# Palaeoindian occupation of the Atacama Desert, northern Chile

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ABSTRACT: Palaeoindian occupation of the Atacama Desert in northern Chile has been found between 12 600 and 10 200 cal. yr BP. The new site at Salar Punta Negra (24°28′S/60°53′W/2976 m) includes about 1000 classifiable, mostly unifacial artefacts and, uniquely, three different diagnostic types of early projectile points. Two of the Lateglacial/early Holocene projectile types have wide distribution and are known from different geographical areas in South America: the Palaeoindian 'Fell' fish-tail point mainly from the southern cone of South America, and the triangular 'Tuina' points typical of the Puna of the south-central Andes in northern Chile and northwestern Argentina. In addition, we found a third type, a stemmed point typical for the Salar Punta Negra. Filling a large geographical gap of 'Fell' occupation, the site at Salar Punta Negra provides evidence for generally much higher mobility and diversity of early cultures, and supports an Andean-Pacific route for early human exploration of South America to the south through the desert at intermediate altitudes. Contemporaneous high-amplitude climatic changes were fundamental preconditions to provide adequate environments and habitats, and to make Palaeoindian hunting-gathering occupation possible in the Atacama Desert.

KEYWORDS: Quaternary; Holocene; Andes; South America; climate change; archaeology; sedimentology; human dimensions.

## Introduction

The current knowledge about Lateglacial peopling of South America after ca. 14 600 calibrated $^{14}C$ years before the present (cal. yr BP; Dillehay, 1989) stems mainly on evidence from distinct lithic traditions with diagnostic projectile points. In general, these traditions had different spatial coverage in South America (Fig. 1). The classic Palaeoindian stemmed fish-tail 'Fell' points occur over large areas and are found associated with Pleistocene and modern fauna in low-elevation areas of northern South America and Peru, in the temperate grasslands, woodlands and Atlantic coastal areas of southern Brazil, Uruguay and the Argentinean Pampa, in inland basins of south-central Chile, and in Patagonia (between ca. 13 000 and 11 000 cal. yr BP; Núñez *et al.*, 1994, 2001; Borrero *et al.*, 1998; Gnecco, 2003; Flegenheimer *et al.*, 2003; Nami and Nakamura, 1995; Miotti and Salemme, 2003; Suarez and Lopez, 2003; Fig. 1; for the list of sites and references see the Appendix). The triangular 'Tuina' points associated with camelid hunters extend over the circum-Puna highlands of the south-central Andes in northern Chile and northwestern Argentina. They are Lateglacial/early Holocene in age, and are often found in open camp sites near or on shorelines of palaeolakes and palaeowetlands, or buried in rock shelters (between 13 000 and 9500 cal. yr BP; Aschero, 1983; Grosjean and Núñez, 1994; Núñez *et al.*, 2001, 2002).

Only recently, the contemporaneity of early lithic traditions in different parts of South America has been shown (e.g. Núñez *et al.*, 2001; Dillehay *et al.*, 2003), which stimulated rethinking of the relationship among the early traditions and the cultural adjustments that were necessary to occupy and exploit a wide range of habitats in different environments across large latitudinal gradients. For instance, the chronostratigraphy of the triangular 'Tuina' points from the north Chilean Andes and the Palaeoindian 'Fell' points in central Chile overlapped beween ca. 13 000 and ca. 10 500 cal. yr BP (Núñez *et al.*, 2001). The clear geographic separation of both lithic traditions served as an explanation why none of the known sites up to now have yielded both components together.

Much focus in this debate centers on the Atacama Desert, in particular the circum-Puna (Altiplano) areas of the south-central Andes, where evidence for Palaeoindian 'Fell' occupation has been lacking. It has been suggested that hostile environments in the Atacama Desert are the reason for a large gap in the 'Fell' distribution in South America (Núñez, 1983). However, recent palaeoenvironmental findings reveal that a significant swing to very favourable climatic and

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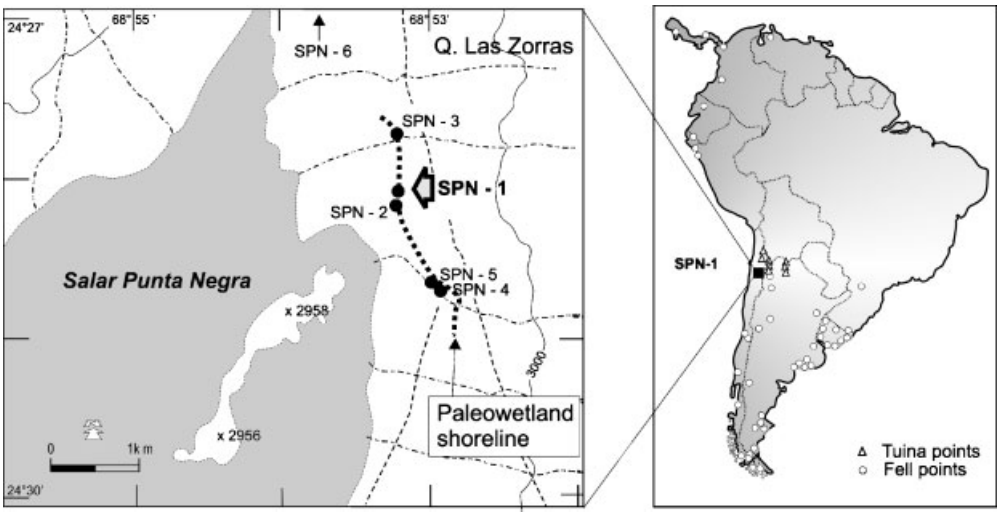


**Figure 1** Map showing the locations of SPN-1 and adjacent sites NE of Salar Punta Negra, and selected early sites of the 'Tuina' tradition (△) and the 'Fell' tradition (○) in South America. Key and references are listed in the Appendix

environmental conditions occurred at the time when the first hunters and gatherers came into this area about 13 000 cal. yr BP (Lynch, 1986, 1990; Grosjean, 1994; Grosjean *et al.*, 2001; Geyh *et al.*, 1999; Betancourt *et al.*, 2000; Núñez *et al.*, 2001, 2002; Latorre *et al.*, 2002; Rech *et al.*, 2002; Maldonado *et al.*, 2005), which in turn challenges the hypothesis of prohibiting environments for early occupation.

The newly discovered site at Salar Punta Negra in the middle of the Atacama Desert not only provides $^{14}$C dated evidence for the presence of the Palaeoindian 'Fell' tradition in the Atacama Desert, it also yielded an extraordinary collection of 964 unifacial artefacts typical of Palaeoindian assemblages of the southern part of South America, and provides evidence for the co-existence of the 'Fell', the 'Tuina' and a third group of artefacts characterised by stemmed points, called 'Punta Negra stemmed points' (first described by Lynch (1986)).

We first describe the modern environment of the site. Then we describe the lithic assemblage of the site and the archaeozoological remains, put this evidence into the local palaeoenvironmental and the regional palaeoclimatic context, discuss the possible palimpsests of an open archaeological surface site, and examine implications for the present knowledge about the early peopling of the Atacama Desert, in particular the new evidence for the Fell distribution in arid areas.

## Methods and materials

Although the Salar de Punta Negra was first systematically prospected by Lynch (1986), the surface sites Salar Punta Negra SPN-1, 4, 5 and 6 (24 °28′S/60 °53′W/2976 m) were discovered only in 2002 by Jay and Barbara Quade, University of Arizona. We systematically studied the sites during fieldwork in 2003 and 2004. This area belongs to the large open-pit copper mine, Mina Escondida, and is located in a sector that is currently heavily threatened by disturbance for water prospecting. The site itself has not been touched.

The archaeological material presented in this article reflects mostly the surface collection, which is, by the nature of open sites along palaeolakes or palaeowetlands in the Atacama Desert the most important part. Topography and surface artefacts of the core area of the site (30 × 41 m) were mapped in detail (grids of 1 m$^2$), adjacent areas were surveyed. Being aware of the limitations and potential problems associated with surface sites, we excavated one test pit (1 × 1 m) to examine the undisturbed stratified deposits to 10–20 cm depth, which revealed that the subsurface artefacts within the $^{14}$C-dated stratigraphy resemble typologically the surface collection, thus linking the buried findings with the surface collection.

The total manufactured lithic material was taxonomically classified according to morpho-functional and techno-typological criteria (Aschero, 1975). Microscopic analysis was used to search for traces of use. Petrographic classification helped to identify the provenance of the primary material.

All of the recovered bones belong morphologically to camelids. Despite the high degree of weathering and fragmentation, osteometric methods and data from regional archaeological sites and modern wild specimens (Cartajena, 2002) helped to distinguish between the larger *Lama guanicoe* and the smaller *Vicugna vicugna*. The range of osteometric data is diagnostic and does not overlap between the two taxa (Wing, 1972; Kent, 1982).

The local palaeoenvironmental reconstruction is based on the sedimentary facies description of $^{14}$C-dated profiles along an 8 m long trench next to the archaeological site and four nearby profile pits. Sedimentary environments were classified according to grain size, lithology, content of organic matter, presence of peat layers, remains of wetland vegetation and the habitus of diatoms (planktonic and epiphytic forms).

## Results and interpretation

### Site description and chronology

The site Salar Punta Negra SPN-1 (24 °28′S/60 °53′W/2976 m, Fig. 1) is a very large open site on the eastern border of the salt lake Salar Punta Negra, northern Chile. The site is located at the intersection of a late Pleistocene terrace with the large alluvial fan of the Quebrada de las Zorras. This currently dry valley (*quebrada*) used to convey water from the high cordillera around Volcán Lullaillaco (6739 m) to the Punta Negra area during the pluvial of the Pleistocene–Holocene transition. Today, the site is located in one of the driest areas of the Atacama Desert and receives less than 20–40 mm annual total precipitation mainly during austral winter. Except at the water

hole 'El Salobre' ca. 10 km to the south, surface water and vegetation is nowadays completely absent in the area.

The site covers 1476 $m^2$ of human occupation. Nine hundred sixty-four classifiable lithic artefacts were recovered, most of them on the surface. The core area of the site spans over 886 $m^2$, where 36 zones with more than five artefacts per square metre were mapped (Figs 2 and 3).

Geologically, the surface consists of diatomaceous silt, wetland and peat deposits that are covered with a thin gravel and artefact bed. The high concentration of surface artefacts suggests rapid use of large unifacial basalt flakes and intense occupation on a stable geologic surface. Wind erosion of the fine-grained sediment matrix may have resulted in the concentration of artefacts and a further development of the desert cover beds. Displacement of artefacts at the site is limited, the artefacts rather show a thin patina on their exposed sides. A test pit within the archaeological site revealed non-point artefacts that are typologically exactly the same as the surface artefacts, but intercalated with undisturbed peat and diatomaceous silt deposits down to 40 cm sediment depth (Fig. 4), encompassing radiocarbon ages for the human occupation between 12 600 and 10 200 cal. yr BP at that site (Table 1). The latter date indicates the maximum age for the end of the occupation. These dates resemble the typical age range of the 'Tuina', the 'Fell' and the 'Punta Negra' points (Núñez *et al.*, 2001, 2002; Lynch and Stevenson, 1992), and Lateglacial/early Holocene palaeowetlands in the Atacama Desert (Geyh *et al.*, 1999; Betancourt *et al.*, 2000; Rech *et al.*, 2002). The radiocarbon dates on bulk organic matter (mainly carbonised macrophytes, $\delta^{13}C$ between −23.3 and −24.6‰) are stratigraphically coherent, consistent with the date on *cortaderia* and consistent with the regional palaeoenvironmental history as developed from materials that are free of $^{14}C$-reservoir effects (Betancourt *et al.*, 2000; Latorre *et al.*, 2002). Therefore, we do not expect significant $^{14}C$ reservoir effects on the dating results from bulk organic sediments and consider the ages as reliable.

## Lithic assemblage and zooarchaeological remains

The collection of artefacts includes nine bifacial projectile points (1 'Fell', 3 'Tuina' and 5 stemmed points typical for the Salar Punta Negra, the 'stemmed Punta Negra point', first described by Lynch (1986), two bifacial and one unifacial knives, and an extraordinary number of 952 large unifacial flakes with peripheral retouch for rapid use (Figs 2 and 3; Table 2). Seven hundred and twenty of these are unifacial plano-convex knives, racloirs and scrapers with straight or convex edges, the remaining 232 are (semi) discoidal or elliptical unifacial scrapers and racloirs with lateral, frontal and all-edges retouch.

Basalt is available from an outcrop 20 km to the south. Basalt is the main material (67%) followed by andesite, dacite and rhyolite (16%), porphyritic aphanite (14%), obsidian, chalcedony, quartzite and volcanic breccia (3%).

Since obsidian is not locally available, interaction with the Puna highlands is suggested where, besides obsidian outcrops, favourable habitats for hunters were present during that time with large palaeolakes, extended grasslands and many animals

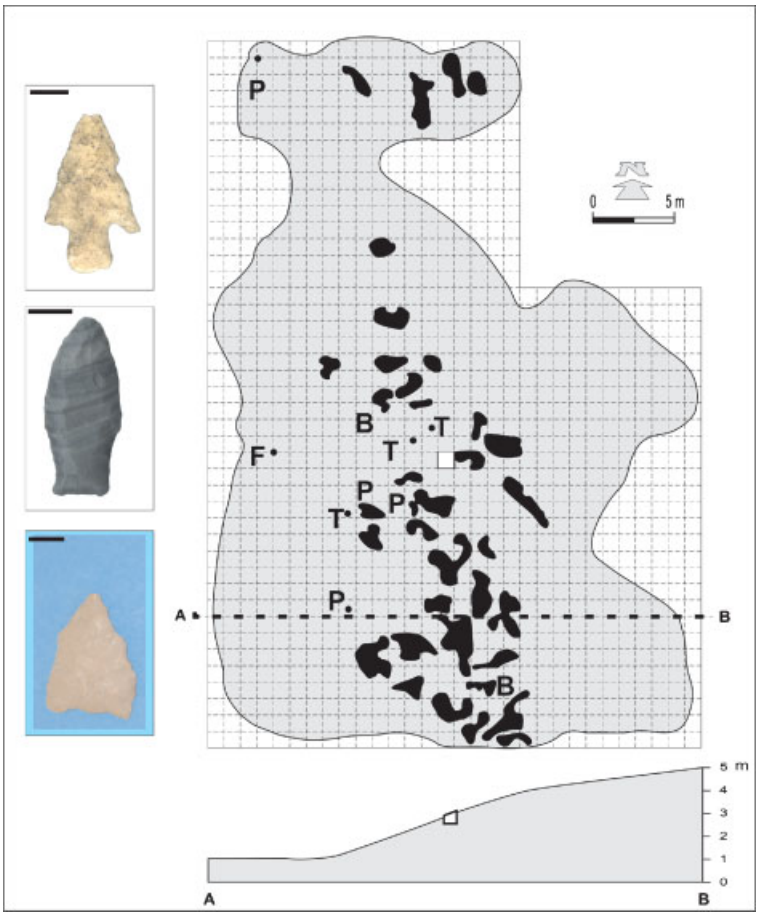


**Figure 2** Map and profile of SPN-1 showing the areas with 1–5 (shaded) and >5 (black) artefacts per square metre and the locations of the stemmed 'Punta Negra' points (P, photos Fig. 3(c); top picture), the 'Fell' point (F, middle picture), the 'Tuina' points (T, bottom picture), and the bifacial knives (B). The scale bars are 1 cm. The white grid in the centre of the site marks the test excavation (Fig. 4). Debris of exotic lithic material is not reported in this figure. This figure is available in colour online at www.interscience.wiley.com/journal/jqs


**Figure 3** Details of artefacts at SPN-1. (a) Elongated lanceolate uniface; (b) discoidal uniface scraper; and (c) stemmed 'Punta Negra' point

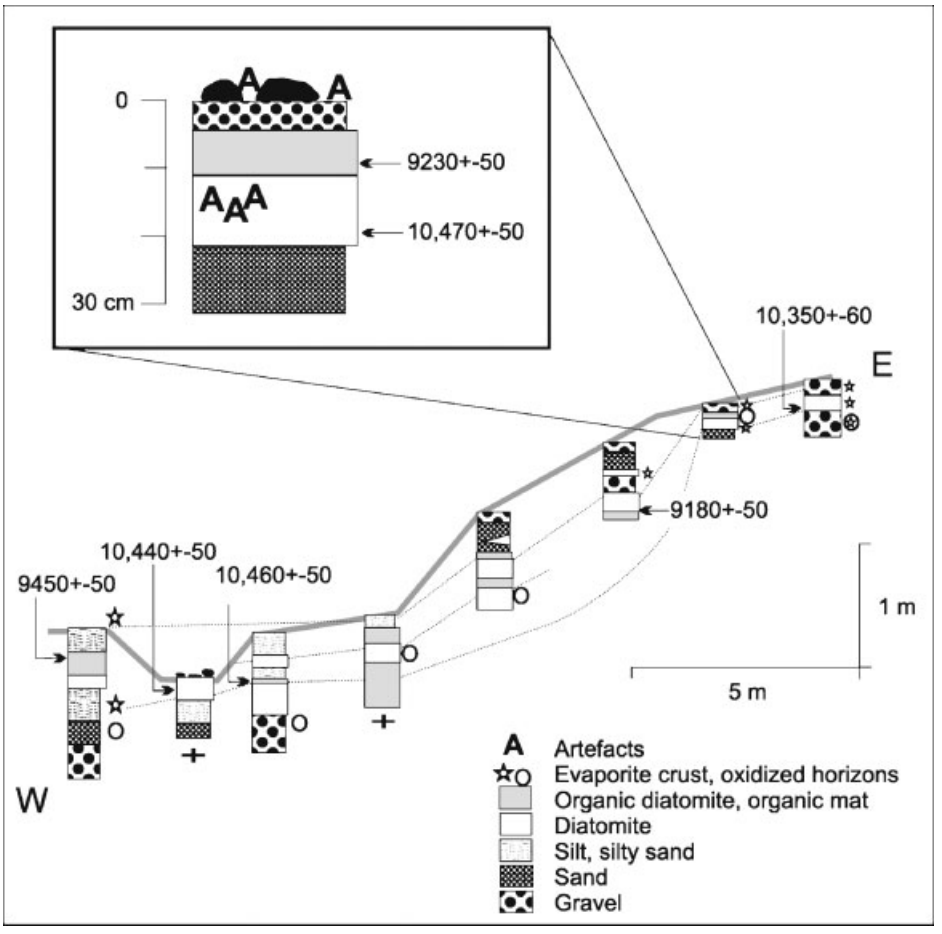


**Figure 4** W–E stratigraphic profile section and ages (in $^{14}$C yr BP) through the terrace 20 m south of the site SPN-1. The test pit (inset) from within the site is projected into the profile

(Grosjean *et al.*, 2001; Núñez *et al.*, 2002). The abundance of local basalt may have stimulated the use of non-point lithic tools as recorded in the extraordinarily large number of classifiable artefacts. The shaft materials are not known.

The archaeofaunal record revealed 109 bone fragments, 30 from the surface and 79 from test excavations. According to the osteometric data (Table 3), all specimens at SPN-1 belong to small camelids, very similar to those recorded at the early Holocene site of Tambillo-1 (see the Appendix) and to modern *Vicugna vicugna* (Cartajena, 2002).

Within the adjacent 3 km to the north and south along the border of the Punta Negra basin, five other spatially

**Table 1** Radiocarbon ages from Salar Punta Negra (*$^{14}$C AMS, **CALIB 4.4; 2004, Southern Hemisphere calibration curve; Poz, Poznan; B, Bern; Beta, Beta Analytic)

| Laboratory code | Sample (ID) | Site | Stratigraphy (depth, cm) | Material dated | $^{14}$C yr BP ($\pm 1\ \sigma$) | $\delta^{13}$C (‰) | cal. yr BP** (95% probability) |
|---|---|---|---|---|---|---|---|
| Poz-3274* | 1207C | SPN-1 | 20–25 | Peaty sediments | 9450 ± 50 | nd | 10 560–10 690 |
| B-8150 | 1208-P1 | SPN-1 | 40–45 | Peaty sediments | 10 460 ± 50 | −24.6 | 12 120–12 630 |
| B-8151 | 1208-P4 | SPN-1 | 60–65 | Peaty sediments | 9180 ± 50 | −23.9 | 10 220–10 380 |
| B-8152 | 1208-P5 | SPN-1 | 22–25 | Peaty sediments | 10 350 ± 60 | −23.6 | 11 940–12 340 |
| B-8153 | 1209 | SPN-1 | 5–10 | Cortaderia | 10 440 ± 50 | −23.7 | 12 110–12 620 |
| B-8154 | 1210-C | SPN-1 | 10–12 | Peaty sediments | 9230 ± 50 | −23.3 | 10 240–10 400 |
| B-8155 | 1210-D | SPN-1 | 18–20 | Peaty sediments | 10 470 ± 50 | −23.5 | 12 130–12 630 |
| Beta-191578 | SPN-6 | Q. Saltillo | 0–8 | Charcoal | 10 260 ± 60 | −25.9 | 11 700–12 280 |
| Beta-191579 | SPN-7 | El Salobre | 0–4 | Charcoal, feathers | 4360 ± 50 | −24.0 | 4830–4970 |

well-defined open sites were found (Fig. 1). These sites are in an environmental context identical to the one at SPN-1, i.e. absolute absence of water and vegetation today, while the only time window with local resources and possible human occupation was the Lateglacial/early Holocene humid period when wetlands were present at these sites. These sites contained the typical triangular 'Tuina' points and a typology of non-point artefacts similar to those from SPN-1. The only datable site (SPN-6) yielded a consistent $^{14}$C age on charcoal for the early occupation between 12 280 and 11 700 cal. yr BP (Table 1). The faunal remains ($n = 150$) of SPN-6 are highly weathered and represent exclusively camelids. Owing to the degree of weathering no osteometric data could be obtained. However, the size of 9 fragments suggests the presence of large camelids, probably *Lama guanicoe*, which again is in line with the existence of grasslands and wetlands at much lower elevations than today.

In order to assess the possibility of re-occupation at SPN-1 we looked for mid-Holocene sites and their cultural components in the Salar Punta Negra area. As expected from the regional palaeoclimatic history and the dynamics of human habitat formation (Grosjean *et al.*, 2005), the only mid-Holocene archaeological site SPN-7 currently known was found in a very different geomorphological and environmental context 20 km to the south of SPN-1 next to one of the very few still existing water holes 'El Salobre'. This water hole was most likely also one of the exceptional focal points for any life present during the arid mid-Holocene (after ca. 9000 cal. yr BP). This site SPN-7 is dated to between 4830 and 4970 cal. yr BP (Table 1). Although the site is already heavily disturbed by modern mining activities it reveals a concentration of non-diagnostic basalt artefacts associated with exposed fire places, feathers and bones of flamingo (*Phoenicopterus sp.*), in general with cultural components very different from those at SPN-1.

## Local palaeoenvironments and regional palaeoclimates

Alluvial and wetland sediments along a trench through the terrace at the site SPN-1 provide insight into the local palaeoenvironmental setting during Lateglacial and early Holocene times (Fig. 4). Basal subangular, poorly stratified sandy gravel beds suggest rapid sedimentation during severe events in a generally very dry regional climate prior to about 14 000 cal. yr BP (Grosjean *et al.*, 2001; Núñez *et al.*, 2002; Maldonado *et al.*, 2005). Stratified sand with banded diatomaceous silt intercalations were subsequently deposited in a marshland environment with fluctuating water tables. This marks the initial formation of extended wetlands around the site. Diatoms are epiphytic and epilithic, indicative of a broad variety of marshland microhabitats with stagnant water or gentle water flow. Water tables increased gradually and reached the terrace level with the site SPN-1 from 12 600 to 10 300 cal. yr BP. Banded to finely laminated carbonaceous diatomaceous silt deposits show Cyperaceae and root marks, and intercalations with peat layers indicating extended wetlands or shallow ponds. Diatoms are entirely epiphytic, no planktonic diatoms or other indicators of deep open lake water were found (C. Bigler, pers. comm. 2004). Erosive surfaces and oxidised horizons in the profiles suggest that the humid phase between 12 600 and 10 300 cal. yr BP was interrupted by one or more significant dry periods, which seems to be systematic in the area (Grosjean *et al.*, 2003). The end of the wetland environment at SPN-1 is younger than 10 200 cal. yr BP. Subangular cross-bedded gravel, sand and reworked slope material were deposited and evaporate crusts cemented the surface. With regard to the water supply for the site, we consider both a shallow aquifer in the alluvial fan, seepage and springs (mainly for the calm sedimentary environment) but also (seasonal) surface runoff from the highlands as possible explanations. Our dates of the wetland deposits coincide with the wettest period as inferred from fast-responding palaeoclimate archives (maximum precipitation 11.8–10.5 cal. kyr BP; Latorre *et al.*, 2002), suggesting that no long (of the order of $10^3$ years) response lags are involved.

In summary, the local palaeoenvironmental reconstruction provides evidence for very favourable habitats for the time of human occupation of that site (12 600 to 10 200 cal. yr BP). Water, abundant grasslands and wetland vegetation provided highly favourable habitats for camelids, and possibly also for birds and rodents.

This local reconstruction is very consistent with wetland deposits found in other parts of the Salar Punta Negra area (Geyh *et al.*, 1999) and the regional palaeoclimatic history. This region experienced large moisture changes during the late Quaternary. Of particular interest in the context of SPN-1 is the Lateglacial, early Holocene pluvial between ca. 14 000 to ca. 9000 cal. yr BP. A broad variety of palaeoclimate archives reveals that the environment at that time was drastically different compared with today. While the area is currently free of glaciers, the Lateglacial ELA was located at 4900 m and most of the high peaks including Vn. Lullaillaco were glaciated (Kull *et al.*, 2002). Large palaeolakes existed in the Altiplano and provided abundant habitat for flora and fauna (Grosjean *et al.*, 2001). The *quebradas* conveyed water from the highlands to the lower elevation areas such as Salar Punta Negra, regional groundwater tables were high and wetlands existed along spring complexes (e.g. Tarajne; Betancourt *et al.*, 2000) and in the distal areas of alluvial fans (Geyh *et al.*, 1999) between ca. 15 000 and 9000 cal. yr BP. Studies further suggest that

**Table 2** Lithic artefacts and raw materials

| N° | Attributes | | Maximum size (mm) | | | Basalt | Andesite, dacite, rhyolite | Aphanite porphyric (andesite, dacite, varicolor) | Aphanite | Chalcedony | Obsidian | Dacite, rhyolite | Basalt (porphyric) | Breccia | Rhyolite | Quarzite | Quarz | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Length | Width | Thickness | | | | | | | | | | | | | |
| 1. | Bifacial Tuina point | Triangular pattern | 36 | 25 | 6 | 1 | | | 1 | | | | | | 1 | | | 3 |
| 2. | Bifacial Fell point | Stemmed point, fish-tail pattern | 48 | 20 | 6 | | | | | | 1 | | | | | | | 1 |
| 3. | Bifacial Punta Negra point | Elongated stemmed point, convex edges | 73 | 30 | 11 | | | | | | | 2 | | | 2 | 1 | | 5 |
| 4. | Unifacial knife | Convergent edges, pressure retouch | 40 | 34 | 12 | | | | | | | | | | | | 1 | 1 |
| 5. | Bifacial knife | Convergent edges, pressure retouch | 55 | 30 | 13 | | | | | | 1 | 1 | | | | | | 2 |
| 6. | Big lanceolate uniface (Knives-racloirs-scrapers) | 6.1 Elongated plano-convex, retouched edges (limace or slug) | 91 | 32 | 11 | 17 | | | | | | | | | | | | 17 |
| | | 6.2 Elongated plano-convex, wide body, retouched edges | 73 | 44 | 12 | 13 | 5 | | 4 | | | | | | | | | 22 |
| | | 6.3 Asymmetrical plano-convex, retouched edges | 85 | 49 | 12 | 67 | | | 4 | | | 5 | | | | | | 76 |
| | | 6.4 Convergent asymmetrical, plano-convex, retouched edges | 88 | 55 | 16 | 68 | 3 | 4 | | 1 | 1 | | | | | | | 77 |
| 7. | Lateral uniface (Knives-racloirs-scrapers) | 7.1 Straight retouched edges | 116 | 88 | 22 | 122 | 15 | 17 | | 1 | | | | | | | | 155 |
| | | 7.2 Plano-convex, convex retouched edges | 111 | 88 | 22 | 224 | 27 | 16 | | | | | | 1 | | | | 268 |
| 8. | Anverse uniface (racloirs-scrapers) | Straight and convex retouched edges | 118 | 64 | 10 | 18 | | 2 | | | | | | | | | | 20 |
| 9. | Multilateral uniface (racloirs-scrapers) | Straight and convex retouched edges | 113 | 52 | 12 | 72 | 2 | | 10 | 1 | | | | | | | | 85 |
| 10. | Discoidal-elliptical uniface (racloirs-scrapers) | 10.1 Discoidal flake, thick, retouched edges | 68 | | 18 | 3 | 35 | 14 | | 1 | 1 | | 12 | | | | | 55 |
| | | 10.2 Discoidal flake, thin, retouched edges | 38 | | 8 | 18 | 50 | 47 | | | 4 | | | | | | | 119 |
| | | 10.3 Discoidal preform | 42 | | 13 | 4 | 7 | 4 | | 2 | | | | | | | | 19 |
| | | 10.4 Elliptical, quadrilateral, rounded, end flakes, retouched edges | 92 | 46 | 16 | 17 | 9 | 13 | | | | | | | | | | 39 |
| | | TOTAL | | | | 644 | 153 | 117 | 19 | 6 | 8 | 8 | 3 | 1 | 3 | 1 | 1 | 964 |

**Table 3** Osteometric data (mm) of Salar Punta Negra site SPN-1 surface collection (B, breadth; F, facies; C, caput; D, depth; GL, greatest length: p, proximal end; d, distal end; l, lateral; m, medial). **sensu* von den Driesch, 1999; **Cartajena, 2002

| Second phalanx (ant.) | Bp* | BFp | Dp | DFp |
|---|---|---|---|---|
| SPN-1 surface | 13.6 | 13.2 | 11.6 | (10.2) |
| *V. vicugna* (mean)** | 13.7 | 13 | 11.9 | 10.7 |
| (st. dev.) | 0.9 | 0.7 | 1.0 | 0.9 |
| Humerus | BC | | | |
| SPN-1 surface | 32.5 | | | |
| *V. vicugna* (mean) | 33.8 | | | |
| (st. dev.) | 3.5 | | | |
| Tibia | Bd | Dd | | |
| SPN-1 surface | (33.9) | (20.0) | | |
| *V. vicugna* (mean) | 33.4 | 22.8 | | |
| (st. dev.) | 3.0 | 1.6 | | |
| Talus | GLl | GLm | Dl | Bd |
| SPN-1 surface | 33.8 | (29.6) | 17.7 | 22.0 |
| *V. vicugna* (mean) | 33.2 | 30.6 | 18.5 | 22.2 |
| (st. dev.) | 1.9 | 2.2 | 1.2 | 1.3 |
| Metapodia | Bd | Dd | | |
| SPN-1 surface | 15.9 | 17.2 | | |
| SPN-1 surface | — | (17.3) | | |
| SPN-1 profile I18 | (16.3) | — | | |
| *V. vicugna* (Mc mean) | 15.2 | 16.7 | | |
| (Mc st. dev.) | 1.1 | 1.0 | | |

monsoon summer rainfall with continental moisture sources increased in the high cordillera by a factor of 2.5–4 to ca. 500–800 mm annually (Grosjean, 1994; Latorre *et al.*, 2002; Kull *et al.*, 2002), compared with ca. 200 mm today.

## Discussion

The site SPN-1 provides and excellent example of the close relationship between environment and human habitation, in this case by early Archaic hunters and gatherers in the Atacama Desert (Núñez *et al.*, 2002; Grosjean *et al.*, 2005). The palaeoenvironmental data suggest that there was only one distinct period of time (Lateglacial and early Holocene) with environments suitable for human occupation at the SPN sites we studied. During the mid-Holocene, environments were absolutely unattractive (Grosjean, 2001; Grosjean *et al.*, 2003, and discussion therein) or possibly even prohibitive for hunters. Exceptions are those particular sites around water holes where resources remained more stable through time. The nearest modern (and likely mid-Holocene) water hole and the closest known site (SPN-7) with mid-Holocene occupation is 20 km south of SPN-1, and in a very different microhabitat. In response to regional climate changes, wetlands around spring complexes or alluvial fans, and palaeolakes on the Altiplano disappeared around 9000 cal. yr BP (e.g. Tarajne Spring (Betancourt *et al.*, 2000); wetlands in Punta Negra (Geyh *et al.*, 1999; Grosjean *et al.*, 2003)). As a consequence of the changing environments, many early Holocene open sites were abandoned, new complementary habitats were created and occupied by hunters at different sites, mostly in newly formed wetlands in *quebradas* (e.g. Puripica and Tulan; Grosjean *et al.*, 1997; Betancourt *et al.*, 2000; Rech *et al.*, 2002). Or occupation persisted at those sites where resources remained stable, such as in large river valleys (e.g. Rio Loa) and springs (e.g. SPN-7) that are connected with large regional groundwater aquifers (Grosjean *et al.*, 2005).

The abundance of Lateglacial/early Holocene-age vicuñas at Tambillo-1 (see the Appendix), an early Archaic site with triangular Tuina points at 2500 m elevation in the Salar de Atacama (Cartajena, 2002), and in the Salar Punta Negra area at an elevation of 2900 m, suggests that vicuña habitats (i.e. grasslands) occurred at much lower elevations than today. This is very much in line with palaeobotanic evidence (Betancourt *et al.*, 2000; Latorre *et al.*, 2002; Maldonado *et al.*, 2005). These studies showed that the Gramineae belt decreased in elevation by more than 800 m, from the current 3900 m to below 3000 m during the period with enhanced tropical summer rainfall between 11 800 and 10 500 cal. yr BP. What is today absolute desert was an extended grassland at that time and provided abundant habitat for camelids and early hunters.

The assemblage and typology of the 1000 large unifacial flakes found at SPN-1 is very similar to the collections found in the typical Patagonian sites of Los Toldos, Ceibo and Fell suggesting that (i) SPN-1 resembles mostly the Palaeoindian 'Fell' pattern, and (ii) the solitary Fell point found at the surface of SPN-1 is most likely not a stray find but a logical component of the whole assemblage of the 1000 classifiable artefacts. This is interesting as the typical early site in the other sectors of Salar Punta Negra (SPN-2, -3, -4, -5, and 6; and those found by Lynch (1986)) and the numerous other early sites in the central Andes of the Atacama Desert (Núñez *et al.*, 2002) mainly resemble the 'Tuina' pattern. To our knowledge, SPN-1 is the first site in the circum-Puna area that assembles both the 'Tuina' and the 'Fell' traditions.

SPN-1 contains only an early lithic assemblage. Evidence for re-occupation, which has to be carefully investigated at surface sites, was not found. Indeed, the site SPN-7, which is 20 km to the south of SPN-1, shows that humans were regionally present during the mid-Holocene, i.e. after the abandonment of the early site SPN-1 after about 10 200 cal. yr BP. However, (i) the absence of mid- and late Archaic cultural components at SPN-1, (ii) the disappearance of wetlands from around 9500 cal. yr BP onwards, and (iii) the clear spatial definition of the site make mid- or late Archaic (ca. 9000 to 4000 cal. yr BP) re-occupation unlikely. On the contrary, since the concurrent presence in a broad sense of the 'Tuina', the 'Fell' and the stemmed 'Punta Negra' points is now established (Lynch and Stevenson, 1992; Núñez *et al.*, 2001), one would in fact expect co-existence of the three Lateglacial/early Holocene patterns.

In summary, the question now is why multi-component sites are so rare in South America. A few multi-component sites are known from Peru, where the early lithic Paiján tradition occurs in restricted near-coastal areas (ca. 12 800 to 11 400 cal. yr BP; Ossa, 1978; Chauchat *et al.*, 1998; Lavallee, 2000; Dillehay *et al.*, 2003; Fig. 1). In a few sites, co-existence of the Paiján and the Fell components has been found and debated (Ossa, 1976; Briceño, 1997; Chauchat *et al.*, 1998; Dillehay *et al.*, 2003).

## Conclusions

In the regional and continental context, the site SPN-1 is very particular in three ways. First, the site confirms unambiguously

the coexistence of different early lithic traditions, the 'Fell', the 'Tuina' and the 'stemmed point Punta Negra' traditions. The newly discovered site at Salar Punta Negra in the middle of the Atacama Desert provides $^{14}$C-dated evidence for the presence of the Palaeoindian Fell tradition in the Atacama Desert, and also reveals an exceptional collection of 964 unifacial lithic artefacts typical for Palaeoindian assemblages of the southern part of South America. The most significant, unprecedented discovery was the presence of both the 'Fell' and 'Tuina' projectile points, the latter being typical for this area, at the same site suggesting that the two groups and perhaps a third group with stemmed points coexisted in the same territory. This finding fills an important gap in the distributional pattern of the early traditions and provides evidence for an exploration corridor of the 'Fell' people along the Pacific border through the Peruvian–Chilean deserts to the south (Sandweiss *et al.*, 1998).

Secondly, the assemblage of these traditions at the same place makes this site fundamentally different from all of the more than 20 known early sites in adjacent but high elevation Puna palaeolakes environments (above ca. 4000 m) and intermediate shelter sites in *quebradas* (above 3000 m). These show exclusively the triangular Tuina tradition. Some 20 km to the south, surface artefacts including triangular and stemmed points similar to those at SPN-1 were previously found and dated to the Pleistocene–Holocene transition (Lynch and Stevenson, 1992). Based on the present knowledge, we hypothesise that the different traditions preferred different habitats at different vertically stacked ecological belts and/or in different climatic zones, whereby the wetland habitats at Salar Punta Negra seem to be a unique area of overlap and common sharing of resources.

Thirdly, why did the 'Fell people' inhabit the Salar Punta Negra? Certainly the climatic changes at the end of the Pleistocene and the formation of extended wetland habitats were a fundamental precondition for attracting Palaeoindians to particular sites where favourable resources were available in the Atacama Desert. We regard this as a clear example of the intrinsic relationship between late Quaternary climatic changes and responses of early cultures.

*Acknowledgements* We thank Jay Quade (University of Arizona) for having discovered the sites SPN-1, 4, 5, 6. We thank Christian Bigler (University of Umeå) for diatom analysis, and Antonio Maldonado (Universidad de la Serena) for pollen analysis. $^{14}$C dates (B-) were kindly performed at the Department of Environmental Physics, University of Bern (Thomas Stocker). Funding was provided by the Fundación Minera Escondida, NCCR Climate, and Universidad Católica del Norte. We thank Jay Quade, Julio Betancourt and Paul Baker for their careful reviews, Tom Lynch for comments on an earlier version of the manuscript, and Dan Sandweiss (University of Maine) and Tom Dillehay (Stanford University) for comments on the lithic collection.

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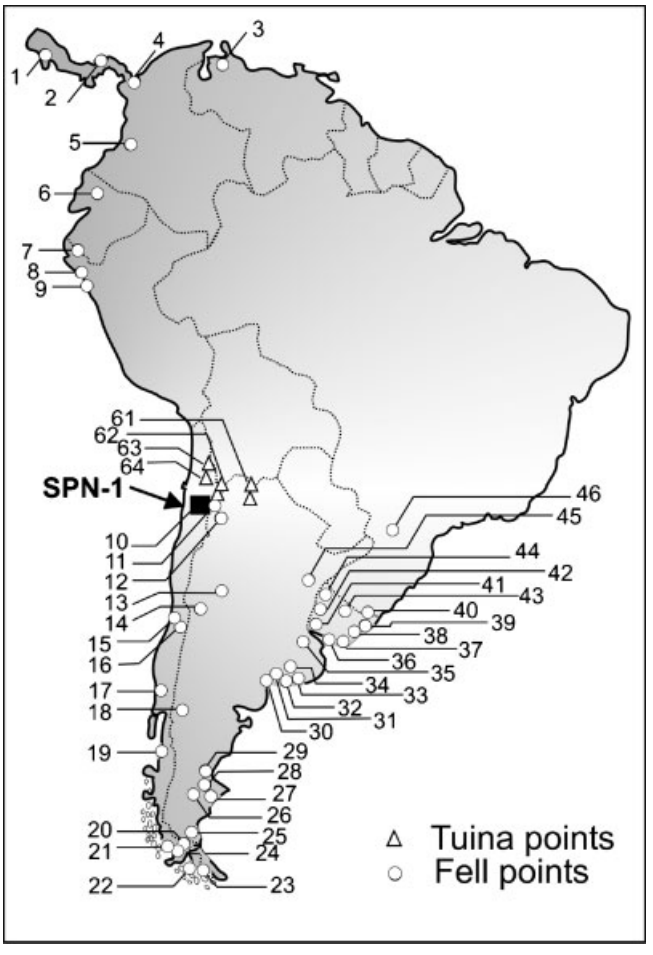
## Appendix

Map showing selected early sites of the 'Tuina' tradition (△) and the 'Fell' tradition (○) in South America. Legend and references are listed in the following table.



(a) Fell sites

| No. | Site | Country | Stratigraphy $^{14}$C yr BP | Associated fauna | Reference |
|---|---|---|---|---|---|
| 1 | Torrialba | Costa Rica | Surface | | (1) |
| 2 | Lago Madden | Panama | Surface | | (2) |
| 3 | La Hundición | Venezuela | Surface | | (3) |
| 4 | Bahía Gloria | Colombia | Surface | | (3) |
| 5 | La Elvira | Colombia | Surface | | (4) |
| 6 | El Inga, Cubilan | Ecuador | 10 300–9100 | | (5) |
| 7 | Piura Alto | Peru | Surface | | (6) |
| 8-a | Chicama-Cupisnique, Pampa de los Fósiles | Peru | Surface | | (7) |
| 8-b | PV-23–130 | Peru | Surface | | (8) |
| 8-c | PV-23–204 | Peru | Surface | | (8) |
| 8-d | Paiján | Peru | Surface | | (7) |
| 8-e | Santa María | Peru | Surface | | (8) |
| 9 | La Cumbre | Peru | Surface | | (9,10) |
| 10 | Salar Punta Negra-1 | Chile | 10 470–9230 | Modern | This study |
| 11 | Antofalla | Argentina | Surface | | (11) |
| 12 | Catamarca | Argentina | Surface | | (12) |
| 13 | Río Tercero | Argentina | Surface | | (13) |
| 14 | Crucecita | Argentina | Surface | | (14) |
| 15 | Tagua Tagua-2 | Chile | 10 190–9700 (3 dates) | Megafauna extinct | (15) |
| 16 | Santa Inés | Chile | Surface | | (16) |
| 17 | Temuco | Chile | Surface | | (13) |
| 18 | Río Limay | Argentina | Surface | | (13) |
| 19 | Aysén | Chile | Surface | | (17) |
| 20 | Cueva del Medio | Chile | 11 120–9595 (17 dates) | Modern and extinct megafauna | (18) |
| 20-a | Lago Sofía | Chile | 10 780–10 140 (5 dates) | Modern and extinct megafauna | (19) |
| 21 | Cueva Fell | Chile | 11 000–10 080 (3 dates) | Modern and extinct megafauna | (20) |
| 22 | Marazzi | Chile | | | (21) |
| 23 | Tres Arroyos-1 | Chile | 10 685–10 130 (10 dates) | Modern and extinct | (22) |
| 24 | Pali Aike | Chile | 8640 | | (20) |
| 25 | Abrigo de los Pescadores | Argentina | Surface | | (23) |
| 26 | Piedra Museo | Argentina | 12 890 (pre-Fell) 11 000–9710 | Modern and extinct megafauna | (24) |
| 27 | El Ceibo | Argentina | | | (25) |
| 28 | Los Toldos | Argentina | Possibly post 12 000 | Megafauna extinct | (26) |
| 29 | Caleta Oliva | Argentina | Surface | | (17) |
| 30 | Río Sauce Chico | Argentina | Surface | | (13) |
| 31 | Arroyo Pinto | Argentina | Surface | | (13) |
| 32 | Chasicó | Argentina | Surface | | (14) |
| 33 | Cerro La China-1 | Argentina | 10 790–10 730 | Fauna extinct | (27,28) |
| | Cerro La China-3 | Argentina | 10 720–10 610 (3 dates) | | |
| 34 | Cerro Sombrero-1 | Argentina | 10 725–10 060 (5 dates) | | (29,34) |
| 35 | Burucayá | Argentina | 10 000–9670 | | (30) |
| 36 | Cueva Brava | Argentina | 10 000–9670 | | (30) |
| 37-a | Abrigo los Pinos | Argentina | 10 465–8750 (4 dates) | | (31) |
| 37-a | Paso Otero 5 | Argentina | 10 440–10 190 (2 dates) | Megafauna | (32) |
| 38 | Cabo Polonio/Balizas | Uruguay | Surface | | (33) |
| 39 | Santa Teresa | Uruguay | Surface | | (14) |
| 40 | Buena Vista | Uruguay | Surface | | (33) |
| 41 | Paso Sena | Uruguay | Surface | | (33) |
| 42 | Paso del Puerto | Uruguay | Surface | | (33) |
| 43-a | Río Negro | Uruguay | Surface | | (33) |
| 43-b | Lago La Veras | Uruguay | Surface | | (33) |
| 44-a | Arroyo Boicua | Uruguay | Surface | | (33) |
| 44-b | Los Pinos | Uruguay | Surface | | (33) |
| 45 | Lobos | Argentina | Surface | | (13) |
| 46 | Itapiranga | Brazil | Surface | | (14) |

(b) Most important sites with triangular points of the 'Tuina' pattern

| | | | | | |
|---|---|---|---|---|---|
| 61a | Inca Cueva-4 | Argentina | 10 620–9230 (3 dates) | | (35) |
| b | Pintoscayoc-1 | | 9190–9080 (3 dates) | | (36) |
| c | Cueva Yavi | | 10 450–8320 (5 dates) | | (37,38) |
| d | Huachichocana | | 10 200–8930 (3 dates) | | (39) |
| 62a | Tulán-109 | Chile | 10 590–8960 | | (40,41) |
| b | San Lorenzo-1 | | 10 400–9960 (3 dates) | | (40,42) |
| c | Tambillo-1 | | 8870–8590 (2 dates) | | (40) |

| | | | | |
|---|---|---|---|---|
| d | Aguas Calientes I | | 8720 | (40) |
| e | Tuyajto 1 | | 8210–8130 | (40,43) |
| f | Tulán-67 | | 8190 | (40) |
| 63-a | Chulqui-1 | Chile | 9590 | (44) |
| b | Toconce | | 7990 | (43) |
| 64-a | Tuina-1 | Chile | 10 820–9080 | (40,45) |
| b | Tuina-5 | | 10 060–9840 | (40) |

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