



The initial peopling of Central Western Patagonia (southernmost South America): Late Pleistocene through Holocene site context and archaeological assemblages from Cueva de la Vieja site



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ABSTRACT

This article discusses new data on the initial peopling of Central Western Patagonia based on research conducted at the Cueva de la Vieja site (45°16'27" S; 71°32'24" W, 718 masl), contextualizing this event in the broader Pleistocene human dispersal of southernmost South America. Archaeological excavations and analyses at this cave site were undertaken to address the chronology of the initial settlement of the region, characteristics of the first human presence and subsequent site redundancy. This paper includes a description of the site context based on macro- and microscopic stratigraphy of the excavated section, the characterization of anthropogenic features and a comprehensive radiocarbon-dating program. Archaeological assemblages (i.e., lithics, bones and charred seeds) are used to explain the variations in the human occupation of this venue, with particular emphasis on the earliest materials and occupational surfaces as well as post-depositional processes. The occupation events at Cueva de la Vieja span the last 12,000 calibrated years and indicate, at this point, the earliest securely dated human presence in Central-Western Patagonia, at least one millennium after other thoroughly-dated sites toward the east. This suggests that the initial settlers must have occupied the eastern flank of the Andes at this latitude only after glaciers and other glaciogenetic features retreated and viable ecosystems emerged.

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1. Introduction

Patagonia (southernmost South America) was the last continental region to be settled during the dispersal of modern humans (e.g., Goebel et al., 2008; Gamble, 2013; Graf et al., 2013). However, this region should not be regarded as homogeneously settled, as it offers a wide range of environments and was the largest part of South America to contain glacial ice sheets. As such, it not only offered considerable challenges to late Pleistocene human dispersal, but also was one of the continental portions that experienced the most dramatic changes in landscapes during the last glacial termination (McCulloch et al., 2000). During the first

exploration/colonization process, human beings evaluated environments by moving through natural routes and selecting the most amenable locations (Borrero and Franco, 1997). In this sense, the peopling of this part of the world should not be viewed simplistically by merely quoting the isolated earliest dates in a plain framework but rather by considering the geographical and environmental differences throughout this macroregion, thereby introducing the possibility of more complex spatio-temporal ranking in the dispersal process. Accordingly, the study of the eastern Andean flank of Patagonia is significant, as it was under the influence of glaciers and glaciogenetic features such as proglacial lakes during the last glacial termination; it thus serves as an ideal location for understanding the timing of the initial human occupation of the last available landscapes in broader Patagonia.

Current evidence from Monte Verde II suggests human presence

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at 41°30'S west of the Andes at 14,600 calibrated years before present (cal BP) (Dillehay et al., 2008). However, the earliest securely dated human presence in Patagonia south of 43°S is approximately 13,000 cal BP (e.g., Steele and Politis, 2009; Prates et al., 2013; Waters et al., 2015), with the earliest sites located mainly in the Central Plateau of Santa Cruz, Argentina (e.g., Miotti and Salemme, 2003; Paunero, 2003a). With the exception of the Última Esperanza region (Martin et al., 2015), sites closer to the Andes are dated to later ages (Méndez, 2013; Prates et al., 2013). Borrero (2004) has suggested population cores located in the eastern steppes as the centers from which hunter-gatherers dispersed into the western Andes. These regions were shaped by glaciers during the last glaciation (Coronato et al., 1999; McCulloch et al., 2000) and developed viable ecosystems later than the zones to the east, which were characterized by rich biota during the late Pleistocene (Miotti et al., 1999).

This paper summarizes recent research conducted at the Cueva de la Vieja, a small cave site to the east of the Andes in Central-Western Patagonia (CWP; 44° to 49°S). Systematic stratigraphic excavations yielded material evidence for human activities starting at 12,000 cal BP and subsequent redundant and intermittent occupations at the same locale until the twentieth century. It is currently the earliest securely dated site in the region. Site formation processes, their archaeological context and material assemblages are analyzed to characterize technological choices, the activities conducted at the site and the occupation timespan. This dataset is then compared to similarly radiocarbon-dated sites in the broader region of CWP, which are used to build an image of the intensity and space hierarchy for the initial settlement of marginal areas in Patagonia.

2. Regional setting

CWP is located along the Andean mountain range to the west of southernmost area of South America (Fig. 1). The Andes produces an accentuated west-to-east precipitation decrease as result of the forced subsidence of the Southern Westerlies (Garreaud, 2009). Therefore, precipitation in this area ranges from ~3500 mm on the Pacific coast to 450 mm near the Chilean-Argentinean international border. Likewise, abrupt vegetation changes occur along an ~100 km gradient, including evergreen forests at the western slope and deciduous forests, a forest-steppe ecotone and grass steppes at the lee side of the Andes (Luebert and Plischoff, 2006).

During the last glacial period, the Andes featured glaciers which shaped extensive sedimentary plains and fluvio-glacial valleys to the east (McCulloch et al., 2000). Ñirehuao is one of several east-west river valleys in CWP excavated by Pleistocene glacial expansions, as indicated by well-developed moraine landforms (Méndez et al., 2013, 2017). A series of tertiary lapilli tuff and pyroclastic breccia buttes (Baño Nuevo volcanic complex) of 720 masl in average stand out (Suárez et al., 2007) in this otherwise open, smoothly rippled terrain. Ice retreat at Ñirehuao, as well as other valleys, was characterized by ice front stabilizations and the formation of regional scale proglacial lakes (de Porras et al., 2012; Méndez et al., 2013). Holocene fluvial erosion reshaped moraines and other glacio-lacustrine deposits.

There are currently no local sedimentary records for climate reconstruction in the Ñirehuao valley. However, the closest available records, such as those in the Cisnes river valley, help to project the timing and characteristics of deglaciation. Available records suggest that the easternmost portions of Andean valleys would have been free of ice around 19,000 cal BP (Markgraf et al., 2007; de Porras et al., 2012), with cold and dry conditions persisting until 14,800 cal BP, when tree taxa pollen started a steady rise at the El Shaman sedimentary core located in the forest steppe ecotone,

95 km north of Ñirehuao (de Porras et al., 2012). The increase in effective moisture, and possibly warming, occurred in a step-wise process as suggested by the combined information of this and other coring sites located within the deciduous forest (Markgraf et al., 2007; de Porras et al., 2012, 2014). Comparisons with modern plant assemblages suggest that the forest steppe ecotone was established east of the Andes by approximately 11,500 cal BP (de Porras et al., 2012). Drier summers promoting burnable biomass and the presence of human beings may have led to an increase in fire activity by that time (Méndez et al., 2016). Most proglacial lakes would have already been drained and east-west river valley systems would have been developing.

Archaeological research at the Ñirehuao valley has long focused on the study of Baño Nuevo 1, a cave site in the volcanic complex (Mena et al., 2003). This site was occupied between 11,100 and 3000 cal BP (Mena and Stafford, 2006) as a campsite by mobile hunter-gatherers, as indicated by long-distance obsidian transport (Méndez et al., 2012) and broad spectrum steppe-based diets reflected in archaeofaunal assemblages and stable isotope markers of human bone remains (Velásquez and Mena, 2006; Mena, 2009; Méndez et al., 2014). The most remarkable feature at the site is the remains of 10 individuals of various ages and both sexes whose direct dates (N = 7) overlap at 2-sigma between 10,180 and 9920 cal BP (Reyes et al., 2012).

Based on the assumption that rock shelters of the Baño Nuevo volcanic complex were ideal locations for stratigraphic deposits created upon glacier retreat, we conducted excavations at Cueva de la Vieja (45°16'27''S, 71°32'24''W, 718 masl; Fig. 2), a cave site located 2.23 km NW of Baño Nuevo 1 site. Because this site provided very limited sheltered area for activities (<20 m² in from dripline) and has high exposition, the initial expectation was that material evidence will indicate highly transitory, short-span, low-impact use by only a handful of occupants per event.

3. Materials and methods

The excavations at Cueva de la Vieja were carried out during three field seasons (between 2012 and 2014) across ~11 m² in the center and rear end of the cave (Fig. 3). Distinctive stratigraphic units were recognized through the excavation of 5 cm artificial levels. The tridimensional positioning of all features and material evidence greater than 1 cm was recorded to understand their horizontal relations. Sediments were sieved with 2.0 mm mesh. Sediment samples were recovered for flotation from each hearth feature and from two columns on units C3 and C4 (Watson, 1976). Only charred seeds and fruits were quantified in the carpological analysis (Miksicek, 1987).

The northeastern stratigraphic section on unit C3 was described using macroscopic properties such as color, structure, texture and compaction. A total of 11 sediment samples were obtained at ~10 cm intervals to measure grain size (Malvern Sedigraph), gravel fraction (by sieving), pH value (SANXIN model PHS-3D-02) and total carbon (%TC, by loss-on-ignition). Additionally, seven undisturbed samples for micromorphological analysis were collected (Fig. 4). These samples were air-dried, impregnated with polyester resin, polished to produce a 25–30 µm-thin section and mounted on a glass slide for analysis under a petrographic polarizing microscope following standard protocols (Bullock et al., 1985; Stoops et al., 2010). The mineralogical analysis consisted of counting minerals at five equidistant spots (10×) along each slide.

Sixteen AMS radiocarbon (¹⁴C) dates were used to establish the chronology of human occupations and to understand site formation processes. All dates discussed in this paper were calibrated into years before present (cal BP) with Calib 7.0.4 (Stuiver et al., 2013) using the ShCal13 curve (Hogg et al., 2013) and are expressed in 2σ

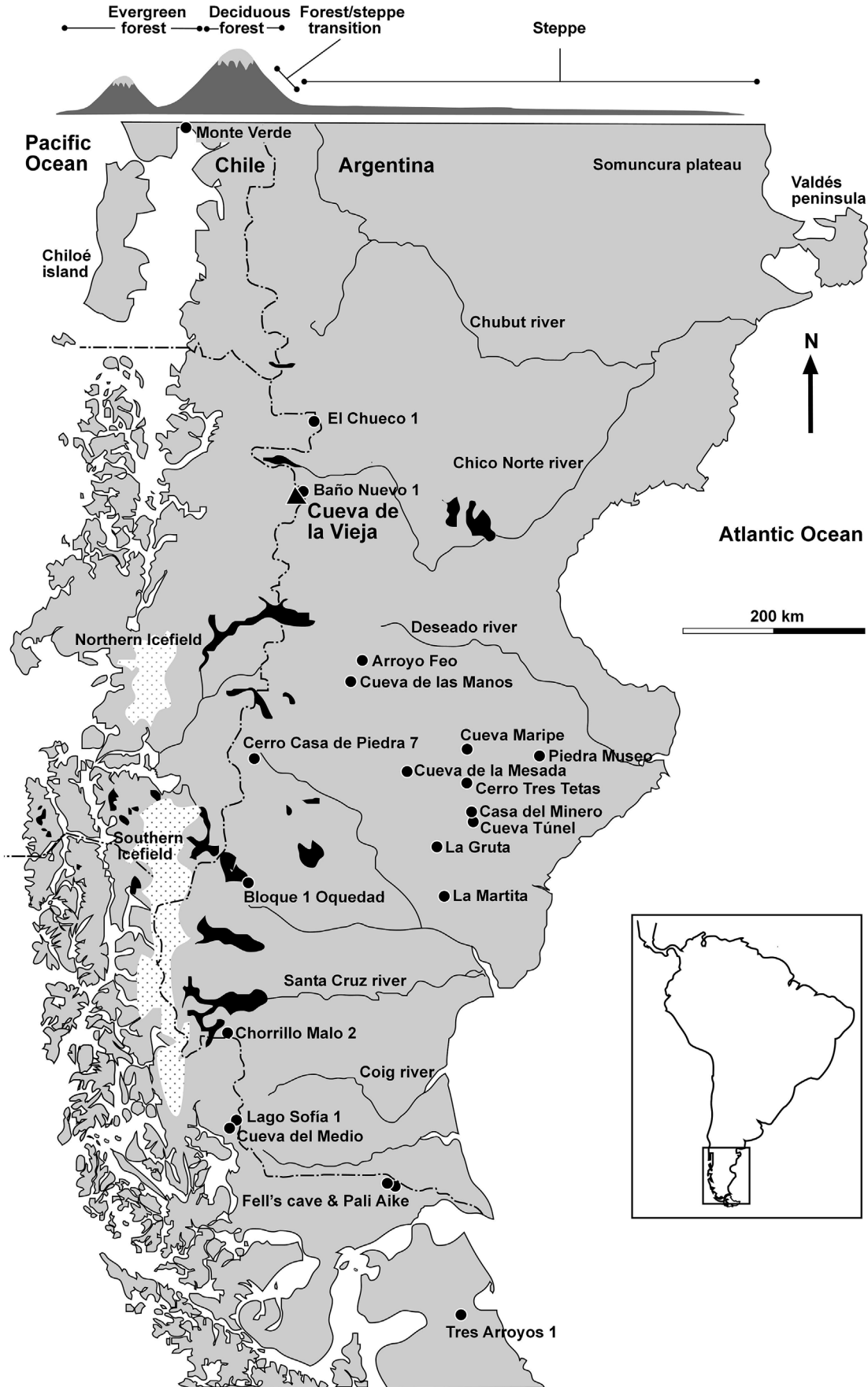


Fig. 1. Map of the Patagonia (southernmost South America) depicting sites earlier than 10,500 cal BP, areas mentioned in the text, and schematic cross-section at 45°S (top).



Fig. 2. Cueva de la Vieja site; (A) Overview of the cave; (B) excavations of the east sector (2014).

ranges. For comparative purposes, whenever two or more of these dates and others in the region were statistically indistinguishable at $\alpha = 0.05$, they were averaged (Ward and Wilson, 1978) to avoid overestimating the chronological signature and to provide calculated occupational events at the site level (Méndez, 2013).

Anatomical and taxonomical analyses of the archaeofaunal record were performed using reference collections (Universidad de Chile) and the available literature in the case of rodents (Mann, 1978; Patton et al., 2015), which were mainly classified at an Order level. Remains were quantified following measures of taxonomical and anatomical abundance, such as the Number of Identified Specimens (NISP) and the Minimum Number of Individuals (MNI) per taxa (Binford, 1981; Grayson, 1984; Lyman,

1994) (Binford, 1981; Grayson, 1984; Lyman, 1994). Weathering stages (Behrensmeier, 1978) were only considered for mammals >1 kg. Modifications of microfaunal remains by natural predators were classified (Andrews, 1990) and traces from fire exposure were recorded (López et al., 2012).

Lithic material was analyzed using technological criteria that focused on assessing the completeness, the cortex index, tool and debitage classes and specific descriptive design attributes (Méndez, 2015). Quantifications distinguished between “valid” counts and “fragments”, considering all complete pieces and those bearing platforms within the former group (Andrefsky, 1998). Raw materials were identified at a macroscopic level and grouped by knapping quality (Aragón and Franco, 1997).

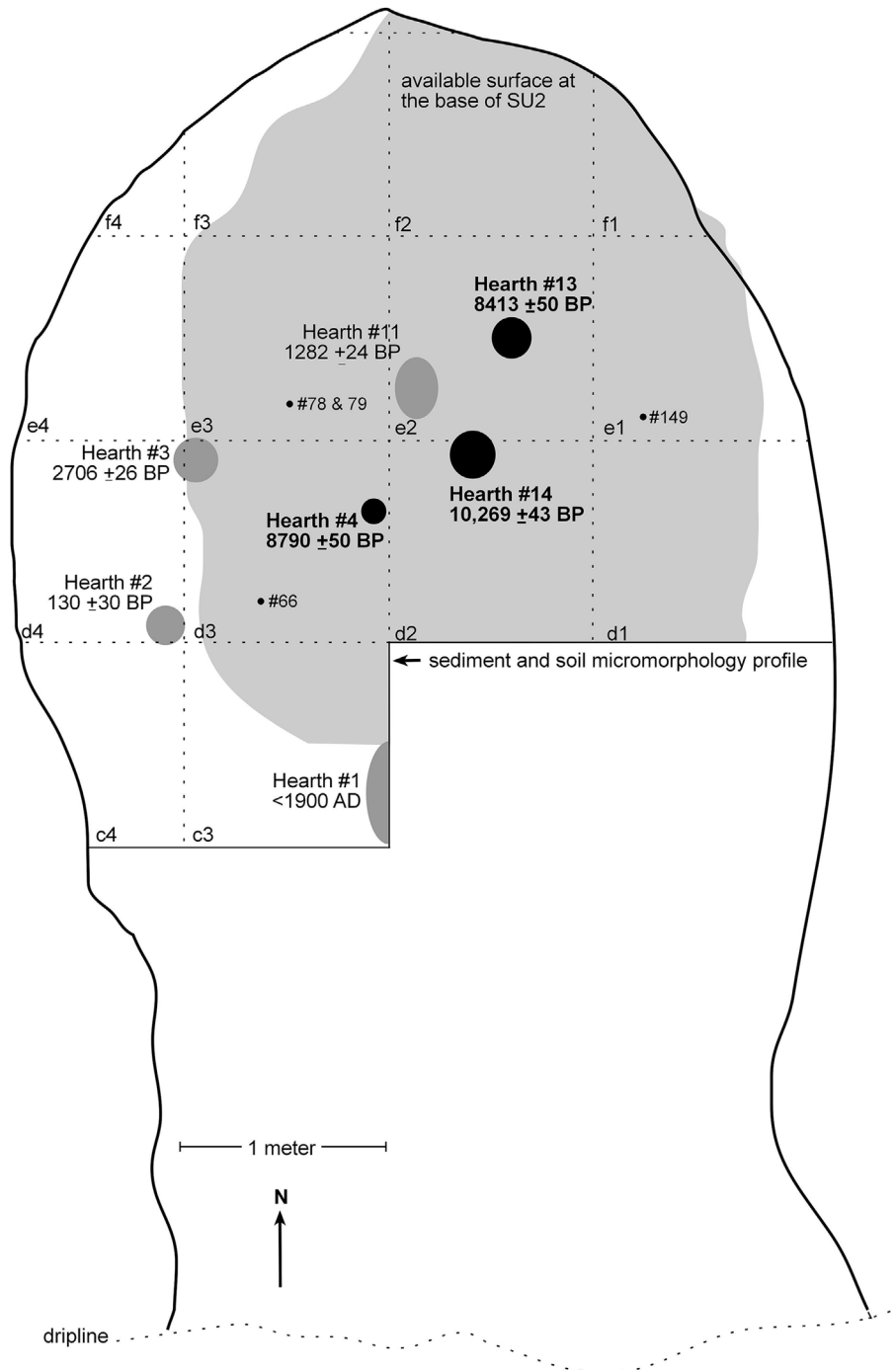


Fig. 3. Excavated plan of Cueva de la Vieja showing horizontal distribution of anthropogenic features, 14C dates on hearths, and individual lithic tools (#) on the occupational surface at the base of SU2. Hearths in the base of SU2 appear in bold letters.

4. Results

4.1. Stratigraphy, site context and chronology

The excavated section comprised six distinctive stratigraphic units (SU) extending in a profile in excess of 100 cm (Fig. 4). The SUs are of variable thickness and recognizable due to differences in color, compactness and texture (Supplementary Material Table 1). The deposit is massive and does not show pedogenetic processes. Rodent burrows are common along the cave walls up to a depth of

70–80 cm.

From top to bottom, SU1 consists of 20–40 cm of sheep dung comprising three subunits differentiated based on fire alteration observed through variable degrees of compactness, color (greyish-brown, orange and black) and structure. Burnt sheep dung in the base (SU1.3) sealed the underlying stratigraphic deposits. This SU is considered to be twentieth century in age based on the date of introduction of sheep into the valley (Martinic, 2005).

SU2 consists of a 50–65 cm brown sandy/silty loam deposit with a significant proportion of gravel. Smaller particles may have

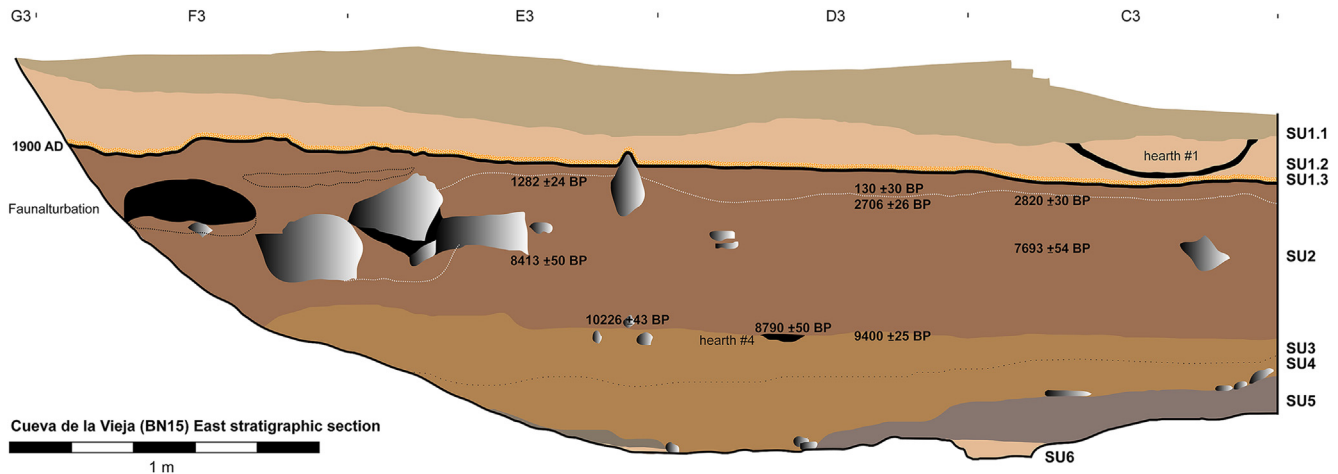


Fig. 4. Stratigraphy of the east cross-section of Cueva de la Vieja site, showing features and the location of selected 14C dates.

entered by air suspension, while larger ones are probably the result of local diagenetic processes. In fact, roof/wall fall particles ($<18,000 \text{ cm}^3$) are particularly common in the rear of the cave in the mid-section of SU2 (Fig. 4). Additionally, thin sections show that sands were the result of in situ weathering of gravel from the cave roof/walls (Fig. 5A). However, the presence of dirty silt/clay coatings around gravel and bone fragments (Fig. 5B) are interpreted as rolling; thus, the incorporation of particles from higher positions outside the cave by colluvial action cannot be ruled out. Although this seems unlikely today, this process has been actively recorded in the Baño Nuevo 1 site (Mena and Stafford, 2006). The high values of the gravel fraction in SU2 (and SU3) could be explained by a fall in the colluvial/aeolian rate and/or higher weathering rock-wall processes due to frost/melting cycles (Bertran et al., 2012).

The SU2 yielded the vast majority of archaeological material, mainly lithics and charcoal particles. For instance, out of the 399 units comprising the lithic assemblage, only 5 pieces were recorded in the surface, 3 in SU1 and 3 in the contact between SU2 and SU3. Bones were mainly from rodents or were small, undistinguishable fragments. However, micromorphological samples throughout SU2 show, besides charcoal and microdebitage, significant amounts of weathered bone material (Fig. 5C), with approximately 5% burnt specimens. Bone fragment sizes range from 600 to 100 μm , which are different than the expected bone sizes in bird regurgitations, as tested within the cave itself. This means that despite the relative absence of macroscopic bone material, human activities may have also involved their discard, especially at the deepest levels of SU2, where the fragment counts are most abundant in the thin sections.

SU2 lies in a gradual contact with the deposit below. SU3 and SU4 present loamy textures with a variable proportion of gravels. Evidence suggests that these units may have been deposited by water entering into the cave, consistent with mass wasting processes. On the one hand, reddish sediments in SU3 (FeO_3) are consistent with an increase in humidity (Fig. 5D), which also in agreement with the presence of vegetation and diatoms (Fig. 5E), though their incorporation in regurgitation pellets cannot be ruled out definitively. Parallel laminated dusty clay coatings in voids are indicative of periodic illuviation episodes (Fig. 5F) and may be due to the entrance of water by rillwash processes. This unit lies in sharp contact with the underlying deposit.

SU5 is composed of a compacted, dark-greyish silt loam deposit. At the bottom, SU6 comprises light-brown, loose fine sands. Both SU5 and SU6 have low organic content and well-sorted quartz particles, with a very minor proportion of gravels (Fig. 6), which clearly suggests wind as the main transport agent over a short time

span. These conditions were uncommon throughout the rest of the analyzed stratigraphic section as suggested by dates showing low sedimentation rates and prolonged exposed surfaces (see SU2).

Radiocarbon dates were used to define the timing of sediment deposition, the magnitude of alteration processes and human occupational events, all of which belong to SU2 or its contact with SU3. Dating was mainly performed on charcoal samples from hearth features and on isolated speckles. The former provide more accurate values for dating the stratigraphic sequence than the latter, which were occasionally observed in an inverted pattern, most likely due to the vertical migration produced by fossorial animals (Table 1). Notably, all dates suspected to have vertically migrated belong to the C3 excavation unit, which necessitates caution when considering information from this area in the cave. Furthermore, one *Lama guanicoe* bone directly retrieved from a rodent burrow (feature #9) in the back of the cave was dated at an age of 5640–5880 cal BP, despite having been located directly on top of SU3 which is terminal Pleistocene (see below). In addition to corroborating how significant bioturbation operated at the site, it suggests such alterations can be measured and considered in the interpretation of site formation processes.

Human occupations are only present in SU1 and SU2, as suggested by the stratigraphic distribution of archaeological material and human-made features. Among these features, seven hearths indicate small activity areas located primarily in the center of the cave (Fig. 3). Direct dates on each hearth feature range from 12,000 cal BP to modern. Hearth #1 is an excavated feature on the dung of SU1, which is probably related to the distinctive scorched layer, given that fire may have extended underground following more organic and less compacted burnable fuel in contact with SU2. The rest of the hearths were located within SU2 (features #2, 3 and 11) or laying in direct contact with SU3 (features #4, 13 and 14). All hearths were small and constrained. Hearth features #2, 3 and 14 correspond to flat unexcavated features. Hearths #11 and 13 were intentionally excavated between 6 and 7 cm, while #4 was 3.5 cm. Differences in dates between the two of the deepest hearths is explained by the fact that #13 (9260–9520 cal BP) corresponds to a higher occupational surface (134 cm from datum) than #14 (11,760–12,060 cal BP), associated with the surface of the first human occupation (141 cm from datum). Hearth #4, also in direct contact with SU3 and in an even deeper position (162 cm from datum), is problematic, since it yielded an age of 9550–9920 cal BP. This may be explained by the inclination of the cave surface towards the center and due to irregularities on the cave floor, rather than vertical migration of the charcoal sample (Fig. 4), since it was

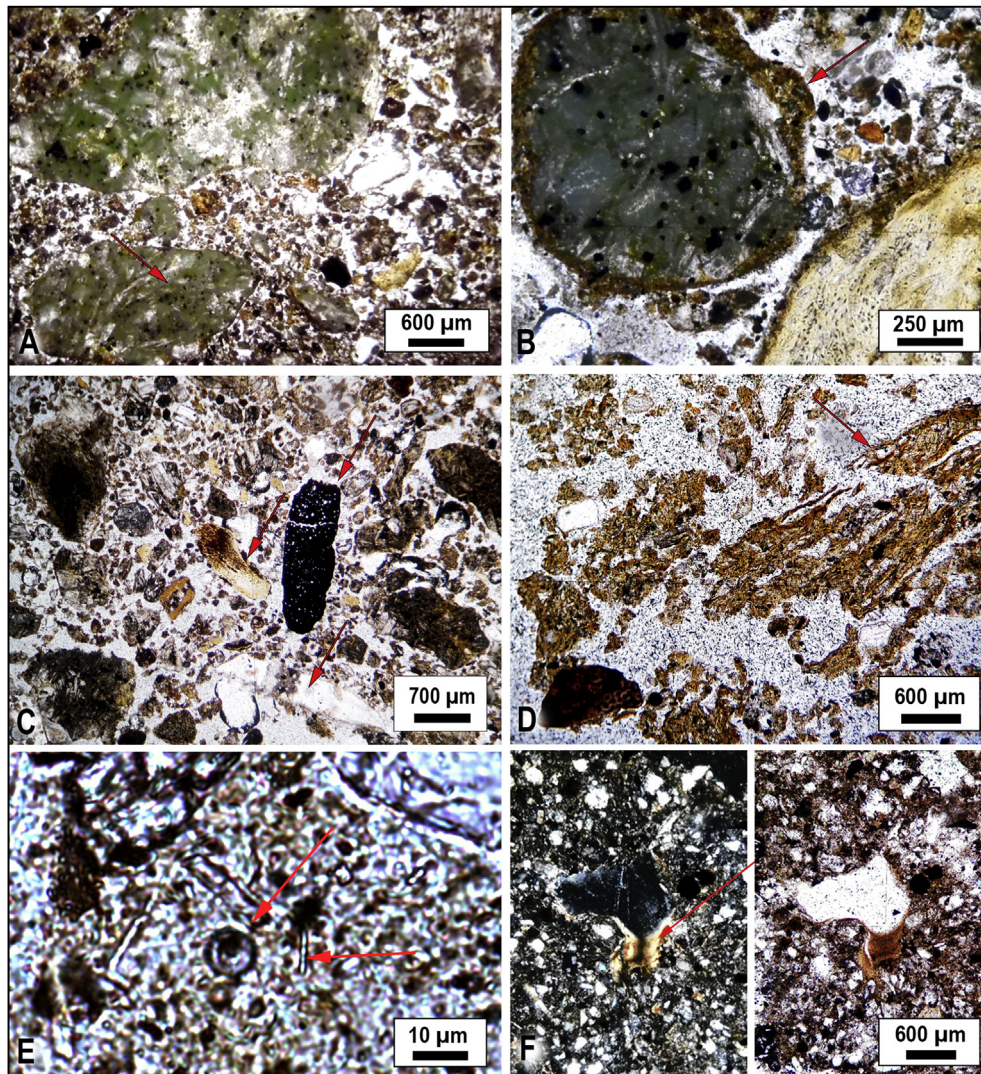


Fig. 5. Microphotographs of the micromorphological thin sections: (A) rock-wall fragment showing in situ gravel fragmentation; (B) dirty silty/clay coatings around a gravel and bone fragments interpreted as particle rolling due to colluvial process; (C) charcoal, microflake of polycrystalline quartz, bone and burnt-bone fragments; (D) highly-weathered plant tissue remains partially replaced by Fe/Mn oxides; (E) articulated phytoliths and a *Crisophycea cys* diatom; (F) well-oriented dusty clay coatings in voids in cross (left) and plane (right) polarized light.

recovered from within the feature. Nevertheless, this situation is indicative of a very low sedimentation rate, which produced a palimpsest of material remains from the occupation events at the cave.

Considering these findings, we ranked dates in terms of their reliability to provide a preliminary division for discussing the studied assemblages, especially considering that the 65 cm of SU2 represent a 12,000-year span. The most reliable dates, those from in situ hearth samples plus other coherent dates on charcoal speckles, were preferentially used in the following division. The late Holocene component is located within the first 15 cm of SU2 and spans from ca. modern to 2840–3000 cal BP. Though middle Holocene ages were produced at the site, their position was questioned due to vertical migration. However, the excavated levels from 15 to 25 cm are constrained by the two bracketing dates and should be regarded as formed roughly between 3000 and 8000 cal BP but were most likely between 4240–4440 cal BP and 5647–5885 cal BP (averaged value) based on the available dates. The excavated levels from 25 to 45 cm yielded early Holocene ages from 8370–8560 cal BP to 9260–9520 cal BP (hearth #13). Finally, from 45 to 65 cm we

identified the late Pleistocene to early Holocene component based on the average of two sets of undistinguishable dates between 10,500–10,670 cal BP to 11,760–12,030 cal BP, all located in contact with SU3. Considering other early Holocene ages at this depth (i.e., hearth #4), this component should be regarded with caution.

A comparative chart considering sedimentological properties of the analyzed section plus the stratigraphic behavior of the different assemblages is shown in Fig. 6. The percentage of total carbon (considered as a proxy for organic matter) remained constant throughout SU2 and was different from underlying levels, suggesting that human activities conducted at the site were the main factor conditioning these values. However, it is worth noting that the curves of carpological remains, rodent bones and other bone taxa are similar in shape. The overall low pH values may be the principal factor affecting the low frequency and poor preservation condition of such material, except for the uppermost 10 cm, where a spike in all three assemblages is significant (Linse, 1992; Hedges, 2002). Lithic material follows a different pattern, indicating the highest discard/activity rates roughly in the late Pleistocene to early Holocene transition levels.

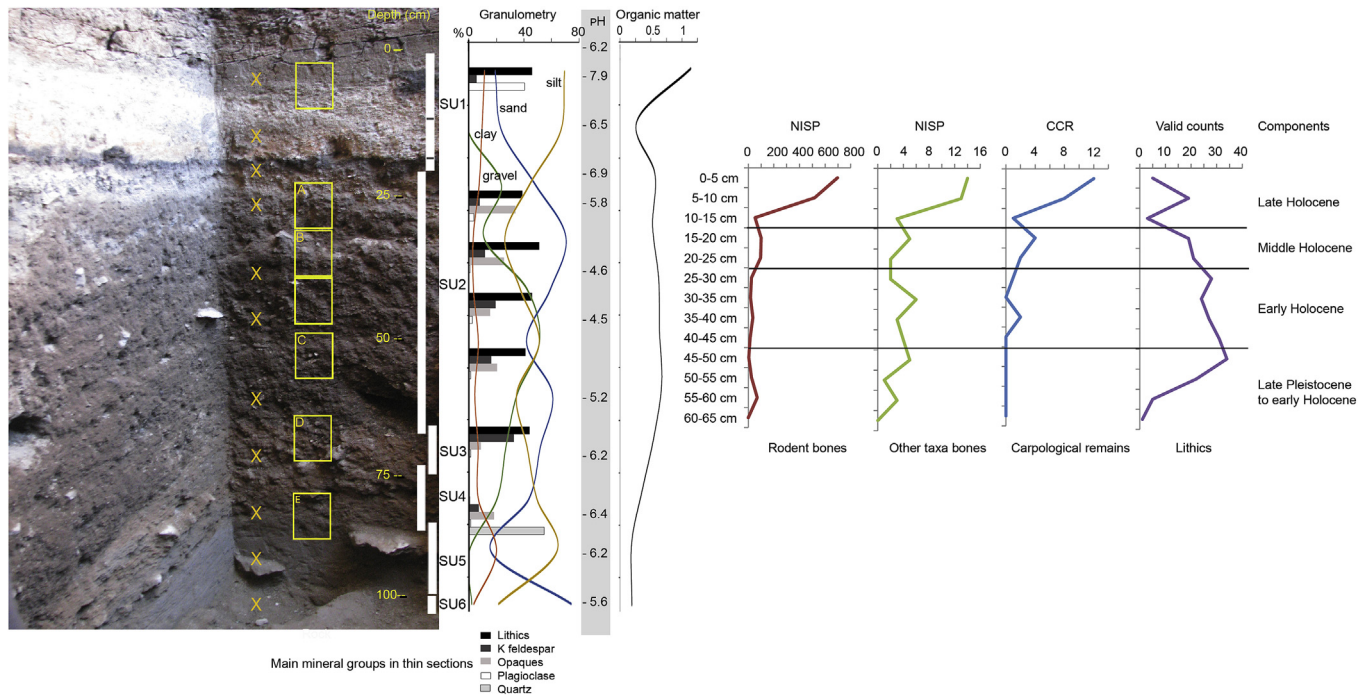


Fig. 6. Eastern profile of unit C3 showing the location of micromorphological (rectangles) and non-structured sediment samples (X), main mineral groups in thin sections, vertical extension of stratigraphic units (SU), granulometry, pH, organic matter content and rodent bones, other animal taxa bones, carpal remains and lithics from SU2 partitioned by excavated levels and components.

Table 1

AMS ^{14}C dates from Cueva de la Vieja site, *probable vertical migration, **retrieved from a rodent burrow, ***rounded out to the nearest tenth.

Laboratory code	Stratigraphical unit (depth from datum)	Level (cm) in SU2	Excavated unit	Feature	^{14}C age yr BP	$\delta^{13}\text{C}$ (‰)	2-sigma cal BP***	Material
BETA 381094	SU2 (106 cm)	5–10	D4	Hearth #2	130 ± 30	–26	Modern–260	Charred material
D-AMS 008981	SU2 (106 cm)	5–10	E2	Hearth #11	1282 ± 24	–21.9	1070–1260	Charred material
AA 103449	SU2 (119 cm)*	15–20	C3	–	1521 ± 38	–23.2	1300–1430	Charred material (isolated speckle)
D-AMS 008979	SU2 (109 cm)	10–15	D3	Hearth #3	2706 ± 26	–18.9	2750–2840	Charred material
BETA 317158	SU2 (116 cm)	10–15	C3	–	2850 ± 30	–23	2840–3000	Charred material (isolated speckle)
BETA 317159	SU2 (143 cm)*	40–45	C3	–	3960 ± 30	–23.8	4240–4440	Charred material (isolated speckle)
AA 103447	SU2 (150 cm)*	45–50	C3	–	4977 ± 49	–26.1	5590–5750	Charred material (isolated speckle)
UGAMS 19835	SU2 (contact SU3, 158 cm)**	55–60	E1	–	5030 ± 25	–20.88	5640–5880	Bone collagen (<i>Lama guanicoe</i>)
AA 103450	SU2 (contact SU3)*	55–60	C3	–	5117 ± 47	–23.9	5710–5920	Charred material (isolated speckle)
AA 103448	SU2 (126 cm)	25–30	C3	–	7693 ± 54	–21.7	8370–8560	Charred material (isolated speckle)
D-AMS 008982	SU2 (134 cm)	40–45	E2	Hearth #13	8413 ± 50	–14	9260–9520	Charred material
BETA 373166	SU2 (163 cm)	55–60	D3	Hearth #4	8790 ± 50	–23	9550–9920	Charred material
UGAMS 170011	SU2 (contact SU3, 159 cm)	55–60	D3	Assoc. lithic artifact #66	9400 ± 25	–25.4	10,500–10,680	Charred material (isolated speckle)
BETA 317157	SU3 (contact SU2)*	–	C3	–	9400 ± 40	–24.7	10,480–10,700	Charred material (isolated speckle)
D-AMS 005300	SU2 (contact SU3, 141 cm)	45–50	E3	Assoc. lithic artifact #78	10,226 ± 43	–28.8	11,700–12,030	Charred material (isolated speckle)
D-AMS 008980	SU2 (contact SU3, 143 cm)	45–50	D2	Hearth #14	10,269 ± 43	–22.4	11,760–12,060	Charred material

4.2. The archaeofaunal assemblage

The archaeofaunal assemblage comprises 4648 bone specimens

(NISP) from all excavated units. Based on NISP, bones appeared mainly in SU2 (77.9%) and SU1 (20.65%) and much less frequently in the uppermost cm of SU3 (1.44%; Table 2). Taxonomic identification

Table 2

Frequencies of archaeofaunal remains from Cueva de la Vieja site partitioned by stratigraphic units and expressed in NISP, %NISP and MNI.

Taxa	SU1		SU2		SU2-3 contact		Total		
	NISP	MNI	NISP	MNI	NISP	MNI	NISP	%NISP	MNI
Mammalia	587	0	1918	0	50	0	2555	54.97	0
Artiodactyla	10	0	11	0	0	0	21	0.45	0
<i>Ovis aries</i>	324	5	4	1	0	0	328	7.06	6
Canidae	0	0	2	0	0	0	2	0.04	0
Rodentia	15	0	309	0	0	0	324	6.97	0
Cricetidae	13	0	812	0	12	0	837	18.01	0
cf. <i>Abrothrix</i> sp.	0	0	41	17	0	0	41	0.88	17
cf. <i>Eligmodontia</i> sp.	0	0	4	3	0	0	4	0.09	3
cf. <i>Geoxus</i> sp.	0	0	22	11	0	0	22	0.47	11
cf. <i>Loxodontomys</i> sp.	2	2	42	21	0	0	44	0.95	23
cf. <i>Phyllotis</i> sp.	0	0	54	30	0	0	54	1.16	30
cf. <i>Reithrodon</i> sp.	4	1	291	109	2	1	297	6.39	111
<i>Ctenomys</i> sp.	3	2	85	13	3	1	91	1.96	16
cf. <i>Microcavia australis</i>	0	0	1	1	0	0	1	0.02	0
Lacertilia	0	0	2	0	0	0	2	0.04	0
Bird	0	0	6	0	0	0	6	0.13	0
Passeriform	1	0	7	0	0	0	8	0.17	0
Undeterminate	1	0	10	0	0	0	11	0.24	0
Total	960	10	3621	206	67	2	4648	100	217

to the level of Genus of bone remains other than 33.75% of sheep (*Ovis aries*) in SU1 and 14.91% of rodents in SU2 was significantly low. However, rodent variability should be considered high (8 genera). The highest concentration of rodents occurred in excavation units C3 and C4 (Supplementary Material Table 2), particularly at the top 20 cm of SU2, in which a raptor regurgitation feature yielded 82.53% of all rodent bones from the SU. This is consistent with the location of these units below a prey bird perch. Consequently, the variability of identified elements and the traces of digestive corrosion (6.82%) suggest rodent remains were incorporated as bird regurgitation (Andrews, 1990). In addition to chemical alterations (23.84%), other alterations such as weathering (0.06%) or carnivore marks (0.04%) are remarkably low or non-existent (i.e., rodent teeth marks and root marks). Only a few remains showed traces of burning (NISP = 1445, 31.1%), which can be attributed to in situ fire of sediments with bone content, rather than human consumption throughout the Holocene. No anthropogenic cut marks or artifacts on bone material were recorded at Cueva de la Vieja.

The low frequency of bone remains in SU2 may be explained by differential preservation or the disposal of post-consumption remains outside the cave, especially considering its size. These scenarios are not mutually exclusive. Surface alterations on bones and the micromorphological analysis showing small (non-rodent) burnt bones (see above) favor differential preservation; however, the low identifiability of the bone assemblage precludes from assessing anatomical profiles.

The only remains for which there is evidence for consumption—mainly intentional fractures in long bones and traces of exposure to fire—are 207 skeletal remains corresponding to *Ovis aries* in SU1, introduced to the valley by the beginning of the twentieth century. Some fragments, identified as Mammalia in SU2, may have been the result of human consumption, as suggested by occasional traces of exposure to fire, though all of these bones have a poor degree of conservation, mainly due to the high level of fragmentation of the sample.

4.3. The archaeobotanical assemblage

Information on plant remains has been produced mainly based on carpological analyses of hearth features as well as samples acquired from two columns throughout SU2. Table 3 shows the main archaeobotanical information partitioned by components, which

was further subsampled with a Historic component based on the high density and richness of hearth #2 (detailed results in Supplementary Material Table 3). Plant taxa repeated throughout the different components include Lamiaceae, Chenopodiaceae and Poaceae, which indicates the overall exploitation of local plants. Greater frequencies, densities and richness of carpological remains were recorded for the late Holocene and Historic components. No plant evidence was observed in the earliest component. However, given that the charred material survived through SU2, this may indicate that the assemblage is not necessarily taphonomically conditioned.

The archaeobotanical assemblage indicates occupational events since the middle Holocene occurred mainly between the end of spring and during the summer, a seasonality that is similar to carpological remains from other sites in the region, such as El Chueco 1 and Baño Nuevo 1 (Belmar et al., 2017). Based on the spatial distribution of vegetation, we can observe that accessible, extensively distributed plants dominate the sequence since the early Holocene. However, the middle Holocene component yielded only *Berberis* sp., which generally occurs in areas of restricted distribution, such as small ravines or streams that are commonly found near the site. The assemblage is further suggestive of plants being used as a source of fuel and food (*Berberis* sp., Chenopodiaceae, Cyperaceae, and Poaceae), in addition to *Galium* sp. in the later components, which may potentially be used as dye (Pardo and Pizarro, 2013). All of these taxa are common in archaeological sites of the region.

4.4. The lithic assemblage

The lithic assemblage from Cueva de la Vieja comprises a total of 399 pieces, almost all (96.99%) recorded in SU2 (Table 4). The spatial distribution of lithics is broadly homogeneous and conditioned by the size of excavation units (i.e., lower frequencies near the rear and walls) and their location, because thicker deposits were recorded along the central axis of the cave. When partitioning the assemblage by components, the early Holocene segment displays the majority of lithics (47%), while the rest share similar proportions (late Pleistocene to early Holocene: 23.76%; middle Holocene: 16.97%; late Holocene: 12.27%; details in Supplementary Material Table 4). By considering only the valid pieces, the assemblage is largely dominated by chipping debitage (59%) resulting

Table 3

Frequency, density, taxonomy and indicators of carpological remains in SU2 from Cueva de la Vieja site; CCR: charred carpological remains.

Component	Frequency	Density (CCR/liter)	Taxa	Richness	Seasonality	Distribution	Potential uses
Historic	107	214	<i>Berberis</i> sp., <i>Chenopodium</i> sp., <i>Conium</i> sp., <i>Galium</i> sp., Lamiaceae, Poaceae, cf. <i>Suaeda</i> sp	7	End of spring- summer, summer	Extensive- restricted	Edible, combustion
Late Holocene	60	3.43	<i>Berberis</i> sp., Chenopodiaceae, Cyperaceae, <i>Galium</i> sp., Lamiaceae, Poaceae, Polygonaceae	7	End of spring- summer, summer	Extensive- restricted	Edible, combustion, dye
Middle Holocene	5	0.5	<i>Berberis</i> sp., Lamiaceae	2	End of spring- summer	Restricted	Edible, combustion
Early Holocene	6	0.27	Chenopodiaceae, Lamiaceae, Poaceae	3	–	Extensive	Edible, combustion
Late Pleistocene to early Holocene	0	0	–	–	–	–	–

from edge modification and other types of debris (retouch: 6.28%; bifacial thinning flakes: 11.72%). Tool classes are very infrequent but were mainly represented in the lower excavated levels, particularly in the late Pleistocene to early Holocene component where retouched flakes, one thick distal scraper, one thick sidecraper and one bifacial fragment were recorded laying directly on the occupational surface in the contact of SU2 and SU3 (Fig. 7).

A preliminary toolstone classification was used to identify basic raw material groups in Cueva de la Vieja (Table 5). By considering only valid pieces, the assemblage is dominated by siliceous rock types (34.31%) widely represented in Holocene sequences from sites in the region (García, 2007; Méndez et al., 2011). Basalt (20.92%) and andesite (17.99%) have significant representation, while high-quality obsidian, exotic to this area, is only present in the form of small fragments of debitage, comprising 1.26% of the assemblage. All other toolstones have only a minor representation. While siliceous types dominate most components, basalt has a slightly higher proportion in the earliest levels. An independent assessment on lithic raw material quality suggests that 35.15% of lithic pieces fall within above-average knapping qualities, and 47.28% can be classified as average.

Two selected technological attributes were used to further classify the assemblage. The coverage of cortex in the dorsal part of flakes was used as a broad indicator of the proximity of procurement zones. Most lithics have no trace of cortex, which is explained by the advanced degree in the reduction sequence of most pieces classified as debitage. However, the late Pleistocene to early Holocene component shows the highest proportion of cortex presence (29.03%) and the highest proportion of full cortex coverage

(76–100%: 14.52%) of the components (Table 6). Regarding the extraction techniques, hard hammer percussion dominated the assemblage (58.16%) and each component by itself.

In particular, the lithic assemblage in the basal centimeters of SU2 is associated with the earliest occupation, as indicated the dating of charcoal in direct contact with lithic artifact #78 and the date on hearth #14, all laying in the SU2/SU3 contact. Although other early Holocene dates at the same depth posit a complex interpretation on the formation processes affecting this assemblage, some technological attributes show consistency. For example, the earliest assemblage is significantly small, comprising a few retouched artifacts, and manufactured mostly on locally procured toolstones, as suggested by cortex values and toolstone quality. Indeed, several of these pieces probably originated from the knapping of a single mid-grained basalt pebble, judging by the similarity in matrix and cortex. This apparent homogeneity suggests that at least part of the assemblage belongs to one depositional event, a hypothesis that will need further testing through conjoining pieces. Except for one fractured bifacial artifact on a siliceous non-local material, retouching was limited to the margins of flakes, and there is no indication of systematic rejuvenation, thus suggesting short-lived, rapidly discarded (i.e., expedient) tools. This is consistent with a short-span occupational event where only a few tasks were carried out. This tool assemblage fits the description of lithic material provided for the initial occupation at El Chueco 1 (Reyes et al., 2007; Méndez et al., 2009). Additionally, lithics from both sites in the eastern steppe of CWP meet the expectations outlined by Borrero and Franco (1997) for occupations during the exploration phase of a previously unknown region.

Table 4

Frequency of lithic classes in SU2 from Cueva de la Vieja site, partitioned by components (pieces recorded in rodent burrows were excluded).

Lithic classes	Late Holocene		Middle Holocene		Early Holocene		Late Pleistocene to early Holocene		Total
	Valid	Fragments	Valid	Fragments	Valid	Fragments	Valid	Fragments	
Nodule	0	0	1	1	5	2	6	0	15
Core	0	0	0	0	0	0	0	1	1
Unintentional by-product	1	4	3	2	2	5	3	4	24
Hammer stone	0	0	1	0	1	0	0	0	2
Pebble	0	0	0	0	4	1	0	0	5
Core flake	0	0	5	4	10	5	5	0	29
Chipping debitage	23	13	22	17	68	48	28	19	238
Retouch debris	1	2	1	0	8	1	5	0	18
Bifacial thinning flake	2	0	3	0	11	2	12	2	32
Retouched flake	0	1	2	0	0	3	2	1	9
Notch	0	0	2	0	0	0	0	0	2
Scraper	0	0	0	1	0	1	0	1	3
Sidescraper	0	0	0	0	0	0	1	0	1
Bifacial fragment	0	0	0	0	0	1	0	1	2
Undetermined	0	0	0	0	1	1	0	0	2
Total	27	20	40	25	110	70	62	29	383

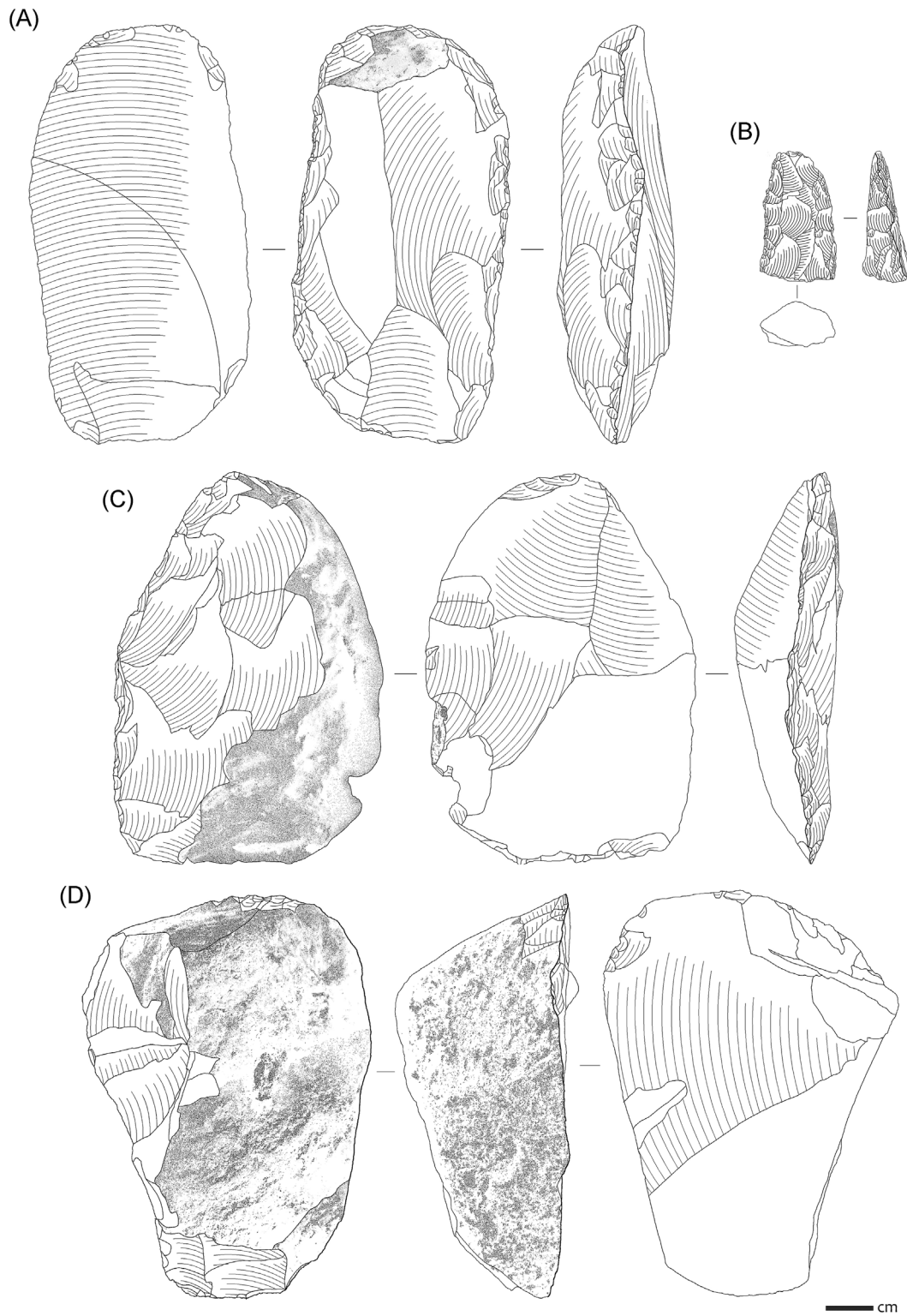


Fig. 7. Lithic tools from SU2 base of Cueva de la Vieja; (A) thick scraper (basalt, same nodule as C; E3 unit, piece #78); (B) bifacial fragment (siliceous rock; E1, unit piece #149); (C) thick sidescraper (basalt; D3 unit, piece #66); (D) retouched flake (tuff; E3 unit, piece #79).

Table 5

Frequency of lithic toolstones in SU2 from Cueva de la Vieja site, partitioned by components (pieces recorded in rodent burrows were excluded).

Toolstones	Late Holocene		Middle Holocene		Early Holocene		Late Pleistocene to early Holocene		Total
	Valid	Fragments	Valid	Fragments	Valid	Fragments	Valid	Fragments	
Obsidian	3	5	0	1	0	1	0	1	11
Siliceous rocks	13	9	14	11	40	28	15	12	142
Andesite	4	0	6	2	19	15	14	2	62
Basalt	3	1	9	2	19	11	19	5	69
Rhyolite	0	0	0	0	1	1	0	0	2
Tuff	2	4	8	7	12	6	4	4	47
Coarse grained	1	0	3	1	7	3	4	2	21
Mid grained	1	0	0	0	0	1	0	3	5
Undetermined	0	1	0	1	12	4	6	0	24
Total	27	20	40	25	110	70	62	29	383

Table 6

Selected technological attributes of lithic material in SU2 from Cueva de la Vieja site, partitioned by components (pieces recorded in rodent burrows were excluded).

		Late Holocene		Middle Holocene		Early Holocene		Late Pleistocene to early Holocene		Total
		Valid	Fragments	Valid	Fragments	Valid	Fragments	Valid	Fragments	
Cortex	0%	20	16	31	18	91	62	44	25	307
	1–25%	6	3	4	1	4	2	5	2	27
	26–50%	0	0	3	2	1	2	3	0	11
	51–75%	1	0	1	4	3	2	1	1	13
	76–100%	0	0	1	0	8	2	9	1	21
	(Not applicable)	0	1	0	0	3	0	0	0	4
Extraction technique	Hard-hammer percussion	16	6	27	16	58	18	38	7	186
	Soft-hammer percussion	7	6	6	4	34	4	12	5	78
	Pressure flaking	2	0	0	0	2	1	0	0	5
	Undetermined	2	7	6	5	6	47	7	17	97
	(Not applicable)	0	1	1	0	10	0	5	0	17
	Total	27	20	40	25	110	70	62	29	383

5. Discussion

5.1. Site scale discussion with special attention to the late Pleistocene occupation

The excavated section at Cueva de la Vieja site shows a continued sedimentary deposition over a 12,000-year span with occasionally inverted radiocarbon dates. The sudden incorporation of big-sized particles from roof/wall erosion and possibly colluvium, as well as significant rodent bioturbation, are among the main agents producing this situation. Given that there is no evidence for any erosional unconformity at a macroscopic level or based on the micromorphological analyses, the best alternative is that the deposition rates were slower than the human reoccupation of the site, thereby producing palimpsests that need to be addressed by considering averaged archaeological assemblages, i.e., components extending beyond the capability of excavation techniques to discern more precise occupational events. Consolidated sediment thin sections also indicate mixture; nonetheless, charcoal, burnt bones and microflakes appear associated in the samples retrieved at the depth of the early Holocene component.

A series of anthropogenic features, specifically hearths, indicate that it is possible to record small segments of occupational surfaces that may be informative of activities conducted at a given time. This is the case with the first occupational surface, especially since it lies on top of the contact with the culturally sterile SU3. This discrete surface (restricted to < 8 m² in the base of SU2; Fig. 2) yielded the earliest hearth (#14), an unexcavated feature dated to 11,760–12,060 cal BP. One bifacial fragment and three other expedient large marginally flaked tools were recovered in direct association (<1.2 m radius); all were laying directly in the contact

between SU2 and SU3. Despite the fact that other non-consistent ages were identified at the same level, the position of these lithic artifacts and one charcoal speckle (recovered in direct association with lithic pieces #78 and 79) that produced a statistically undistinguishable age from that of the hearth suggest that this assemblage may have originated during the earliest occupation of the site. This seems to follow the principle that “stratigraphic relationships, properly handled, are the least ambiguous and arguably the most accurate of all time measurements available to archaeologists” (Dincauze, 2000, p. 96).

About 6 cm above this occupational surface, hearth #13 corresponds to an excavated feature dated to 9260–9520 cal BP. Excavated hearths have been identified as distinctive features of the earliest populations in southernmost Patagonia (Magallanes, Última Esperanza, and Tierra del Fuego) between 12,000 and 13,000 cal BP (Massone, 2002). Experiments have suggested this mode was technologically apt for keeping fuel over longer periods and ideal within limited spaces (Arroyo and Jackson, 1998). On the other hand, hearths from early sites in the Central Plateau of Santa Cruz are generally flat, lacking a limiting structure and varying in size, which has been interpreted as indicative of low-intensity occupations in which fire ignition involved little energy (Frank, 2012). Hearths from Cueva de la Vieja fit the second interpretation, which implies that less formalized heating structures should be expected under short-span, low-intensity occupations, suitable during exploration activities. Moreover, the fact that both flat and excavated features were recorded throughout the sequence and that hearths #1 (twentieth century) and #11 (1070–1260 cal BP) were excavated features indicate that such a combustion technique should not be regarded as a normative indicator for the earliest dispersal of humans in Patagonia.

In addition to the hearths, the most recognizable material evidence at the base of SU2 is a small lithic assemblage composed of pieces that were knapped from the same basalt nodule. Low tool-stone diversity and other technological attributes shared by this group such as cortex type, flake thickness, location and technology of the retouch, suggest that they belong to an integrated assemblage. The relatively important cortex proportion in flakes and dominant hard-hammer percussion further indicate early stages of reduction of a raw material procured within a short range. Tools are thick and display marginal retouching that did not alter the overall shape of flakes, thus producing short-lived – expedient – designs on local raw materials, which is to be expected in an initial, low-intensity exploration of an unknown space (Borrero and Franco, 1997). The only high-quality curated lithic tool was a broken piece of a siliceous bifacial artifact, possibly on a non-local tool-stone. Such attributes have been described for similar situations in early sites of Patagonia (Franco, 2002; Civalero and Franco, 2003; Méndez et al., 2009; Skarbutin et al., 2015) and elsewhere in the southern cone of South America (Méndez, 2015) for discriminating stages in the peopling process of a region (Borrero, 1989–90).

Ages in the order of 12,000 cal BP are synchronic (or few centuries after) to the last relicts of extinct mammals in the best-studied regions in Patagonia (Villavicencio et al., 2015; Metcalf et al., 2016) and in other parts of the southern cone (Barnosky and Lindsey, 2010). Locally, the only evidence of large extinct fauna has been recorded in the Baño Nuevo 1 site with direct dates on *Xenarthra* dermal bones between 13,010–13,150 and 14,280–14,970 cal BP (Mena and Stafford, 2006; López and Mena, 2011). However, no such evidence was recorded at Cueva de la Vieja, possibly because the cave size was unfit for herbivores the size of *Mylodon* or provided too much exposure and was therefore unfavorable for a den for felines. These herbivores and carnivores have been acknowledged as recurrent inhabitants of caves in Patagonia (e.g., Borrero and Franco, 1997; Borrero and Martín, 2012; Martín, 2012). The size of Cueva de la Vieja was no constraint to hunter-gatherer parties, however, which are expected to move in small groups while transiting through an unfamiliar landscape, although remaining connected with other social units (Kelly, 2003).

5.2. Regional scale discussion, with a particular focus on site redundancy

Cueva de la Vieja, while small and unfit for any type of prolonged dwelling, yielded evidence of occupations at various times since the Pleistocene–Holocene transition. The distribution of material evidence throughout the excavated section coupled with the position of specific ages yielded discriminating components that may be used in discussing changes in the behavior of specific assemblages. For instance, the increase of plant taxa (richness) and charred seed density during the late Holocene has been interpreted as indicative of the higher intensity in use of the steppe area after 3000 cal BP (Reyes et al., 2009), which may have led to the greater exploitation of local plants (Belmar et al., 2017). The collection of plant resources may have operated as a behavior embedded within other activities (Binford, 1979), as suggested by the ubiquity of most of the selected plant resources and their overall low significance throughout assemblages of this cave and other redundantly occupied sites in the region, such as El Chueco 1 and Baño Nuevo 1 (Belmar et al., 2017). However, looking at the distribution of lithic evidence across time, the Cueva de la Vieja site does not fit the traditional idea that later occupations were characterized by higher discard rates and should therefore be regarded as more intensive. This situation is similar to El Chueco 1, where higher densities of lithics and bones were recorded in the two middle Holocene components (Méndez et al., 2011). At Cueva de la Vieja, most lithic

evidence was gathered at levels corresponding to the early Holocene. To a certain extent, it can be argued that the Baño Nuevo 1 human bone assemblage, directly dated between 10,180 and 9920 cal BP (Reyes et al., 2012), is a trait of higher intensity, or at least recurrent visits to the valley of Ñirehuao in the early Holocene.

As such, discriminating components serves the purpose of describing the assemblages recognizing that they were built over recurrent small occupational events within those time frames. However, in some cases, redundancy at specific sites produces an apparent intensity, which is better explained by the higher density of averaged debris produced by a series of different occupational events in palimpsests (Bailey, 2007; Jackson, 2007; Borrero, 2011). In order to resolve this, site redundancy was assessed using radiocarbon dates as a means for defining minimal occupational events at the site level, which may be used as a comparative measure of the human signature over time when considering equivalently sampled sites. The infrequent archaeological record of CWP, as shown by the small assemblages and repeated occupation of few multi-component sites, is appropriate for gauging human occupation of a region since such low densities are highly sensitive for showing the alternation between occupation and abandonment at different scales (Méndez et al., 2016).

For this comparison, we considered radiocarbon data from three sites in CWP whose records span the Holocene. At Cueva de la Vieja, out of 16 radiocarbon dates, we calculated a minimum of 12 occupational events based on averaging statistically undistinguishable ages. These were compared to the available dataset of Baño Nuevo 1 (excluding all pre-human dated material; Mena and Stafford, 2006; Reyes et al., 2012), where out of 31 dates we calculated a minimum of 15 occupational events. Finally, out of 18 dates from El Chueco 1, we obtained 13 occupational events (Reyes et al., 2007; Méndez et al., 2011, 2016). All three sites show a remarkable synchronicity in periods of activity and abandonment throughout the Holocene (Fig. 8). El Chueco 1 and Cueva de la Vieja were first occupied during the Pleistocene–Holocene transition, and all three sites show recurrent (and a higher density of) occupational events during the early Holocene. Around 8000 cal BP, a series of abandonment phases became interspersed with “pulse”-like occupational events. Many more similarities are observed when comparing Cueva de la Vieja and Baño Nuevo 1 (only 2.23 km apart from each other), which further suggest a trend representative of the occupational behavior of the Ñirehuao valley. Preliminarily, we suggest that similarities between these three datasets expand beyond the collation of independent events towards a correlation of an emerging regional trend in the terms suggested by Sandweiss and Quilter (2012). The reasons for such change should be explored in the future, though the change at 8000 cal BP corresponds with the eastward expansion of forests (Markgraf et al., 2007; de Porras et al., 2012) and the disappearance of glaciers at elevations over 1000 masl (McCulloch et al., 2016).

6. Conclusions

Shifting the augmentation in scales of analyses provides an advantageous way to integrate site- and regional-based data into broader explanations (Barberena et al., 2017). Cueva de la Vieja and CWP provide appropriate cases at different scales for exploring the antiquity and evolution of marginally settled areas along the eastern Andean flank of Patagonia (Borrero, 2004). The area between 43° and 51° S at the lee side of the Andes is among the last regions to exhibit evidence of the late Pleistocene human dispersal in the broader Southern Cone. The first arrival dates in sites such as El Chueco 1 (11,240–11,650 cal BP; Reyes et al., 2007), Cueva de la Vieja (11,760–12,030 cal BP), Cerro Casa de Piedra 7 (12,430–12,710 cal BP; Aschero et al., 2007), Bloque Oquedad 1

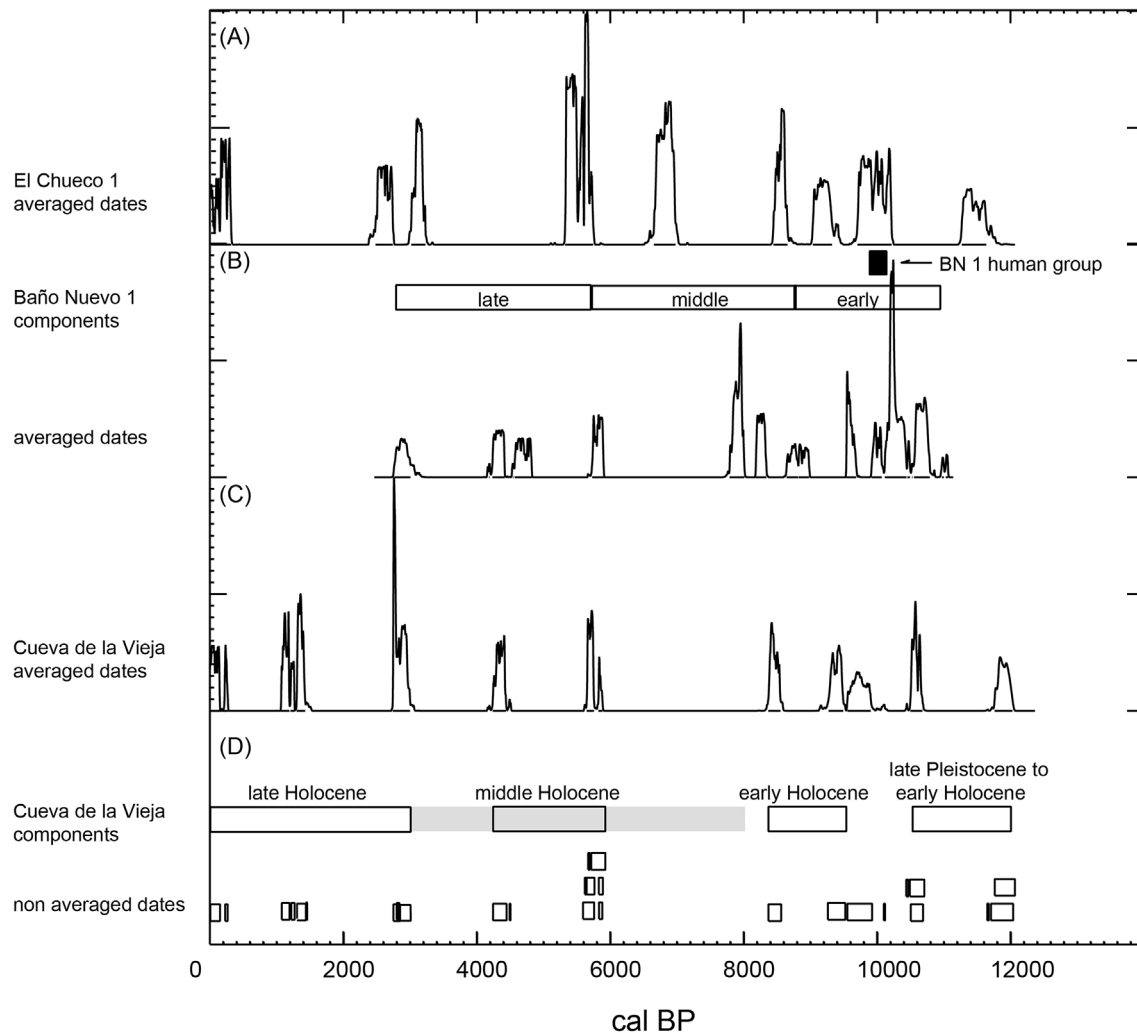


Fig. 8. Calibrated chronology (ShCal13 curve; Hogg et al., 2013) of dated archaeological sequences in CWP showing summed probability plots (Calib 7.0.4; Stuiver et al., 2013) based on averaged occupational events for: (A) El Chueco 1 (Méndez et al., 2016), (B) Baño Nuevo 1 (Mena and Stafford, 2006) including components and average of the directly dated human assemblage, and (C) Cueva de la Vieja. (D) Cueva de la Vieja block plot of individual dates and components.

(10,790–11,250 cal BP; Belardi et al., 2010) and Chorrillo Malo 2 (10,860–11,230 cal BP; Franco and Borrero, 2003) provide evidence for occupations close to the Andean mountain range that are on average more than one millennium later than at sites in the Central Plateau of Santa Cruz (Prates et al., 2013). An earlier presence and higher rates of activities/discard in locales such as Piedra Museo (12,710–12,990 cal BP; Miotti and Salemme, 2003), Cerro Tres Tetras (12,700–13,190 cal BP; Paunero, 2003a), Casa del Minero (12,720–12,980 cal BP; Paunero, 2003b) or La Gruta 1 (12,670–12,830; Franco et al., 2010) suggest that populations settled earlier in the east, creating demographic nuclei from where the west was explored (Borrero, 2004). This region offered high prey diversity (Miotti et al., 1999) and abundance and variability of high-quality lithic raw materials (e.g., Hermo, 2009; Skarbutin et al., 2015); moreover, it was never exposed to late Pleistocene glaciations (Coronato et al., 1999). Sites further south along the Andes in the region of Última Esperanza, such as Cueva del Medio (12,370–13,260 cal BP; Nami and Menegaz, 1991; Martín et al., 2015) or Cueva Lago Sofía 1 (12,440–12,730 cal BP; Massone and Prieto, 2004), indicate first arrival dates comparable to those of the Central Plateau. This region was also rich in prey, as judged by the ubiquity of extinct faunal remains (Barnosky and Lindsey, 2010;

Borrero and Martín, 2012; Villavicencio et al., 2015; Metcalf et al., 2016); thus, it was probably better suited for human occupation by the late Pleistocene in comparison to the eastern Andean slope to the north. This demonstrates that simplistic north-to-south dispersal models do not fit the archaeological evidence of late Pleistocene Patagonia and that considering natural routes and ecological differences between regions may prove much more fruitful when attempting to unveil the first peopling process (see Borrero and Franco, 1997).

The initial dispersal of hunter-gatherers into unfamiliar landscapes may have represented a significant challenge requiring specific sets of decisions at the technological and organizational levels (Kelly, 2003). It is possible that recently deglaciated areas were only settled after earlier populations were fully established over eastern landscapes (Méndez, 2013), as periglacial environments offered notable challenges to human dispersals (Borrero, 2012; Rademaker et al., 2014). Although full glacial conditions were already absent by the initial time of entry to CWP and other adjacent areas, the “Andean dead ends” (Borrero, 2004) required the establishment of well-developed and attractive ecosystems for hunter-gatherers to begin their occupation. Current radiocarbon information discussed in this article suggests this occurred no

earlier than 12,000 cal BP. Thereafter, the human presence in the steppe of CWP appears to have been neither intense nor continuous but rather punctual and interspersed with pronounced abandonment periods (Méndez et al., 2016). The fact that occupations were of low intensity (low discard rates) and within small sites fits well with the idea that hunter-gatherers were organized in a flexible system of small social units (Borrero et al., 2008; Yellen and Harpending, 1972; Woodburn, 1968). Brief-span occupations and the remarkable synchronicity between the archaeological record of the areas of Cisnes and Ñirehuao are further consistent with a highly mobile regime that was maintained over the Holocene.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.quaint.2017.07.014>.

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