Hakenasa Cave and its relevance for the peopling of the southern Andean Altiplano

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Researchers in the High Andes in northern Chile report the study of a fine cave sequence, supported by 19 radiocarbon dates. The initial occupation at c. *11 500 cal BP represents the earliest human occupation known at this altitude. The toolkit suggests a hunting (logistical) camp used to take advantage of the animals gathering in the rich wetland of the neighbourhood.*

Keywords: Chile, Andes, Altiplano, Late Pleistocene, 11 500 BP, logistical camp, lithic analyses

Introduction

The human colonisation of the earth's high plateaux took place towards the end of the Pleistocene in the Old World (Africa and Asia; Aldenderfer 2006, 2007), and during

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the Pleistocene–Holocene transition in the New World. The Andean Altiplano has been regarded as a marginal human habitat due to its low biological productivity, extreme temperature fluctuations and the negative biological effects of hypoxia (Aldenderfer 1998; Llanos *et al.* 2007). Yet today, it possesses considerable climate variability and cultural diversity, and its tropical region has witnessed the rise and fall of prominent civilisations (Binford *et al.* 1997).

The Altiplano of northern Chile, close to the southern border of the tropical belt, has lacked evidence of early human occupation, perhaps the consequence of unfavourable palaeoenviromental conditions, the conservation and visibility of the sites and/or the failure of the archaeological surveying tactics. Nevertheless, previous studies have not taken into account the palaeoecological variability or the complexities involved in the introduction and settling of human groups in previously uninhabited regions (Ingold 1987, 2000; Beaton 1991; Dixon 2001; Dillehay 2002; Kelly 2003; Steele & Rockman 2003; Jackson & Méndez 2004; Gaudin 2006; Santoro & Latorre 2009).

Here, we present a dated sequence including the earliest level of human occupation at Hakenasa, a cave located at 4100m asl in the Altiplano of northern Chile, in the Atacama Desert (17.5° S). The lithic technology allows us to propose that Hakenasa functioned as a logistical camp, considering its highly curated pattern, the occurrence of final stages of the lithic operational sequence and a medium frequency of lithic breakage (Binford 1979; Lemmonier 1991). A series of known, and new, radiocarbon and AMS dates indicate that this high Andean area was settled by the end of the Pleistocene (*c.* 11 500 cal BP). This coincided with an improvement in the previous harsh glacial conditions which then became considerably more favourable for human habitation than today (Moreno *et al.* 2009).

Hakenasa: palaeoenvironment

Hakenasa Cave is located at 4100m asl in the high Andean steppe of northernmost Chile at 17° 50′S, 69° 22′W (Figure 1). Situated along the northern slope of the Ancopujo canyon that drains into the Cosapilla or Caquena River, the site is at the base of a low ignimbrite cliff. The cave overlooks a high altitude wetland or *bofedal* in which vicuñas, rodents and birds abound (Figure 2). The associated plant communities are dominated by grasses and shrubs of the families Asteraceae and Solanaceae and are situated within the high Andean steppe (Villagrán *et al.* 1999). The climate is arid and rainfall, from summer convective storms, rarely exceeds more than 300mm/yr. Daily thermal amplitude is high at 10–20° C.

Moreno *et al.* (2009) recently summarised some of the most important impacts of regional past climate change by comparing the major cultural discontinuities at Hakenasa to the limnogeological record of Lago Chungará (located 40km south). In turn, two ice-cores collected from the summit of Nevado Sajama (55km from Hakenasa) record major changes in δ^{18}O along with anion concentrations and dust accumulation over the last 25 000 years (Thompson *et al.* 1998, 2000). Both records, along with lake level data from the Uyuni basin (Placzek *et al.* 2006) indicate that the climate was wetter and possibly colder (see also Betancourt *et al.* 2000; Grosjean *et al.* 2001; Blard *et al.* 2009) between 17 500 and 14 000 cal BP: the Tauca lake cycle. This was followed by a regionally extensive, submillenial-scale drought that took place around 14 000 cal BP (Latorre *et al.* 2006; Placzek *et al.* 2006;

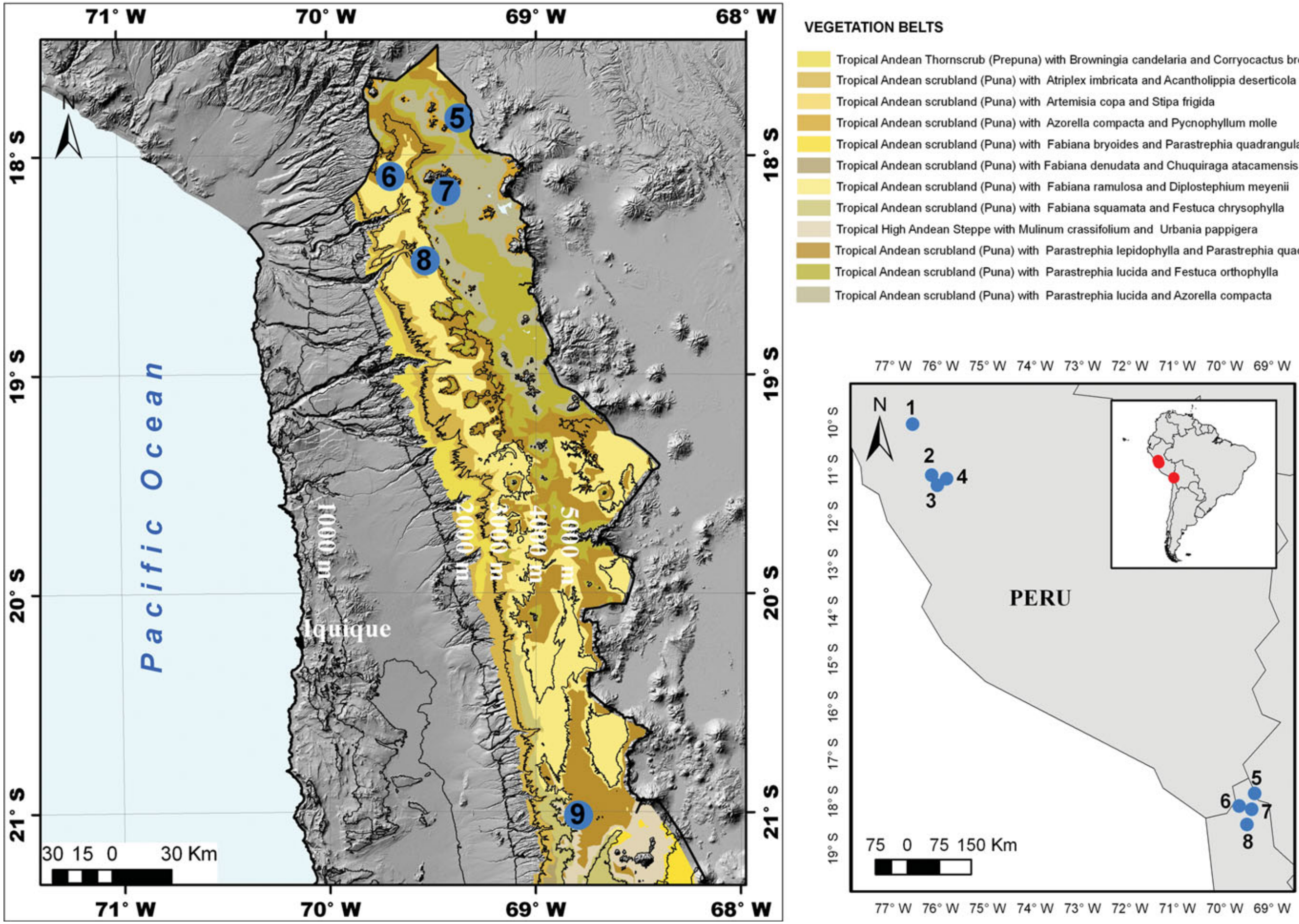

Figure 1. Location of Hakenasa Cave (5) and other related Pleistocene/Holocene archaeological sites in the Andean Altiplano in western South America: 1) Lauricocha; 2) Pachamachay; 3) Telarmachay; 4) Panaulauca; 6) Patapatane; 7) Las Cuevas; 8) Tojo-Tojone; 9) Quebrada Blanca.

Figure 2. Landscape surrounding Hakenasa Cave. The dominant shrubs in the foreground are Parastrephia quadrangularis (Asteraceae), typical of the high Puna (or Tolar). Note the bofedal *(marshy plain) in the background that likely offered better ecological conditions during the Pleistocene/Holocene transition.*

Placzek *et al.* 2009). These records also reveal that high lake levels returned to Salar de Coipasa along with decreased $\delta^{18}O$ values at Sajama between 13 000 and 11 000 cal BP, the Coipasa lake cycle. Lake levels remained high at Lago Chungará until 10 900 cal BP, after which the lake began to recede reaching a minimum by 7500 cal BP due to intense local drought (Moreno *et al.* 2009).

Sequence at Hakenasa

Hakenasa Cave is 5m deep and 7.8m wide, with a reduced current cave height of 1.2m due to the accumulation of cultural and natural strata which, at the time of excavation, was more than 2m thick (Santoro 1989; LeFebvre 2004; Moreno *et al.* 2009; Figure 3). Excavation defined 15 levels (Figure 4), from which 19 radiocarbon dates were obtained (Table 1).

The existence of wetter and warmer conditions and a more productive environment supported the oldest signs of human activity as evinced by three >11 000 cal BP AMS-dated hearths at the base of the stratigraphy (Table 1, level 13) (Moreno *et al.* 2009). The AMS date of 11 262–11 619 cal BP indicates that Hakenasa is the earliest known occupation site in the Altiplano of northernmost Chile (17°–22° S). There is no evidence of earlier human presence at the site because the excavation reached bedrock. After the first

Table 1. Conventional radiocarbon and AMS dates, including two new dates, from Hakenasa and other nearby Altiplano archaeological sites (>4000m asl). All dates are from charcoal.

Site	Level	Lab	Conventional radiocarbon age	Error	Cal max(5)	Cal min(5)	Median (cal BP)(6)
Hakenasa[1]	13	UGAMS 2953	9980	40	11 619	11 262	11 427
Hakenasa	13	UCIAMS 77762	9975	40	11 613	11 262	11 407
Hakenasa	13	UCIAMS 77761	9830	40	11 307	11 192	11 235
Hakenasa[2]	13	Beta187535	9580	40	11 107	10 741	10 934
Hakenasa[2]	12	Beta 187534	9520	70	10 630	10 588	10 858
Hakenasa[2]	11	Beta 187533	9260	60	10 577	10 257	10 435
Hakenasa[2]	11	Beta 187532	9170	70	10 515	10 219	10 349
Hakenasa[2]	10	Beta 187531	8789	60	9571	9563	9820
Hakenasa[4]	23	I-13287	8340	300	8572	8558	9288
Hakenasa[1]	10/9	Beta 219701	6960	50	7872	7683	7792
Hakenasa[1]	8/7	Beta 219700	6200	80	7273	6891	7095
Hakenasa[2]	7	Beta 187530	5140	70	5674	5664	5886
Hakenasa[4]	9	I-13230	4380	120	4763	4626	5008
Hakenasa[2]	6	Beta 187529	4270	70	4769	4581	4838
Hakenasa[2]	5	Beta 187528	3700	60	4164	3875	4041
Hakenasa[4]	4	I-13229	2850	280	3645	2334	3005
Hakenasa[2]	4	Beta 187527	2810	60	3078	2771	2920
Hakenasa[2]	3	Beta 187526	1860	60	1670	1624	1795
Hakenasa[2]	2	Beta 187525	1550	60	1316	1551	1447
Quebrada Blanca	3	Beta 139632	9610	70	11 181	10 738	10 949
Tojo-Tojone[3]	H1(3)	Gak 7958	9580	1950	16 502	6667	11 103
Las Cuevas[4]	8	I-12835	9540	160	11 240	10 412	10 865

[1]Moreno *et al.* 2009; [2]LeFebvre 2004; [3]Dauelsberg 1983, Hearth 1 from an exposed profile; [4]Santoro 1989, excavated with a different stratigraphy with 24 levels; [5]Calibrated at 2σ; [6]Calib 6.0, Intcal 09.

occupation (level 13), hunter-gatherers continuously used the cave as a base camp for *c.* four millennia, as reflected by complete operational sequences of lithic artefacts (Binford 1980), along with camelid, bird and rodent bones, with high anthropic breakage (levels 12–10, which encompass six ^{14}C dates ranging from 10 588–10 630 to 7683–7872 cal BP; Table 1) (Santoro 1989; LeFebvre 2004; Moreno *et al.* 2009).

The onset of extreme aridity is observed in the record from Lago Chungará sediment cores (7500 –6500 cal BP), which coincides with a stratigraphic cultural gap dated between 7792 cal BP (level 10/9) and 7095 cal BP (level 8/7) (Moreno *et al.* 2009). Afterwards, the cave was continuously re-inhabited until recent times from the interface of levels 8 and 7 dated 7095 cal BP to level 2 dated 1447 cal BP determined by eight ^{14}C dates (see Table 1 for all the radiocarbon dates of Hakenasa). This includes Late Archaic hunter-gatherers followed by pastoral societies that carried pottery, metal and bone goods, and who used the cave as a temporary camp and burial place (Santoro & Núñez 1987; LeFebvre 2004; Moreno *et al.* 2009; Núñez & Santoro 2011).

Within the regional chronological sequence, the initial record of Hakenasa extends to the beginning of the Early Archaic Patapatane phase from 11 500–11 000 cal BP. This phase is substantiated by sites such as Las Cuevas (4500m), Tojo-Tojone rockshelters (3800m)

Figure 3. Hakenasa Cave viewed from the south.

and the Caru (2500m) and Toquepala caves (2800m), which correspond to hunter-gatherer camps that shared the same projectile point morphology. The open camp Quebrada Blanca (4500m; Table 1) belongs chronologically to this phase, but with no diagnostic tools (Figure 1) (Santoro & Latorre 2009).

Techno-morphological analyses of lithic assemblages

To better comprehend the first occupation of Hakenasa in terms of site function and technological strategy, we define the operational sequences of the lithics (Binford 1980; Nelson 1991) through techno-morphological analyses (Bate 1971; Andrefsky 2005). From a total of sixteen 1 × 1m grids excavated in 2001, we selected six grids that were not affected by post-depositional processes (burial chambers). The full assemblage of 1284 lithic pieces from the earliest level (level 13) was examined. The techno-morphological analyses included identifying the raw materials as well as the trimming and reduction techniques of cores and blanks, type and size of debris, their platforms and flaking type (Andrefsky 2005). Other cultural data of level 13 includes intentionally fragmented and charred camelid and rodent bones with cut marks, currently under study. There are also scattered charcoal pieces and three well-defined hearths located on the bedrock from which we obtained the material that yielded the oldest AMS dates. No plant macrofossils were found. The lithic analyses reported in this study, however, can address the functionality of the site, which we present in the discussion and conclusions section.

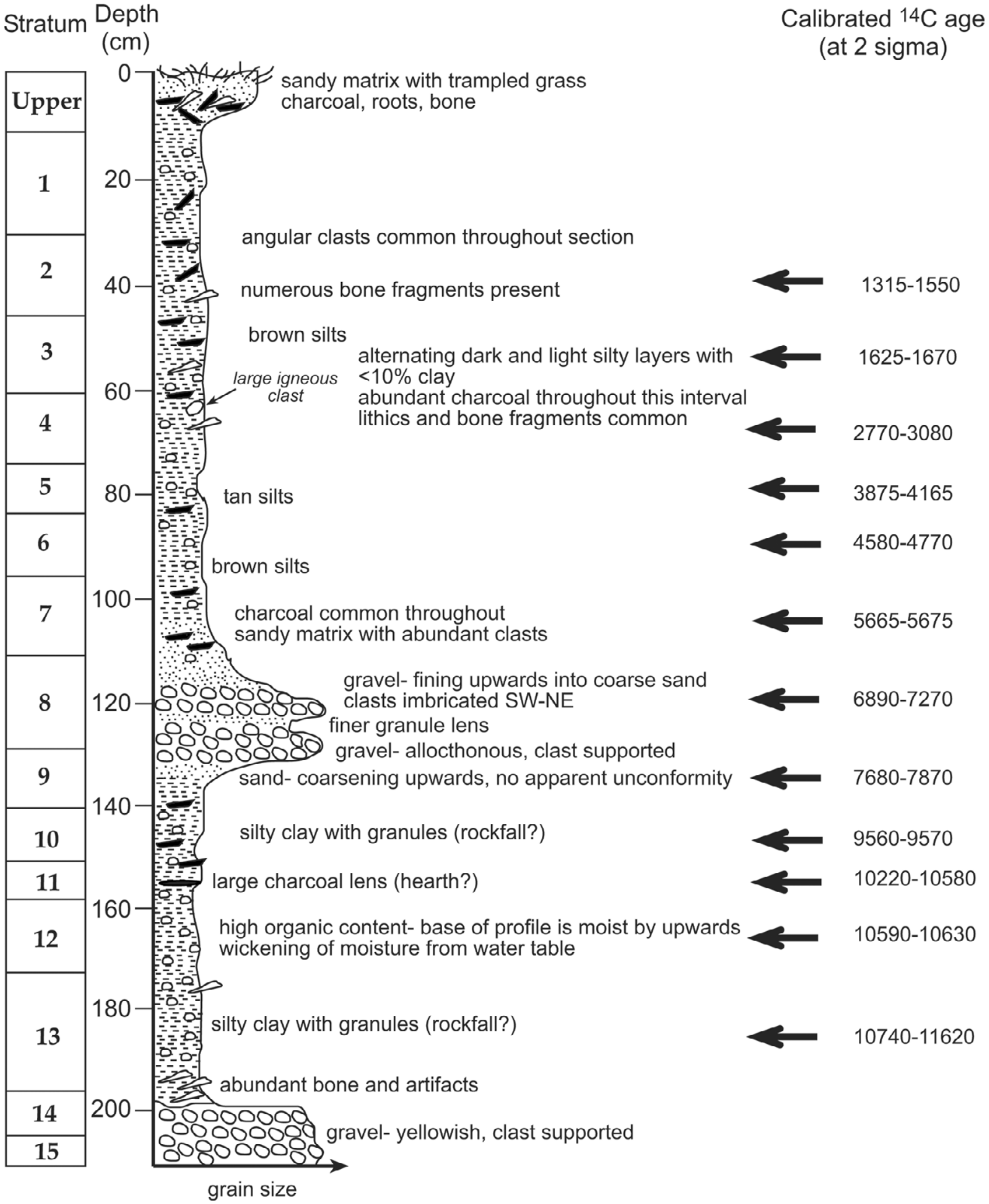

Figure 4. A stratigraphic profile of the excavated northern wall of Hakenasa Cave. The section spans the last 11 500 years cal BP. Note concordant transition to gravels at a depth of 1.4m and the lack of any visible sedimentary hiatus in the sequence (all dates are given as ranges at 2-sigma (see Table 1) and have been rounded to the nearest half decade).

A clear dominance of lithic debris (n=1246; 97%) over instruments (n=38; 3%) is apparent in the total number of pieces studied. The debris, mostly of silicate rock, shows a small range of sizes (Figure 5) and mostly corresponds to the resharpening of eroded cutting edges and final stages of artefact formalising, including generation of bifacial trimming

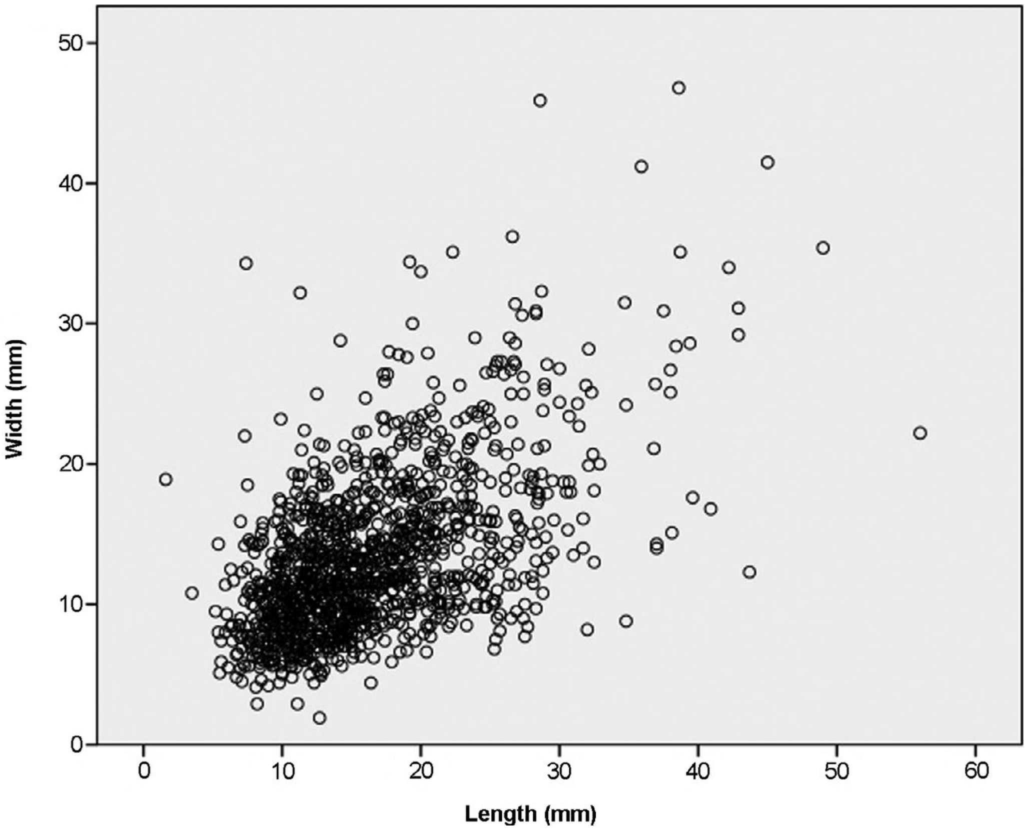

Figure 5. Scatter plot showing the distribution of the debris size (length and width). Note the large clustering of samples under 20mm.

flakes. These results match the reduced platform size (<4mm) and the low frequency of debitage with less than 50% of cortex in the dorsal surface (n=230; 18.4%) whereas all the other debris assemblages show no cortex at all (n=1054; 81.6%). Thus, we affirm that the first stages of instrument manufacture did not take place on site. An exception is the occurrence of a higher percentage of obsidian debris with cortex (n=87 from a total of 307; 28.3%) which agrees with the presence of a small exhausted obsidian core and few angular pieces — including both obsidian and silicate rock — that could be fragments of other exhausted cores from which flakes were obtained in the cave.

Regarding raw materials, the large amounts of debris reflect a preference for high quality lithic resources, especially silicate rock of varied tonalities (n=815; 65%) and obsidian (n=307; 25%), suitable for bifacial artefacts. Fair quality fine-grained rocks (basalt and others unidentified) are present in smaller quantities (n=124; 10%). These results are repeated among the tools, made mostly of silicate rock (n=21; 65.7 %) and obsidian (n=7; 18.4%). Consequently, the debris is a by-product of tool resharpening of eroded edges, both from bifaces and other instruments, including the final trimming of blanks.

An exploration of an 80km^2 area around Hakenasa on the Chilean side of the border revealed no obsidian or silicate rock sources which might, then be located on the Bolivian

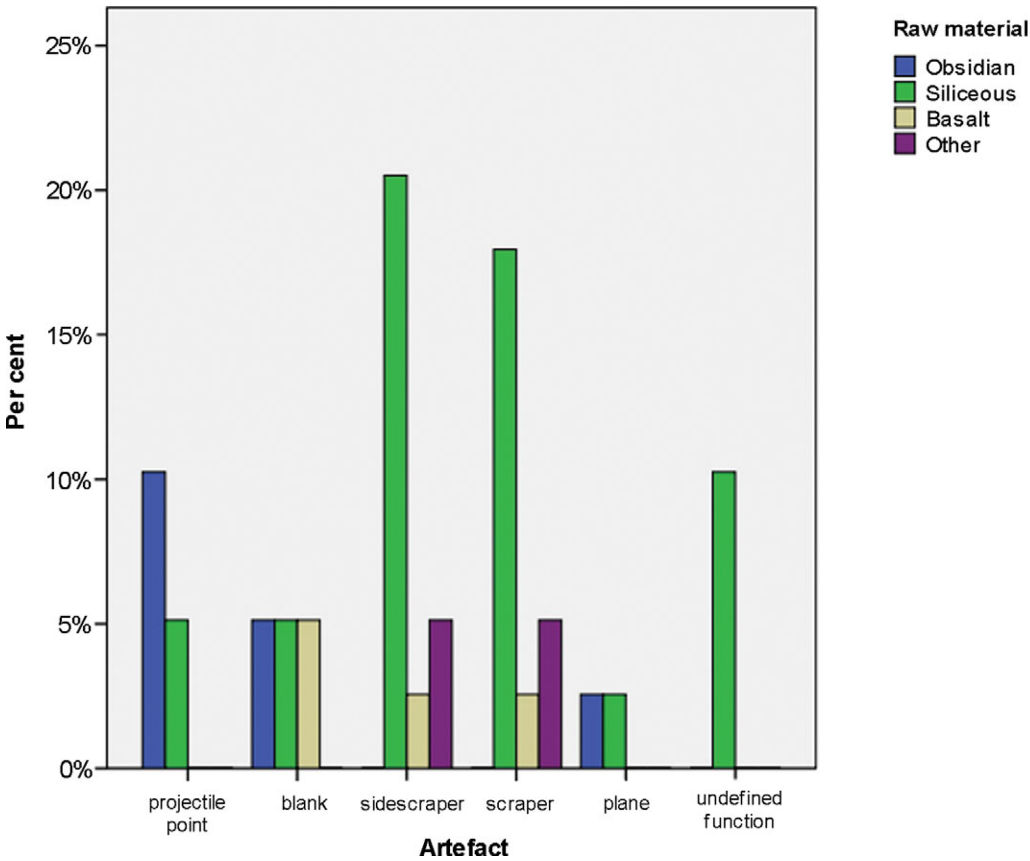

Figure 6. Tools classified according to raw materials from level 13 of Hakenasa Cave.

side (Hakenasa is right on the border). Nevertheless, small basalt nodules are found on the terraces and low hills near to the site. Further investigation is needed to localise the specific sources of the raw materials of Hakenasa.

The instruments (n=38; 3%) are highly formalised and show signs of considerable investment in time and effort in their elaboration (Figures 6 & 7). Projectile points (n=6) are triangular with convex or slightly concave bases, and lanceolate with constricting stem, similar to the typological models previously defined for the study area (Santoro 1989). The remaining instruments are semi-discoidal, trapezoidal and morphologically undifferentiated scrapers, besides small bifacial and unifacial side-scrapers, core tools similar to thick scrapers, bifaces and other tools of indefinable function (Figure 8). The projectile points, as well as some scrapers and side-scrapers, were intensely reworked and some pieces even evidenced signs of heat treatment.

Based on the small size of the artefacts and their degree of exhaustion, the scarcity of cores and the characteristics of the debris, we conclude that the inhabitants of Hakenasa gave more importance to the maximisation of high quality raw materials over refining those of medium or low quality. This could have been a consequence of a cultural pattern or, more likely, the fact that high quality raw materials were further away from the cave. Equally

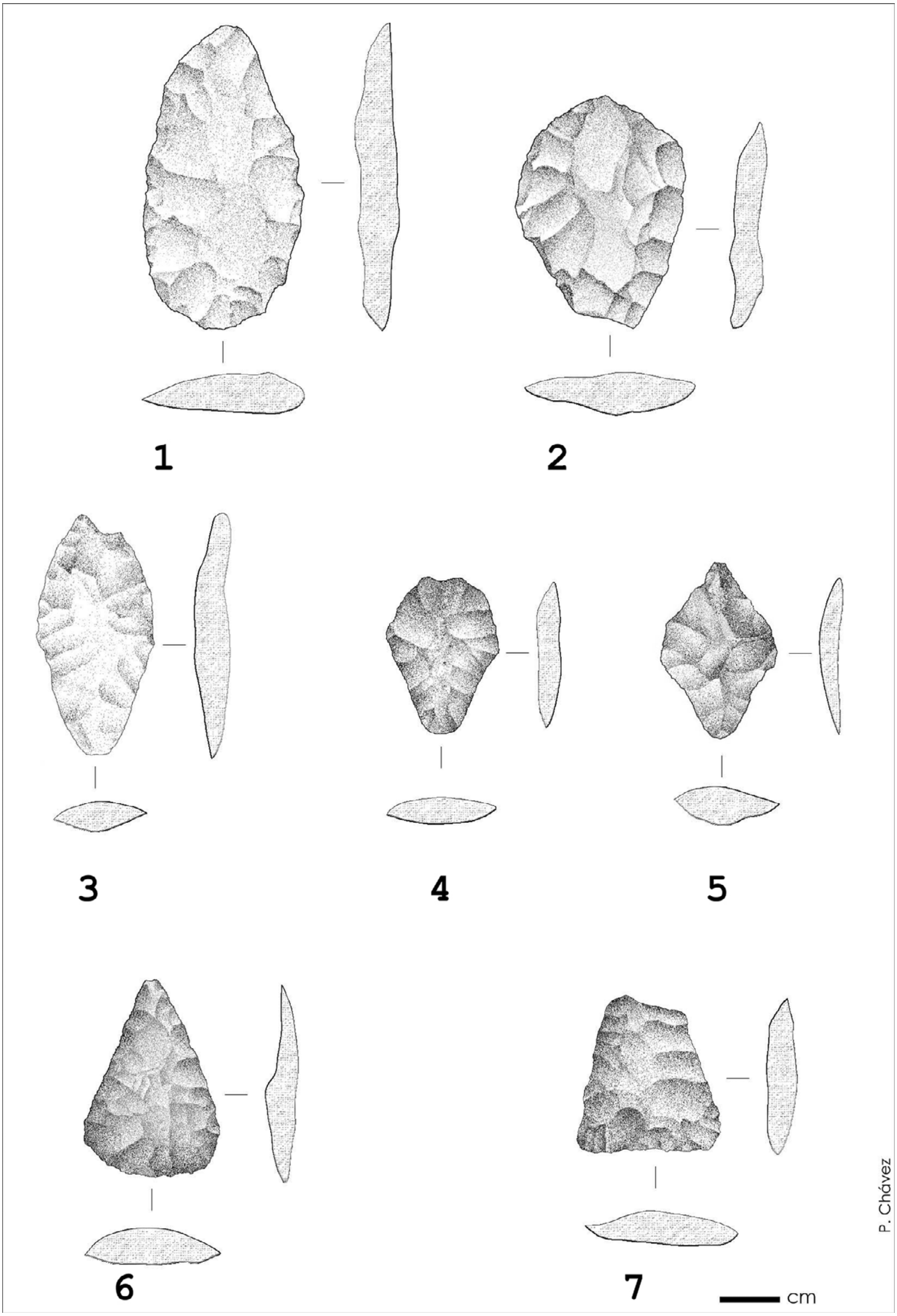

Figure 7. Lithic tools from level 13 of Hakenasa Cave: 1 & 2) blanks; 3–5) resharpened stemmed projectile points; 6 & 7) triangular projectile points with convex and straight base respectively.

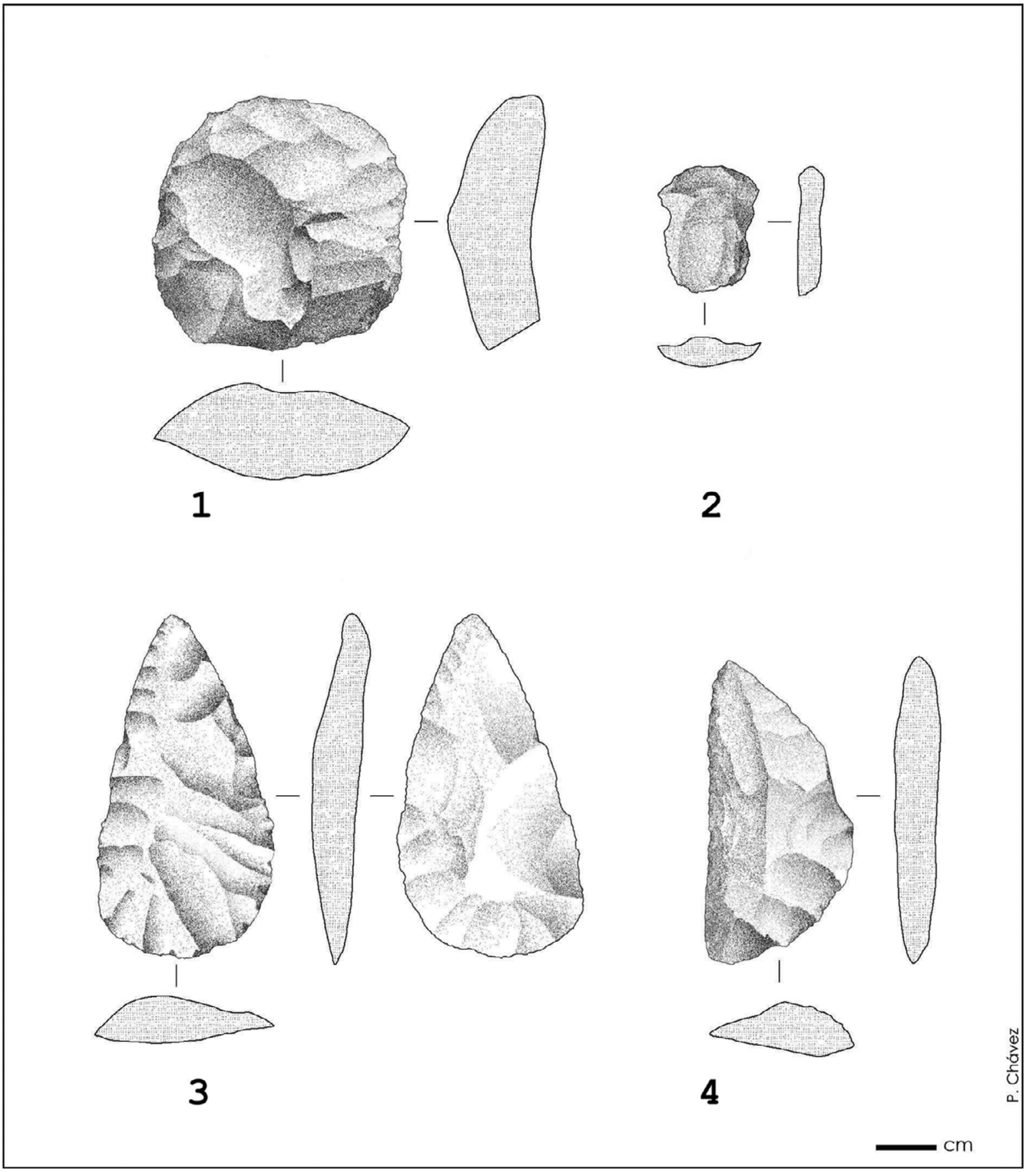

Figure 8. Scrapers (1 & 2) and side-scrapers (3 & 4) from level 13 of Hakenasa Cave.

important is the high amount of fragmentation of the instruments and the debris (51% & 41% respectively). The small size of the pieces with maximum lengths <60mm and with an average of 31.3mm, reflects the high level of tool exhaustion and the absence of elements linked to the different stages of lithic reduction, with the exception of the final trimming of some blanks. Consequently, the debris is the result of instrument resharpening, which is concomitant with the low frequency of maintained instruments, most of them repeatedly reworked, broken and discarded (i.e. a high degree of curation, in Binford's terms [1979]).

These characteristics may imply that the activities carried out at the site did not include tool making.

Discussion and conclusions

Previously, the earliest evidence for occupation of the Chilean Altiplano was at least 2000 years before the dates from Hakenasa reported here (Núñez *et al.* 2002). Sites earlier than Hakenasa such as Tuina-5, Tuina-1, Tulán-109, San Lorenzo and Salar de Punta Negra-1, situated in the Central Atacama (*c.* 22–24° S), are located at a lower altitude of <3000m (Núñez *et al.* 2002; Grosjean *et al.* 2005; Santoro *et al.* 2011). The archaeological evidence from the Altiplano of the Central Andes shows people beginning to live above 4000m asl after the latest Pleistocene. The Altiplano of the Peruvian Central Andes (9.5° & 11.5° S) exhibits earlier dates than those at our study site, which Aldenderfer (2006, 2007) averaged at *c.* 12 500 cal BP. This includes the sites of Telarmachay, Pachamachay, Lauricocha, Panaulauca and Ushkumachay (Cardich 1964; Rick 1980, 1983, 1988; Lavallée *et al.* 1995; Rick & Moore 1999). However, the earliest date from this area, from Telarmachay (14 209–13 581 cal BP), has been rejected by the excavators (Lavallée *et al.* 1995) as being too early. The other early date, from Pachamachay (16 682–11 601 cal BP) has a very large error at 2-sigma (11 800±930 BP) and so is possibly unreliable, but should be at least *c.* 11 600 years old (Rick 1980; Kaulicke 1980). Given this rather scant evidence, the Hakenasa site can help shed considerable light on the Late Pleistocene peopling of the high Andes.

The earliest level of Hakenasa (level 13), dated to *c.* 11 500 cal BP, constitutes the oldest evidence of human occupation of a high plateau environment above 4000m in the Altiplano of northernmost Chile. The absence of a complete lithic operational sequence suggests that this site was a logistical camp (Binford 1979; Bamforth 1986; Nelson 1991). Another slightly older site from the coast of southern Peru shows a similar pattern, but the occurrence of several habitation structures has been used to suggest that the site served as a base camp (Tanner 2001; Sandweiss 2008). The absence of constructions inside or outside the cave and the lack of cleaning behaviour regarding the final disposal of the lithic debris, however, also suggest that Hakenasa was a logistical camp. Another consideration is that, even though the climate for human habitation improved over previous conditions, when the area was subject to near glacial conditions it was still a harsh environment because of its high altitude. Thus, one can imagine that people used this habitat temporarily to take advantage of the faunal resources concentrated at Hakenasa, which is flanked by a rich wetland: the *bofedal*.

The characteristics of the artefact assemblage allow us to conclude that level 13 embodies a multiple tasks logistical camp, considering the relative diversity of bifaces, projectile points, scrapers, side-scrapers and planes, most of which are highly exhausted and possibly related to activities such as hunting, butchering, consumption and the preparation of animal skins. These activities are also observed in the bone assemblage, which is mostly composed of fragments of unidentified carbonised bones and some camelid and rodent bones with cut marks. A few bird bones show a cut pattern possibly corresponding to the manufacture of beads. No other materials beside lithics, bones and charcoal were found in this early level.

The operational sequence that only includes late phases of the lithic process is linked to the use of high quality and imported raw materials — obsidian and silicate rocks — taken to the site in the form of bifacial blanks and other formalised tools. These features are characteristic of a technological curatorial strategy that implies advanced planning to deal with inadequate resources such as a lack of good raw material and time for preparation, large energy and time investment in tool elaboration — before entering the cave — and maintenance, as confirmed by the constant resharpening of such tools (Nelson 1991). The curatorial strategy observed in Hakenasa seems to be a good response, within the framework of the foraging mobility model (Binford 1980), to anticipate the adverse conditions of the Altiplano, as it minimises the risk by guaranteeing an efficient return of calories (Aldenderfer 1998, 1999).

We note that the morphology of the toolkit, specifically the projectile points from Hakenasa, shows morphological similarities with other nearby sites such as Las Cuevas and Patapatane and, to a lesser degree, Tojo-Tojone (Dauelsberg 1983; Santoro & Núñez 1987; Santoro 1989; Figure 1). Particularly, ongoing analyses at Patapatane, Las Cuevas and Tojo-Tojone mostly show final stages of the lithic operational sequence and similar good quality raw materials, such as amorphous silica rocks, and a low amount of obsidian. Conversely, we observe a common pattern in lithic procurement and manufacturing among these early sites in the Altiplano of northern Chile, although we have not sourced the provenience of these raw materials. Moreover, the projectile point morphology and certain technological gestures observed in the manufacture of scrapers at Hakenasa are comparable to lithic assemblages from a series of sites along the high Andes in Colombia, Ecuador and Peru (Ravines 1967; Rick 1983, 1988; Santoro & Núñez 1987; Lynch 1990; Aldenderfer 1998; Kaulicke 1980; Lavallée 2000; Kelly 2003; Klink & Aldenderfer 2005).

In summary, the lithic evidence from the earliest occupation of Hakenasa is linked to the oldest human occupations of high Andean environments in western South America. This occupation took place after the regional climate improved considerably following the last local glacial maximum (*c.* 17–14 ka). Based on future palaeoecological work, we expect to discover new and different types of sites possibly contemporaneous with Hakenasa, such as residential camps and quarries. These may include buried landscapes and collapsed caves and rockshelters where earlier groups may have resided. The potential exists for thus documenting even earlier phases of human entry into the Altiplano.

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