing the grass steppe are Poaceae and *Ephedra sp*. Representing shrub steppe are Asteraceae, Mimosaceae, Halorgaceae, *Chuquiraga sp*. and *Fabiana sp*. The following taxa are identified as local humidity indicators : *Tagetes sp*., *Myriophyllum quitense*, pteridophytes, *Nototriche sp*, Cyperaceae, and various types of fungal spores. Pollen types from trees such as *Alnus acuminata* (from the "yunga") have also been found. Pollen types have been grouped that, found together, may be good indicators of the anthropogenic impact, i.a.: Malvaceae, Urticaceae, Chenopodiaceae and Amaranthaceae. Fern spores, fungal spores, and algae colonies are excluded from the pollen sum.

It is possible to register two different periods in taxa composition: 1) between 9280 and 8400 ^{14}C BP, in which a mixed steppeland vegetation of grasses and bushes is observed (mostly the Poaceae and Asteraceae families) with intervals with high percentages of *M. quitense*, interpreted as an indicator of local humidity and low temperatures, with a maximum between 8600 and 8400 ^{14}C BP (*M. quitense*, Cyperaceae, *Nototriche sp*., *Tagete sp*.; among others). Diatom studies also show a dry phase around 8400 ^{14}C BP detected by an increase of the littoral species (Tchilinguirian et al., 2014a); 2) From 8400 to 7600 ^{14}C BP, a fall is observed in the local humidity indicators. However, the presence of a water body is still evident. Conditions of aridity set in towards 7600 ^{14}C BP, with the drying out of the wetland (Fig. 6). From the application of the humidity index, negative values have been detected around 8840 ^{14}C BP (sample M18) and 9080 ^{14}C BP (sample M21), which are interpreted as moments of particular aridity (Fig. 7). The results confirm the preliminary pollen results and the palaeoenvironmental interpretations presented for the same localities in previous works (Morales, 2011; Tchilinguirian et al., 2014a; Oxman and Yacobaccio, 2014; Tchilinguirian et al., 14b).

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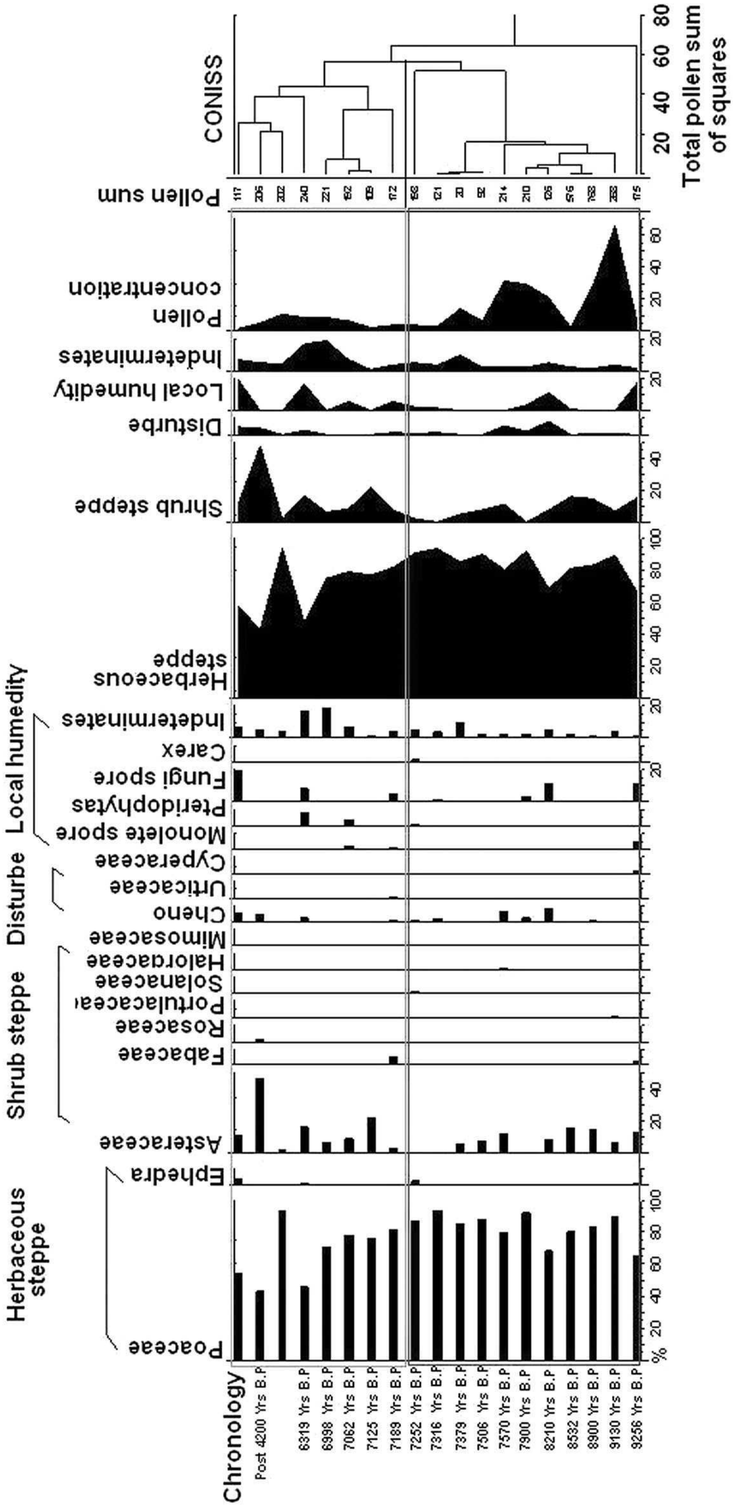

Fig. 4. Pollen diagram of Pastos chicos profile.

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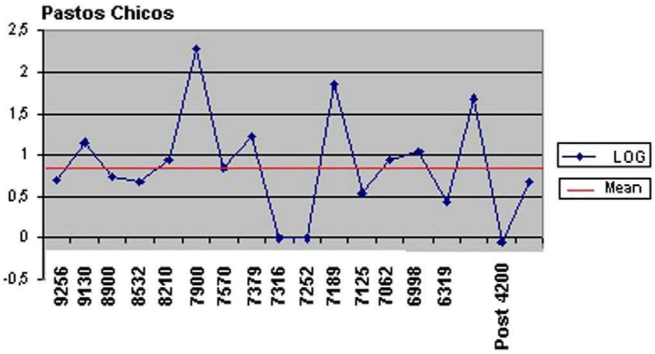

Fig. 5. Moisture index of Pastos Chicos profile (Log P/A).

4.2. Lithic technology

In northern Chile and northwest Argentina, triangular stemless weapon-heads predominate for use in individual hunting strategies (Pintar, 1995; Aschero and Martínez, 2001; De Souza, 2004; Núñez et al. 2005; among others). In Chile, two phases were distinguished for the early Holocene: Tuina (11,000–9500/9000 ^{14}C BP), characterized by the presence of eponymous weapon-heads and a raised-back scraper; and Tambillo (9500/9000–8500/8000 ^{14}C BP), characterized by the presence of “cupuliform” points (see Núñez and Santoro, 1988). It is not the objective of this work to use these phases as operative units for this investigation, but to contextualize the diagnostic artifacts that might possibly be identified in the area under investigation. An important superposition between the contexts with a simultaneous presence of these diagnostic artifacts is noticeable, with an early tendency for Tuina and Tambillo towards the end of the early Holocene (Table 6, Fig. 8).

Table 6
Early Holocene sites, radiocarbon dates and frecuencies of Tuina and Tambillo points.

Site	Radiocarbon date (yrs BP no calibrated)	Tuina	Tambillo	References
Tulán 109	10590 ± 150	–	–	Núñez et al. 2005
Salar Punta Negra-1	10470 ± 50	3		
	10460 ± 50			
	10440 ± 50			
	10350 ± 60		–	Grosjean et al. 2005
	9450 ± 50			
	9230 ± 50			
	9180 ± 50			
Tuina-1	10820 ± 630	2	–	Núñez et al. 2005
Tuina-5	10060 ± 70	2	–	Núñez et al. 2005
	9840 ± 110			
San Lorenzo-1	10400 ± 130	1	–	
	10280 ± 120			Núñez et al. 2005
	9960 ± 125			
Inca Cueva 4	10620 ± 140	8	–	Hocsman et al. 2012
	9900 ± 200			
	9650 ± 110			
	92330 ± 70			
Hornillos 2 layer ensemble Early Holocene	9710 ± 270	7		Yacobaccio et al., 2013
	9590 ± 50		–	Hoguin 2013 Ms
	9150 ± 50			
Hornillos 2 layer 4	8280 ± 100	–	2	Yacobaccio et al., 2013
Aguas Calientes I-1	8720 ± 100	13	–	Núñez et al. 2005
Tuyajto-1	8210 ± 110	14	4	Núñez et al. 2005
	8130 ± 110			
Tambillo-2	8870 ± 70	–	4	Núñez et al. 2005
	9590 ± 110			
Tambillo 1	8590 ± 130	–	8	Núñez et al. 2005
Tulan-67	8190 ± 120	1	6	Núñez et al. 2005
Toconce	7990 ± 125	–	2	Núñez and Santoro 1988

At Hornillos 2 (Fig. 9), the relation between tools and debitage flakes is reverted between the sum of layers from the beginning of the early Holocene (Hornillos 2 layers 6, 6A, B, C, and D) and the layer from the end of early Holocene (layer 4 at Hornillos 2). In the first assemblage, in quartzite (directly local <1 km) and andesite (intermediately local <30 km), the tools are represented in a smaller proportion than are the flakes, whereas for the obsidian (non-local >90 km) and various silica (local <10 km) their representation is greater. In layer 4 the opposite phenomenon is found: quartzite and andesite tools are more highly represented in relation to the flakes of these raw materials, whereas obsidian and the silica are to a lesser degree. Finally, in layer 4, andesite is better represented than in the diverse layers of the beginning of the early Holocene at Hornillos 2, and the proportion of obsidian tools is lower.

From the cores discovered and from the identified blanks (unshaped) it is possible to infer main debitage procedures at the start of the early Holocene. One consists in the frontal unidirectional exploitation from a single scar front (Fig. 10:1), and the other in an alternating centripetal exploitation (Fig. 10: 2). For this period, flakes from unidirectional extractions dominate. Although there are no cores for layer 4 at Hornillos 2, the analysis of the flakes, shaped as well as unmodified and their comparison with other sites (see Hoguin, 2013) indicates a variability of blanks, as well as a complexity of debitage procedures (Fig. 11). It is possible to determine a unidirectional method such as occurred previously, but the existence of blanks which characteristics (platforms and removals) indicates that the cores were mostly exploited, with the incorporation of new stages which alternated extraction surfaces and platforms (Fig. 11). In some cases, a third platform was used to obtain overspilling flakes, with an abrupt back (Fig. 11). In this case, obtaining this kind of blank would depend on the previous series of removals. In this way, greater diversification can be observed in the types of blanks obtained, with the presence of dihedral-but flakes (exploitation alternating surfaces and platforms) and nucleus flanks (Fig. 11).

As at other sites in Chile, Tuina points are preferentially present in the layers from the beginning of the early Holocene, and the Tambillo points are preferentially present in the layer from the end of the early Holocene. Two shaping procedures were identified for Tuina points. The first consists of bifacial shaping in two interdependent sequences. The second consists in shaping by hierarchical treatment of the surfaces, with partial alternate finishing retouches (Fig. 12). In this last case the different sequences do not seem dependent on each other, and may reflect different life-stages of the artifact. In the cases in which it was possible to identify the technical axis, this did not coincide with the morphological axis. These observations were also made at Inca Cueva 4 and Alero Cuevas (Hocsman et al., 2012; Hoguin and Restifo, 2012). This might indicate independence between the production of blanks and the shaping of the tools, as well as a low predetermination during the debitage procedure. These observations can be extrapolated to other tools that are not projectile-points (Fig. 12: 6 and 7). For layer 4 at Hornillos 2 and the Lapao

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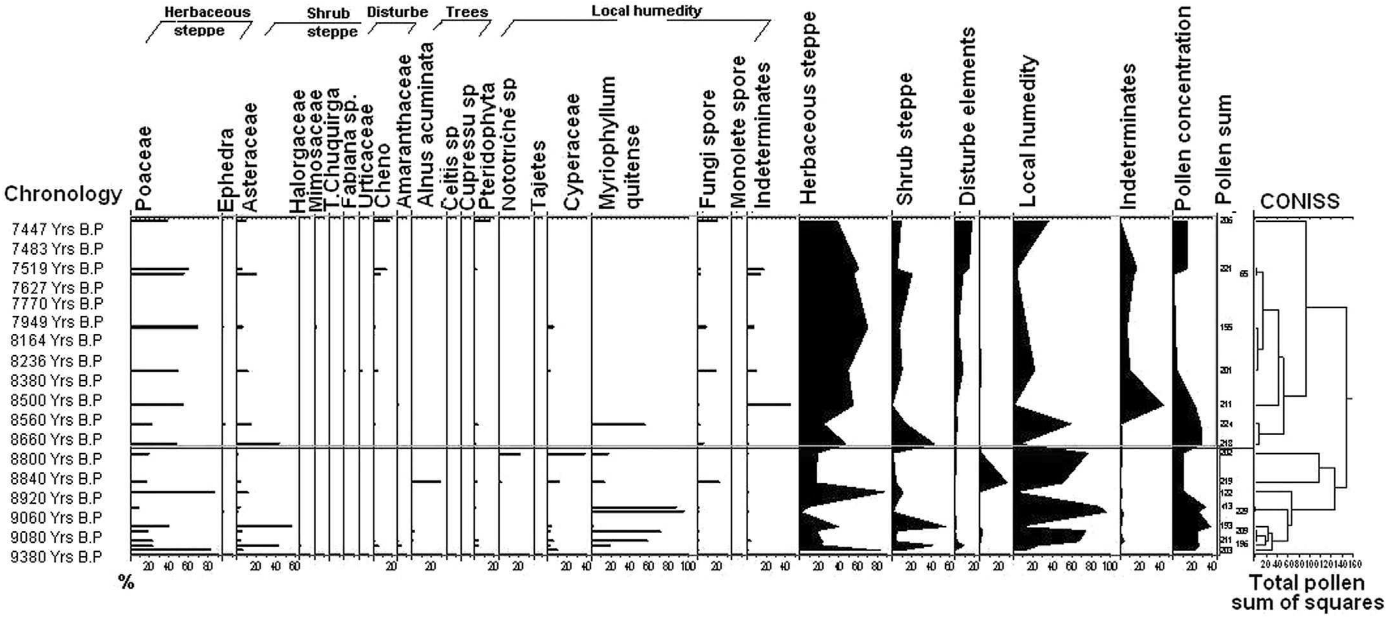

Fig. 6. Pollen diagram of Lapao 5 profile.

9 sequence, we can observe on Tambillo points a shaping-procedure by hierarchical treatment of the surfaces in three or four sequences, possibly interdependent, as they do not seem to correspond with reactivation stages, and with coinciding negative bulbs on the cutting edges (Fig. 13). Layer 4 additionally contains other types of projectile-points (Fig. 14), among them a few fragments of Huiculunche 2 points identified at several locations in Chile and Argentina (De Souza, 2004; Núñez et al. 2005; Hoguin, 2013 Ms).

During the early Holocene, various tools show 2 transformative TFUs that were made in 3 unifacial sequences (Fig. 15). The blanks employed vary in their dimensions, and may have been obtained by

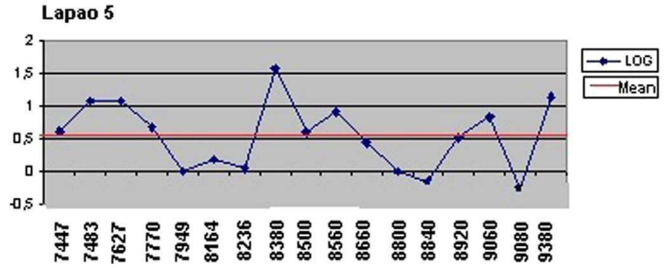

Fig. 7. Moisture index of Lapao 5 profile (Log P/A).

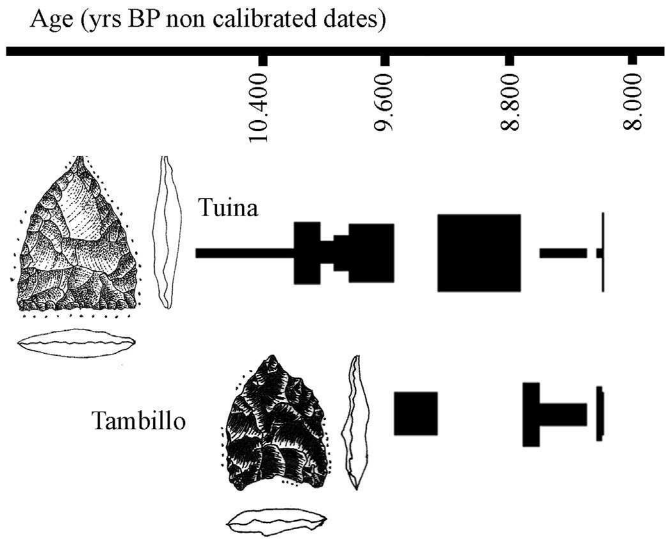

Fig. 8. Seriation of Tuina and Tambillo points (using logarithmic values frequencies with the Past version 2b17b Spindle Diagram).

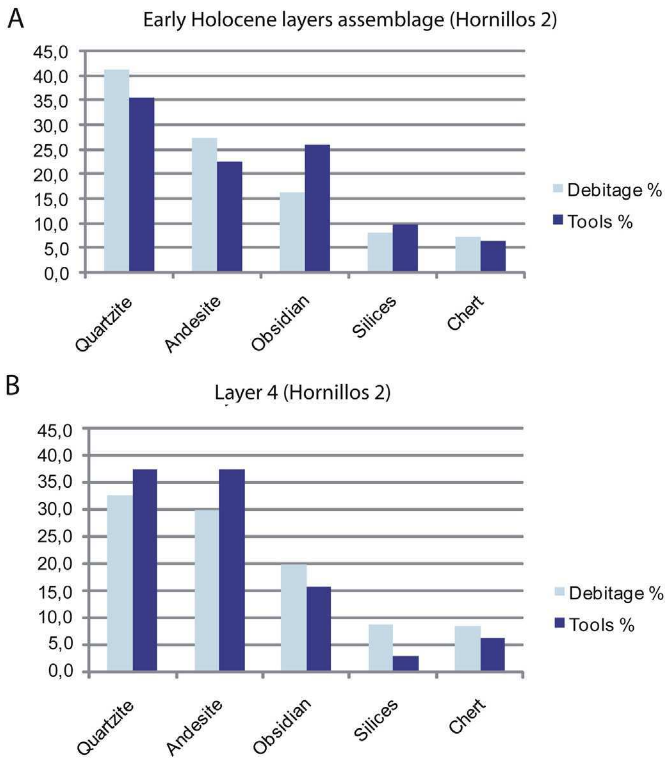

Fig. 9. Raw material proportions for tools and debitage flakes. A: Early Holocene layers ensemble of Hornillos 2; B: Hornillos 2 layer 4.

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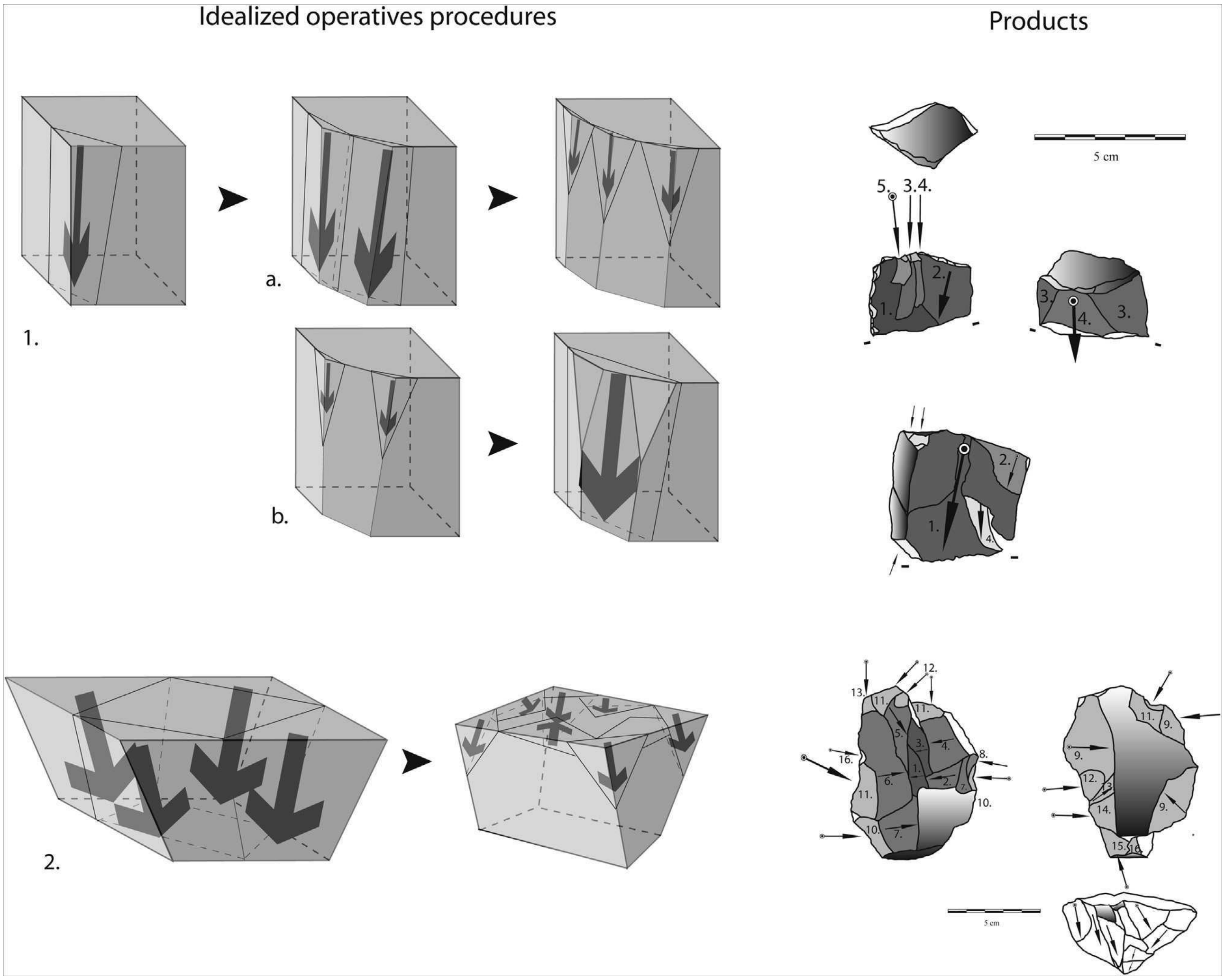

Fig. 10. Idealized debitage procedures and its products for initial early Holocene.

the unidirectional recurrent method. However, some of these tools were manufactured with flagstones as blanks (Fig. 15: 3). There appears to be independence between the techno-functional objectives and the production of blanks. In layer 4 at Hornillos 2, towards the end of the early Holocene, various types of tools and various shaping-procedures were observed. Some show a 4-stage shaping process of two different sorts of TFUs. One is a sinuous cutting-edge made by alternating bifacial shaping, and the other (an abrupt cutting-edge) by unifacial shaping in two sequences (Fig. 16). Finally, there is another artifact class showing a hierarchic treatment of the surfaces (Fig. 17).

5. Discussion

During the early Holocene, herbaceous vegetation is recorded ~500 m below its present location, characteristic of higher and more humid zones. This increase in regional humidity would have brought about an extension and increase of productive patches, as well as that of associated critical resources and a reduction of the distance between them, which may have enlarged the capacity to support animal biomass. These conditions may be explainable owing to rises in temperature in relation to the previous period, accompanied by a rise in rainfall, cloudiness, and therefore a decrease in evapotranspiration. In turn, the maintenance of these grasslands can also be attributed to water produced by the thawing of glaciers (Núñez and Grosjean, 1994).

Regional conditions towards greater aridity set in *ca.* 8000 ^{14}C BP though certain localities may have retained humid conditions to *ca.* 7000 ^{14}C BP according to the Pastos Chicos record. In the Quebrada de Lapao the retreat of humid conditions began *ca.* 8400 ^{14}C BP, and the apparent disappearance of the water body *ca.* 7600 ^{14}C BP. These conditions are compatible with the observations at Pastos Chicos (Tchiliguirian et al., 2014a). Thus, the presence of grassland can be detected until *ca.* 7000 ^{14}C BP (Tchilinguirian et al., 2014b).

The changes to more arid conditions in the mid-Holocene were not synchronous, which would indicate the existence of productive patches of different quality and availability during the early Holocene. This would represent a change in the segmentation of the space, with patches of differential quality and productivity.

The expectations arising from this climatic context, and for this stage of settlement of the area *ca.* 10,200 and 9300 ^{14}C BP (see Yacobaccio and Morales, 2011), would be the predominance of individual learning and flexible operative chains. This gradual adaptation process, biological as well as cultural, will have been followed by greater complexity of the operative chains and

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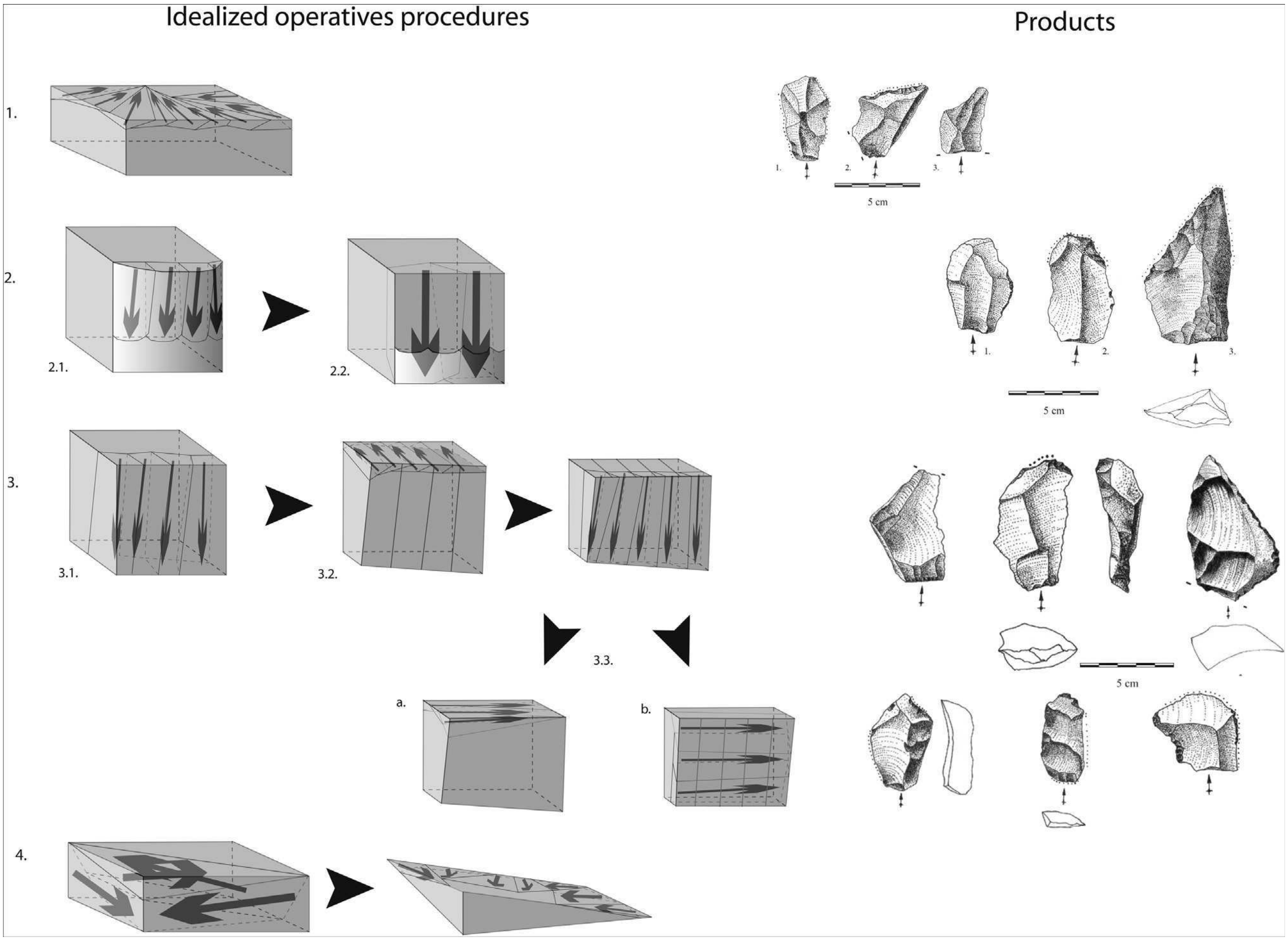

Fig. 11. Idealized debitage procedures and its products for final early Holocene.

stabilization in the networks for the transmission of technical knowledge, specially visible from 8500 ^{14}C BP, as mechanisms dependent on density came into action (see Yacobaccio and Morales, 2011).

For the first occupations in Susques, the lithic archaeological evidence that allows the proposed expectations to be contrasted, corresponds to a lapse between *ca.* 9700 and 9100 ^{14}C BP, which would reflect an averaged archaeological record. This would be the

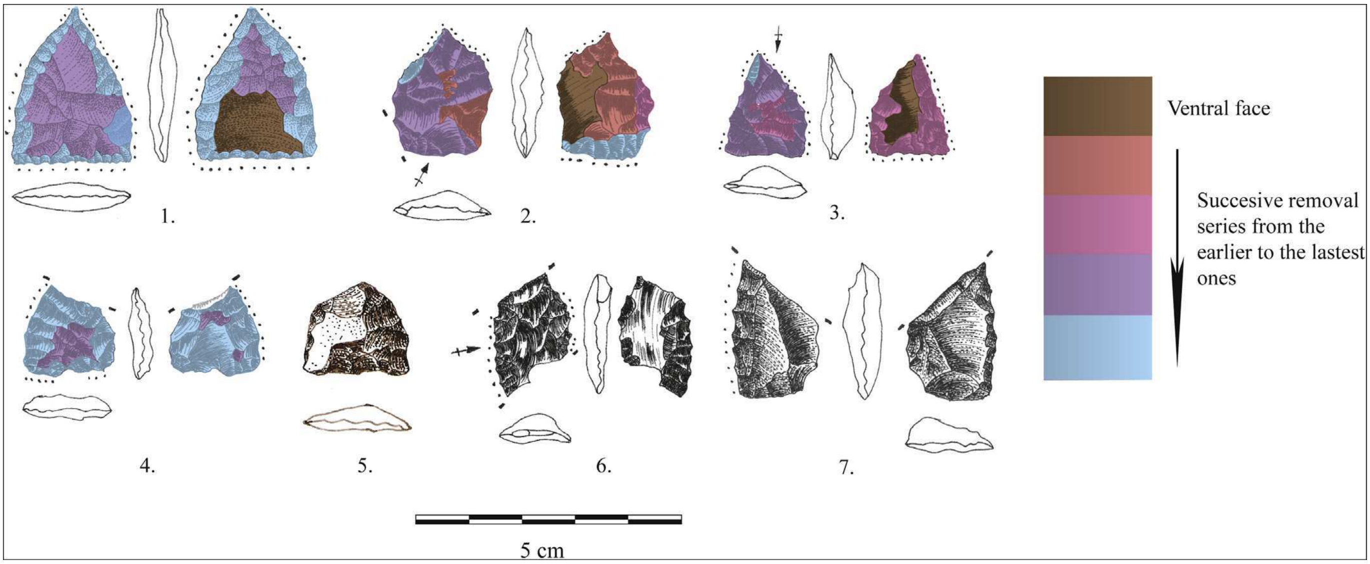

Fig. 12. Tuina weapon head type.

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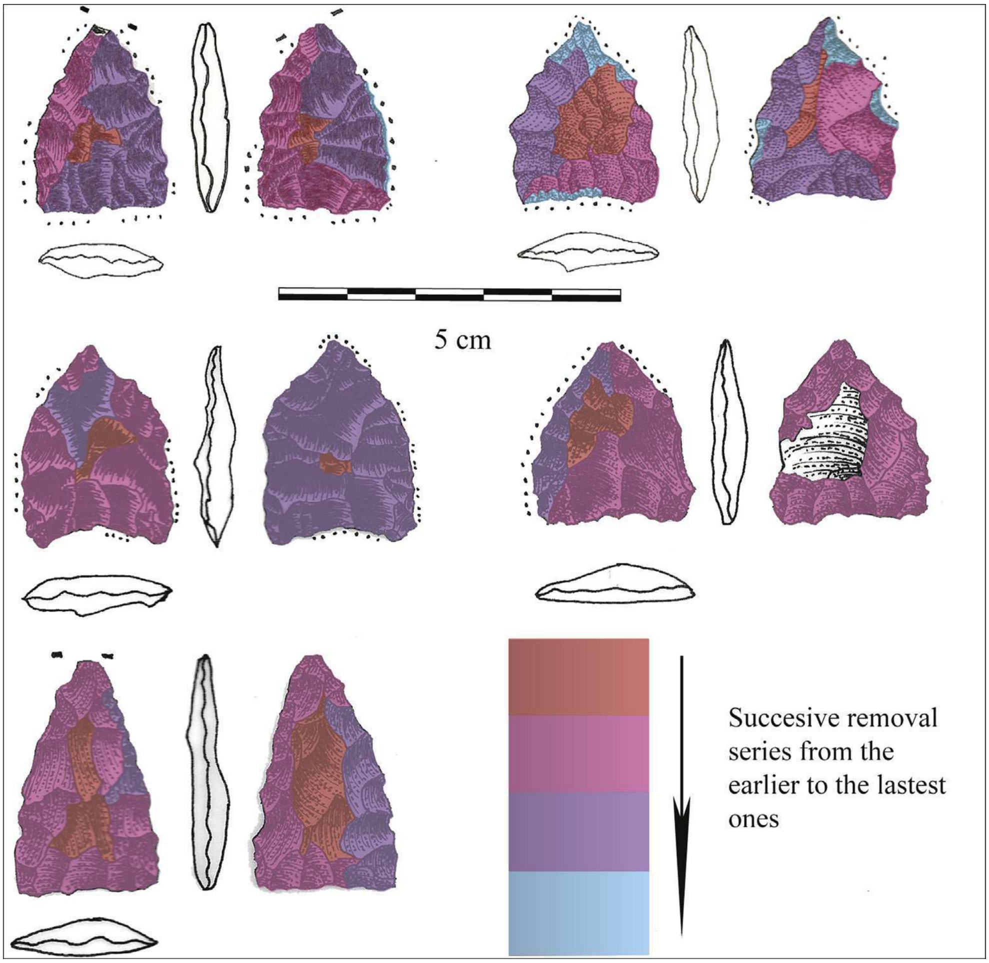

Fig. 13. Tambillo weapon head type.

product of diverse events, of dispersal as much as colonization (Dillehay, 2000; Yacobaccio, 2010) of the Puna. This context is characterized by the presence of Tuina points, in which the shaping design can be variable. The blanks for these points seem to have been the product of an *ad hoc* selection, as the technical axis never corresponds with the morphological. This could indicate a low predetermination in the production of blanks, and independence between the production and tool project. As shown, other tools also

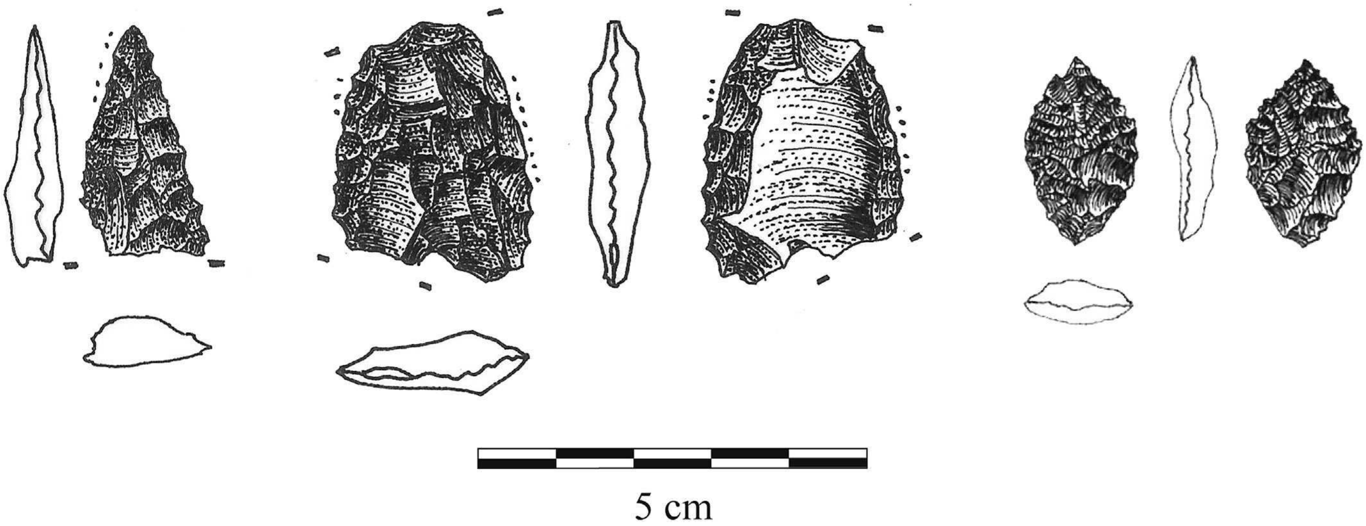

Fig. 14. Other projectile points types.

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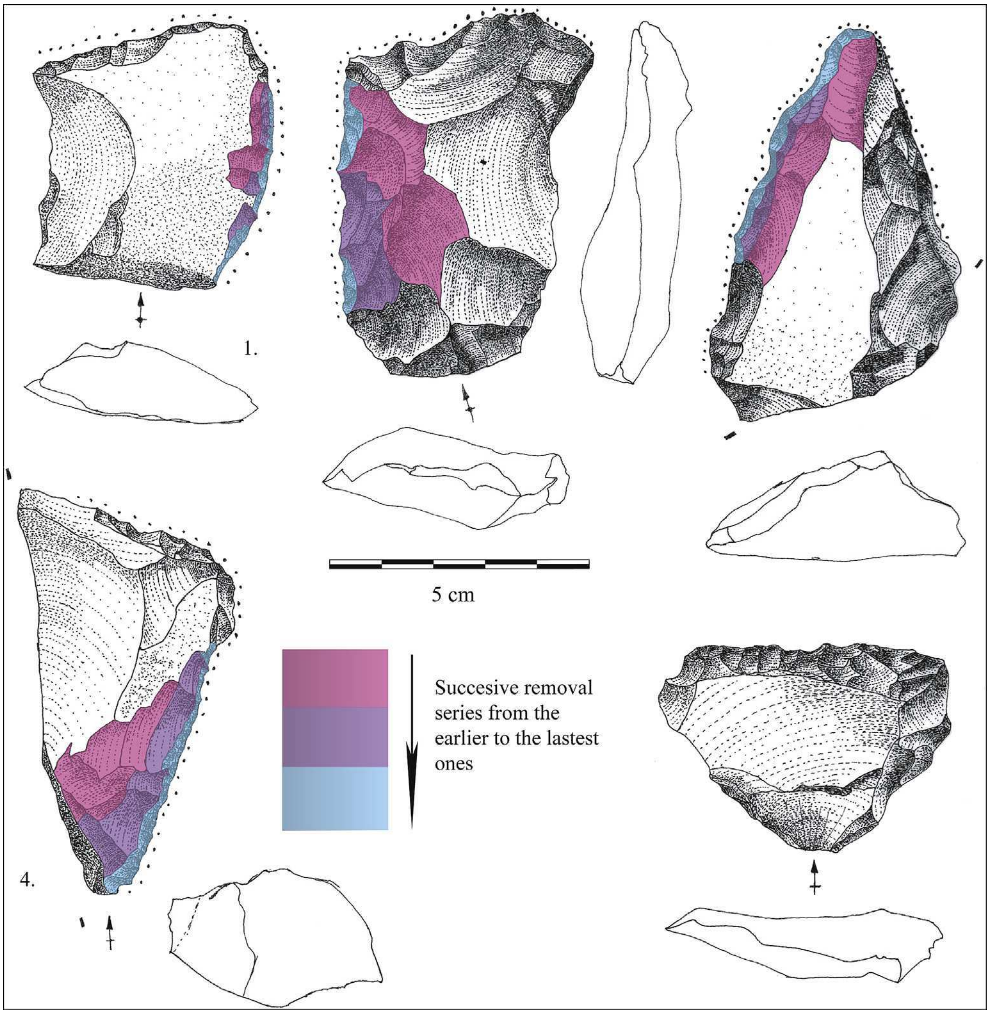

Fig. 15. Initial early Holocene processing tools types.

present the same characteristics. Other larger-sized artifacts have two perpendicular TFUs shaped in two or three sequences, and were fashioned from diversified blanks (in some cases made directly with flagstones), possibly also chosen *ad hoc*. These tools may correspond to what some authors called "raised-backed" (Núñez and Santoro, 1988), due to their thickness or in some cases the presence of a thick projecting ridge, obtained prior to the shaping of these tools. Several of the blanks for these tools are obtained from a type C debitage procedure, thus an additional structure (Boëda, 2013). There is a certain independence between blank production schedules and the objectives of their final carving, allowing technical flexibility.

In layers 5 and 4 at Hornillos 2, the latter dated at *ca.* 8300 ^{14}C BP, a greater diversity of artifacts is observed, including projectile points as in other tools. The shaping process of Tambillo points differs from those of Tuina. Through the shaping protocols of the different tools from layer 4, clearer patterns have been detected than in the previous layers (6, 6A, B, C, and D), as well as greater technical investment. This possibly involved an increase in the learning time and greater skills, with more systematized knapping projects, which may have been maintained by biased transmission in a context of more stable relationships between individuals.

The diversity observed in layer 4 could be the result of an increase in technical innovations relative to the previous period. Although the debitage procedures are also of additional structure, they present a greater degree of integration in the productive stages and higher complexity from the incorporation of certain predetermined stages and objectives such as obtaining cores flank flakes. From the evidence at other sites, it was possible to propose that there might be a certain dependence between the debitage and shaping processes of tools for this period (Hoguin, 2013).

In the same way, the changes observed between both contexts on the proportions of the different raw materials and the indices of the tool-debris relationship, might reflect changes in supply strategies from *ca.* 8500 ^{14}C BP. They could be the result of systematization in the supply of raw materials from an intermediate distance, such as andesite (~20–30 km) with blanks. This could reflect diminished residential mobility of the groups, resulting from more permanent occupations in higher quality resource patches (Aschero, 1994; Morales, 2011).

6. Conclusions

Pre-Holocene conditions seem not to have permitted human occupation, at least on a sustained basis (Yacobaccio and Morales, 2011; Tchilinguirian et al., 2014a). Neither has evidence been found of associations between human occupations and megafauna, despite their contemporaneity in the region. It has been proposed

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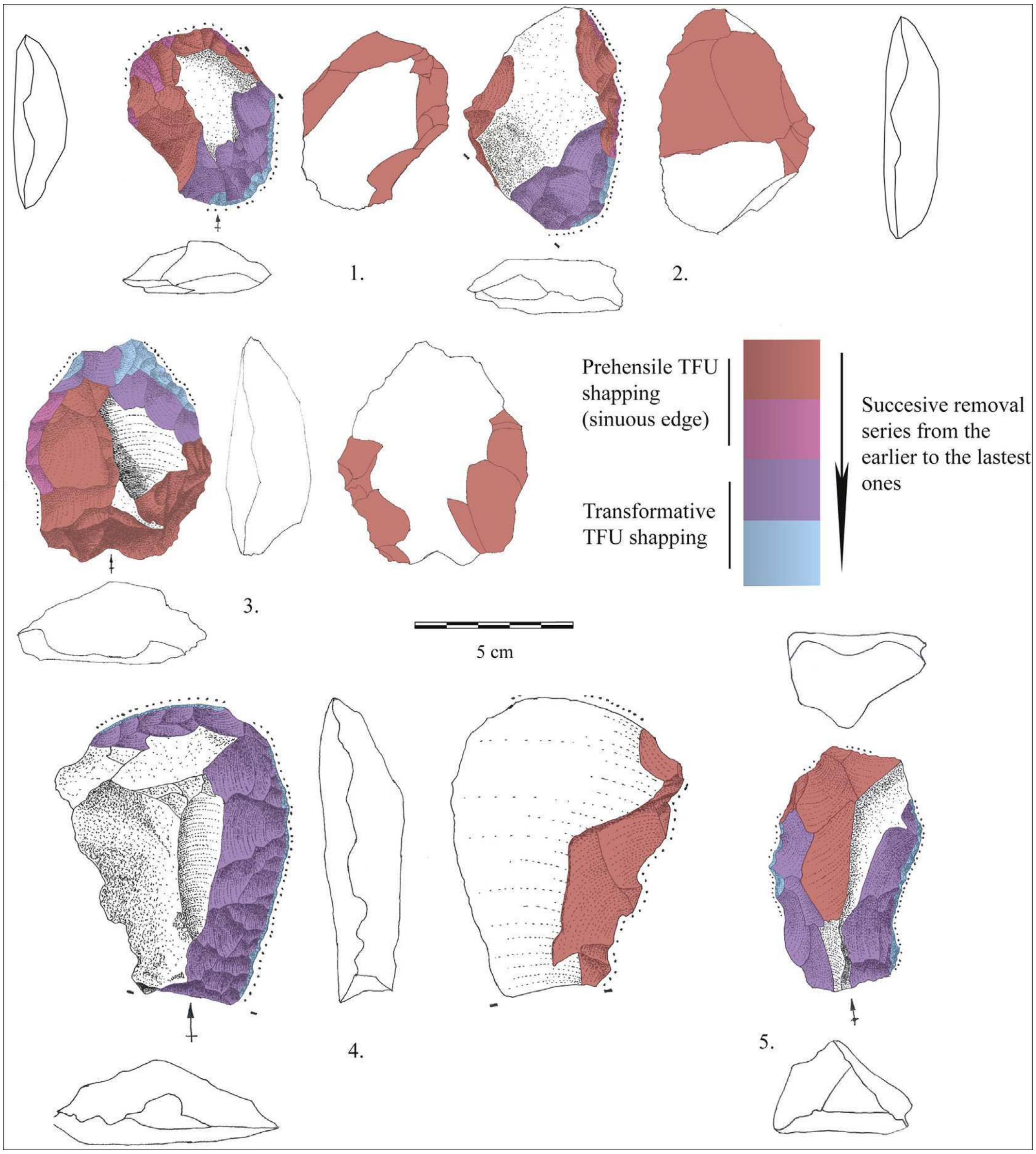

Fig. 16. Final early Holocene processing tools types.

that the earliest settlement of land above 4000 m asl would have taken place during a span of *ca.* 900 years, and towards 9387 ± 18 ^{14}C BP all the Puna living spaces had already been occupied by the hunter–gatherer groups (Yacobaccio and Morales, 2011). These permanent occupations will have been possible due to the stabilization of the resource patches (Aldenderfer, 1999), as palaeoenvironmental data generated for the early Holocene in the area seem to show. The archaeofaunal evidence suggests the resources were highly available locally in a humid environment and were obtained close to the sites (Yacobaccio and Morales, 2011), which is associated with opportunist hunting of locally available resources (Oxman and Yacobaccio, 2014).

In this context, it is possible to conclude that the groups stabilized rapidly, at least from the evidence available at Hornillos 2. In addition, the choice of pigments for the rock-art at Hornillos 2 and Inca Cueva 4 reflects provisioning from local ranges, without precluding interaction (Yacobaccio et al. 2008). Although at the very start of the colonization the use of Puna space may have been exclusively temporary owing to the restrictions of biological adaptation to the region, as from 9500 ^{14}C BP, it is conceivable that the groups exclusively occupied the Puna (in the case of the study area), following a North-to-South mobility, as the supply of obsidians and pigments shows (Yacobaccio et al. 2008; Yacobaccio and Morales, 2011).

In addition, it is possible to show that the technical changes that took place *ca.* 8300 ^{14}C BP are synchronous with the climate changes. All these changes could also be related to a longer residence of population in this environment, a better knowledge of the landscape, and greater stability of their transmission networks. The new conditions of aridness could have had consequences on the organization of the populations, on the strategies of resource provisioning in general, and on hunting in particular, as shown by the gradual rise in the representation of camelids towards the end of the early Holocene at various sites (Yacobaccio et al., 2013). These changes may have fostered the rise of the innovations observed in the archaeological record through a diversification of artifacts, as observed at the Hornillos 2 rockshelter.

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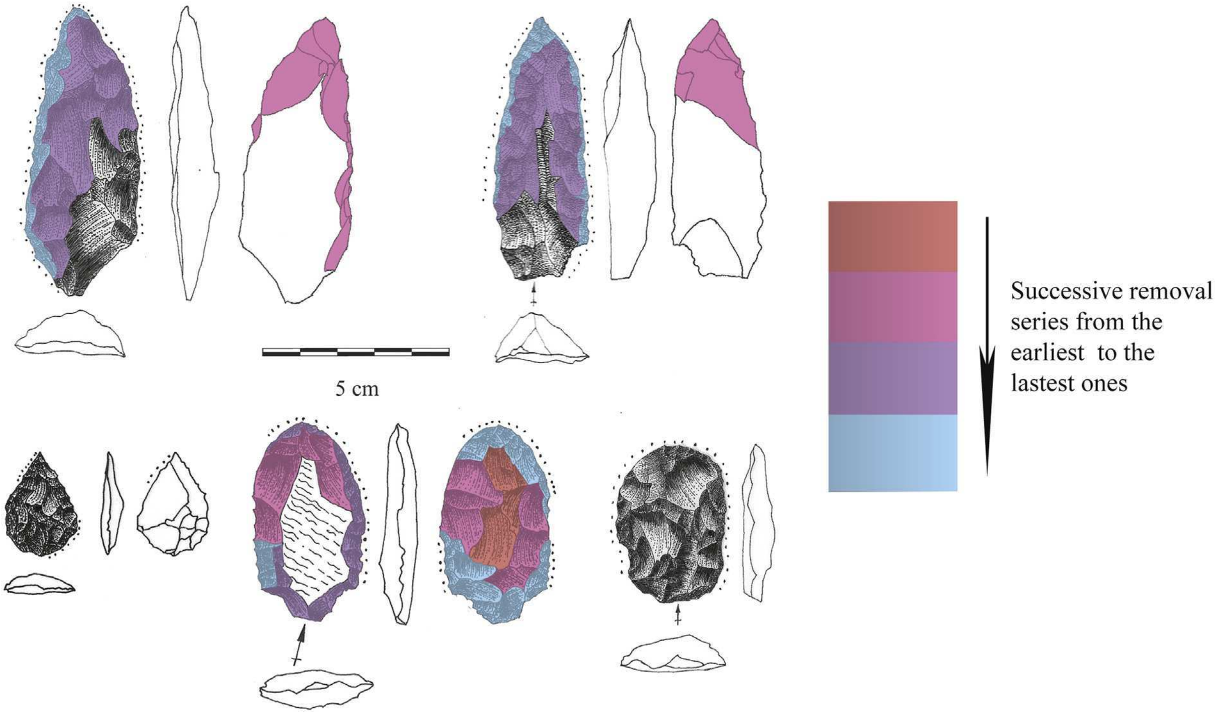

Fig. 17. Tools with hierarchic treatment faces shaping (Hornillos 2 layer 4).

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References

Aldenderfer, M., 1999. The Pleistocene/Holocene transition in Peru and its effects upon human use of the landscape. Quaternary International 53 (54), 11–19.

Aschero, C.A., 1994. Reflexiones desde el Arcaico Tardío (6.000-3.000 A.P). Rumicatana Año 1, 13–17.

Aschero, C.A., Martínez, J.G., 2001. Técnicas de caza en Antofagasta de la Sierra, Puna Meridional Argentina. Relaciones de la Sociedad Argentina de Antropología XXVI, 215–241.

Bennett, K.D., 1994. Confidence intervals for age estimates and deposition times in late-Quaternary sediment sequences. The Holocene 4, 337–348.

Binford, L.R., 2001. Constructing Frames of Reference. An Analytical Method for Archaeological Theory Building Using Ethnographic and Environmental Data Sets. University of California Press, London.

Boëda, E., 2013. Techno-logique et technologie. Une paléo-histoire des objets lithiques tranchants. @rchéo-éditions.com.

Bradbury, J.P., Grosjean, M., Stine, S., Sylvestre, F., 2001. Full- and Late-glacial lake records along PEP-1 transect: their role in developing inter-hemispheric paleoclimate interactions. In: Markgraf, V. (Ed.), Interhemispheric Climate Linkages. Academic Press, San Diego, pp. 265–291.

Cabrera, A.L., 1976. Regiones Fitogeográficas Argentinas. Editorial Acme, Buenos Aires.

De Souza, P., 2004. Cazadores Recolectores del Arcaico Temprano y Medio en la cuenca superior del río Loa: Sitios, conjuntos líticos y sistemas de asentamiento. Estudios Atacameños 27, 7–43.

Dillehay, T., 2000. The Settlement of the Americas: a New Prehistory. Basic Books, New York.

Dillehay, T.D., Ardilla Calderdn, G., Politis, G., de Moraes Coulinho Beltrao, M. da C., 1992. Earliest hunters and gatherers of South America. Journal of World Prehistory 6, 145–204.

Faegri, K., Iversen, J., 1989. In: Faegri, K., Kaland, P.E., Krywinski, K. (Eds.), Textbook of Pollen Analysis. John Wiley and Sons, Chichester.

Fernández Distel, A., 1986. Las Cuevas de Huachichocana, su posición dentro del precerámico con agricultura incipiente del Noroeste argentino. In: Beitrage Zur Allegemeinen und vergleichenden Archaeologie, Band 8. Verlag Phillip von Zabern, Mainz Am Reim, pp. 353–430.

Fernández Distel, A., 1989. Una nueva cueva con maíz acerámico en el N. O. Argentino: León Huasi 1, excavación. Comunicaciones Científicas 1, 4–17.

Grimm, E., 1987. CONISS: a FORTRAN 77 program for stratigraphically constrained cluster analysis by the method of incremental sum of squares. Computers and Geosciences 13 (1), 13–35.

Grimm, E., 2004. Tilia and TGView 2.0.2 Illinois State Museum. Research and Collection Center, Springfield, Illinois.

Grosjean, M., Núñez, L., Cartajena, I., Messerli, B., 1997. Mid-Holocene climate and culture change in the Atacama desert, northern Chile. Quaternary Research 48, 239–246.

Grosjean, M., Núñez, L., Cartajena, I., 2005. Palaeoindian occupation of the Atacama Desert, northern Chile. Journal of Quaternary Science, 643–653.

Henrich, J., 2004. Demography and Cultural Evolution: why adaptive cultural processes produced maladaptative losses in Tasmania. American Antiquity 69 (2), 197–214.

Hernández Llosas, M.I., 2005. Pintoscayoc and the archaeology of the arid puna and rift valley, northern Argentina. In: Smith, H. (Ed.), 23° South, Archaeology and Environmental History of the Southern Deserts. National Museum of Australia Press, Canberra, pp. 186–197.

Heusser, C.J., 1971. Pollen and Spores of Chile. Modern Types of the Pteridophyta, Gymnosperma, and Angiospermae. The University of Arizona Press, Tucson.

Hocsman, S., Martínez, J.G., Aschero, C.A., Calisaya, A.D., 2012. Variability of Triangular Non-Stemmed Projectile Points of Hunter-Gatherers of the Argentinian Puna. Current Research in the Pleistocene. Southbound: Late Pleistocene Peopling of Latin America, 63–67.

Hoguin, R., Restifo, F., 2012. Patterns of Cultural Transmission in the Manufacture of Projectile Points: Implications for the Early Settlement of the Argentine Puna. Current Research in the Pleistocene. South Bound. Late Pleistocene Peopling of Latin America, 69–73.

Hoguin, R., 2013. Evolución y cambios técnicos en sociedades cazadoras recolectoras de la Puna Seca de los Andes Centro-Sur. Tesis de doctorado en Arqueología de la Facultad de Filosofía y Letras, Universidad de Buenos Aires, Université de Paris X.

Inizan, M.-L., Reduron, M., Roche, H., Tixier, J., 1995. Technologie de la pierre taillée, Tome 4. CREP, Meudon.

Kelly, R.L., 1992. Mobility/sedentism: concepts, archaeological measures, and effects. Annual Review of Anthropology 21, 43–66.

Krapovickas, P., 1987–1988. Noticia. Nuevos fechados radiocarbónicos para el sector oriental de la Puna y la Quebrada de Humahuaca. Runa XXVII–XVIII, 207–219.

Kulemeyer, J.A., Lupo, L.C., Kulemeyer, J.J., Laguna, L.R., 1999. Desarrollo paleoecológico durante las ocupaciones humanas del precerámico del norte de la Puna Argentina. In: Schäbitz, F., Liebricht, H. (Eds.), Bejträge zur quartären Landschaftsentwicklung Südamerikas. Bamberger Geographische Schriften, Bamberg, pp. 233–255.

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Liu, K.B., Carl, A.R., Thompson, L.G., 2005. Ice-core pollen record of climatic changes in the central Andes during the last 400 yr. Quaternary Research 64, 272–278.

López, G.E., 2008. Arqueología de Cazadores y Pastores en Tierras Altas: Ocupaciones humanas a lo largo del Holoceno en Pastos Grandes, Puna de Salta. BAR International Series, Argentina. Oxford.

Lynch, T.F., 1983. The Paleo-indians. In: Jennings, J.D. (Ed.), Ancient South Americans. W.H. Freeman and Co, San Francisco, pp. 87–137.

Markgraf, V., 1985. Paleoenvironmental history of the last 10,000 years in northwestern Argentina. Zentralblatt fur Geologie un Palaontologie 11, 1739–1749.

Markgraf, V., D'Antoni, H.L., 1978. Pollen flora of Argentina. The University of Arizona Press, Tucson.

Meltzer, D.J., 2003. Lessons in landscape learning. In: Rockman, M., Steele, J. (Eds.), Colonization of Unfamiliar Landscapes. The Archaeology of Adaptation. Routledge, London, pp. 222–241.

Morales, M.R., 2011. Arqueología ambiental del Holoceno temprano y medio en la Puna Seca Argentina. British Archaeological Reports. In: South American Archaeology Series, vol. 15. Archaeopress, Oxford.

Núñez, L., Grosjean, M., 1994. Cambios Ambientales Pleistocénico-Holocénicos: Ocupación Humana y Uso de Recursos en la Puna de Atacama (Norte de Chile). Estudios Atacameños 11, 11–24.

Núñez, L., Santoro, C., 1988. Cazadores de la Puna Seca y Salada del Área Centro Sur Andina (Norte de Chile). Estudios Atacameños 9, 13–65.

Núñez, L., Grosjean, M., Cartajena, I., 2005. Ocupaciones Humanas y Paleoambientes en la Puna de Atacama. Taraxacum: Instituto de Investigaciones Arqueológicas y Museo Universidad Católica del Norte.

Oxman, B.I., Yacobaccio, H.D., 2014. Pollen analysis of *Pastos chicos*: palaeoenvironmental and archaeological implications during the Holocene in the Dry Puna of Argentina. In: Kligmann, D.M., Morales, M.R. (Eds.), Physical, Chemical and Biological Markers in Argentine Archaeology: Theory, Methods and Applications, British Archaeological Research International Series. Archaeopress, Oxford (in press).

Pintar, E., 1995. Los conjuntos líticos de los cazadores Holocénicos en la Puna Salada. Arqueología 5, 9–24. Instituto de Ciencias Antropológicas, FFyL, UBA.

Ratto, N., Montero, C., Hongn, F., Randall, M., 2008. Gente y volcanes: el registro arqueológico de ambientes inestables del oeste Tiñogasteño de Catamarca (ca. 5000–1500 AP). In: Primeras jornadas de arqueología del área Puneña de los Andes centro-sur, Horco Molle, Tucumán, Argentina, pp. 113.

Richerson, P.T., Boyd, R., Bettinger, R.L., 2009. Cultural innovations and demographic changes. Human Biology 81, 211–235.

Roux, V., 2007. Ethnoarchaeology: a non historical science of reference necessary for interpreting the past. Journal of Archaeological Method and Theory 14, 153–178.

Ruthsatz, B., Movia, C., 1975. Relevamiento de las estepas andinas del noreste de la provincia de Jujuy. FECYT, Argentina.

Tchilinguirian, P., 2009. Paleoambientes holocenos en la Puna austral, Provincia de Catamarca (27 S): Implicancias geoarqueológicas. Ph.D. thesis. Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires.

Tchilinguirian, P., Morales, M.R., Oxman, B., Lupo, L.C., Olivera, D.E., Yacobaccio, H.D., 2014a. Early to Middle Holocene transition in the Pastos Chicos record,dry Puna of Argentina. Quaternary International 330, 171–182.

Tchilinguirian, P., Morales, M.R., 2013. Mid-Holocene paleoenvironments in Northwestern Argentina: main patterns and discrepancies. Quaternary International 307, 14–23.

Tchilinguirian, P., Morales, M.R., Oxman, B., Pirola, M., 2014b. Paleoenvironmental studies of the Quebrada de Lapao, Jujuy Province, Argentina (23° 22′ 01″ S, 66° 21′ 52,8″ W, 3650 m a.s.l.) for the 9400–7300 yrs B.P. span. In: Kligmann, D.M., Morales, M.R. (Eds.), Physical, Chemical and Biological Markers in Argentine Archaeology: Theory, Methods and Applications, British Archaeological Research International Series. Archaeopress, Oxford (in press).

Vuille, M., Hardy, D.R., Braun, C., Keimig, F., Bradley, R.S., 1998. Atmospheric circulation anomalies associated with 1996/1997 summer precipitation events on Sajama ice cap, Bolivia. Journal of Geophysical Research 103, 11191–11204.

Yacobaccio, H.D., 1994. Biomasa animal y consumo en el Pleistoceno-Holoceno Surandino. Arqueología 4, 43–71.

Yacobaccio, H.D., 2010. The Paleoindian and Archaic of Central and South America. In: Renfrew, C., Bahn, P. (Eds.), The Cambridge World Prehistory.

Yacobaccio, H.D., Catá, M.P., Solá, P., Alonso, M.S., 2008. Estudio arqueológico y físico-químico de pinturas rupestres en Hornillos 2 (Puna de Jujuy). Estudios Atacameños 36, 5–28.

Yacobaccio, H.D., Morales, M.R., Solá, P., Samec, C.T., Hoguin, R., Oxman, B., 2013. Mid-Holocene occupation in the Dry Puna in NW Argentina: evidence from the Hornillos 2 rockshelter. Quaternary International 307, 38–49.

Yacobaccio, H.D., Morales, M., 2011. Ambientes pleistocénicos y ocupación humana temprana en la Puna argentina. Boletín de Arqueología PUCP 15, 337–356.

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