

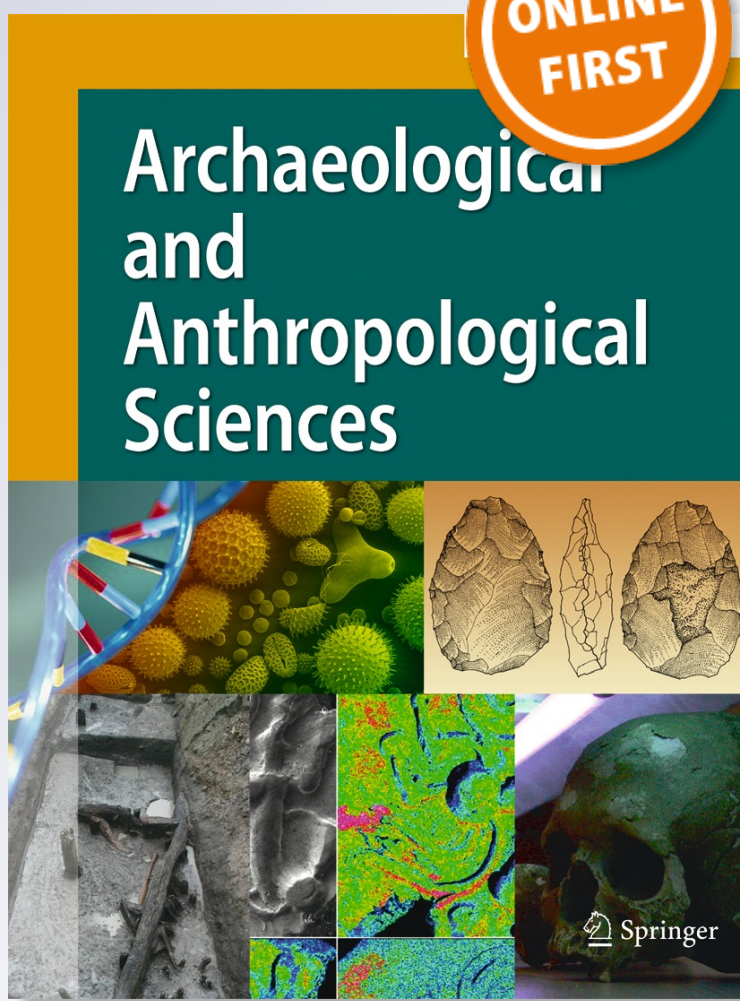
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Taphonomic study in Argentinian Patagonia: analysis of variability through time and space in the Central Plateau (Santa Cruz Province)

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Abstract The basin of the Zanjón Rojo and Blanco is located in the northeast of the Central Plateau of Santa Cruz province (Argentina). Each sector of the basin has specific characteristics which represent different microenvironments. We have studied two different archeological contexts in the period from the Final Pleistocene to Late Holocene in each of these sectors. In this paper, we analyze the effects of different taphonomic processes and agents on the zooarcheological assemblages in order to evaluate the role played by those that can redeposit or move bones pre- and post-depositionally during site formation in this sector of Patagonia. The bone specimens that were analyzed come from two stratigraphic contexts with wide sequences of human occupation; one is AEP-1 at Piedra Museo and the other is Cueva Maripe at La Primavera, located in the lower and upper sectors of the basin, respectively. The comparison between both sites was based on different modification patterns identified on bone surfaces for the different phases of settlement in Patagonia. The results showed complex and different taphonomic histories in both sites, and while the main processes involved in bone movement were roots and rodents, both had little significance in comparison with others, such as manganese and carbonate.

Keywords Pleistocene-Holocene · Patagonian plateau · Hunter-gatherer · Bone modifications · Taphonomic history

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Introduction

In Argentinian Patagonia, taphonomic studies have been systematically developed for some decades as part of archeological research (Borrero 1988, 1990, 2000, 2001, 2003, 2007; Borrero and Muñoz 1999; Borrero et al. 1991, 2005; Cruz and Muñoz 2010; Fernández 2008, 2010; Martín 2006; Mondini and Muñoz 2014; Muñoz 2009, among others). This significant increase over the last few years reflects the wide spectrum of questions that researchers have about this region that they seek to answer by means of the taphonomic study of sites (Barberena 2008, 2014; Borrero 2003; Borrero and Martín 2008; Mengoni Goñalons 1999; Muñoz 2009; Rindel 2009) and actualistic and experimental studies (Belardi et al. 2012; Borella and Borrero 2010; Borrero 1990, 2007; Borrero et al. 2005; Cruz and Muñoz 2010; Durán 1991; Fernández et al. 2010).

Although in certain areas of Patagonia, such as the Austral-Magellan Basin and the Andean lakes, the development of taphonomic research has been strong (Barberena 2008; Belardi et al. 2012; Borrero 1988, 2001, 2007; Borrero and Martín 2008; Cruz and Muñoz 2010; Fernández 2010; Fernández et al. 2010; Martín 2006; Muñoz 2009, among others); this has not been the case in the Central Plateau (Durán 1991; Miotti and Marchionni 2011; Miotti et al. 1999). Zooarcheology, on the other hand, has been an important research line in the area since the 1980s (Alberdi et al. 2001; Cardich and Laguens 1984; Marchionni et al. 2010; Marchionni and Vázquez 2012; Miotti 1998, Miotti and Marchionni 2011; Miotti and Salemme 1999; Miotti et al. 1999). We started with the systematic development of taphonomic studies in the northeast of this massif in 2008 (Marchionni 2012, 2013; Marchionni et al. 2012; Miotti and Marchionni 2011). As part of this program, this work represents the first approach to studying “bone movement in space”

in this sector of Patagonia, and its goal is to understand what processes and agents could redeposit bones pre- and post-depositionally, and which of them were significant in the formation history of the two studied contexts, both located in different sectors of the same basin. The evaluation of whether pre- and post-depositional processes have moved or displaced bone specimens will provide new data regarding the formation processes involved in the taphonomic history of each assemblage. Likewise, with this work, we hope to provide new taphonomic information on the sites and the region to contribute to the discussion on Patagonian archeology and peopling.

In the case of cave environments such as Cueva Maripe and Alero El Puesto 1, the sites that were studied here which have heterogeneous dynamics at the microenvironmental level, it is essential to study the processes of site formation to evaluate the archeological integrity and resolution at different levels of analysis. Within this perspective, caves are presented as exceptional cases of sedimentary deposition. Following Waters (1992: 243), “The stratigraphic sequence in any rock shelter is unique because of differences in shelter lithology, weathering processes, hydrologic conditions, and types of depositional environments present outside the shelter.” This, along with the intensity of human occupation, means that the stratigraphic correlation between these types of sites becomes more complex. Even inside the same cave, we can recognize environments with great sedimentary difference (Farrand 1985; Kornfeld et al. 2007). The environmental and stratigraphic singularity inherent to caves (Farrand 1985) means we must face different study situations at the intra- and inter-site levels to understand the conditions and agents involved in the formation of the archeological assemblages. This kind of study, carried out by means of the analysis of standardized variables, was originally proposed by Behrensmeier (1991), and in zooarcheological research in Patagonia, it has been performed by several authors (Mengoni Goñalons 1999; Muñoz 2008; Rindel 2009).

Animal carcasses begin their taphonomic history as articulated skeletons whose degree of skeletal part scattering depends on the taphonomic processes and agents such as scavengers, carnivores, humans, fluvial action, gravity, and trampling (Lyman 1994). Consequently, the main goals proposed in this paper are as follows: (a) to assess the potential movement of specimens, on intra- and inter-site scales based on the record of bone modifications; (b) to discuss the impact of the processes that can reorganize and redeposit bones in different microenvironments of the study area in relation with other variables which enable us to evaluate the integrity and resolution of the zooarcheological record in each sector; and (c) to discuss the scale or degree of microenvironmental variability involved in post-depositional contexts.

The faunal remains that archeologists recover from the sites are the result of both human selective transport and taphonomic processes and the agents can affect the original deposits to a

greater or lesser extent (Borrero 1988, 2001, 2011; Lyman 1994; Nash and Petraglia 1987; Mengoni Goñalons 1999). Due to the fact that bone specimens are affected by multiple depositional and post-depositional processes (Nash and Petraglia 1987), taphonomy seeks to understand the processes that can produce, modify, and destroy bone assemblages (O'Connor 2000: 19) through the study of preservation processes and how they affect the information contained within the record (Behrensmeier and Kidwell 1985). In this sense, the crucial role of taphonomy is to support the building of zooarcheological knowledge (Borrero 2011: 268).

Materials and archeological contexts

This work focuses on one of the main hydrographic basins in the northeast of the Mesocócton or Deseado Massif (Fig. 1a), which is located between the Deseado and Chico rivers, in Santa Cruz Province, Argentina (Miotti 1998). This region is characterized by a steppe plateau where the dominant landscape is of volcanic origin and shows an irregular relief (Panza 2001). Here, we studied the Zanjones Rojo and Blanco basin (Fig. 1b), a residual basin that runs 140 km west–east and 80 km north–south (Panza 2001) and is located between 47° 30' 53" and 48° 6' 43" south and between 67° 36' 59" and 69° 10' 2" west. This basin shows specific features in different sectors that allow us to consider them as microenvironments. The upper level of the basin is characterized by wide plateau plains covered by basaltic layers and cut by depressions of different dimensions. In this sector of the basin, we studied Cueva Maripe site, in La Primavera locality (Fig. 1b, c). The lower level is characterized by an irregular relief with low and isolated hills, where we studied Alero El Puesto 1 (AEP-1) site, in Piedra Museo locality (Fig. 1b, d).

Both archeological contexts are stratigraphic sites within a cave and rock shelter, and show wide occupational sequences which cover the Pleistocene-Holocene transition through to the late Holocene (Table 1; Miotti et al. 1999, 2003, 2007, 2014). The two sites are strategic enclaves for studying the peopling of the region and the changes in the subsistence and mobility strategies carried out by the hunter-gatherer societies of Patagonia.

We studied ten zooarcheological assemblages: seven of them correspond to Cueva Maripe site: 4 are from squares C5, D5, and D6 of the north chamber (NC) and 3 correspond to squares A12 and B12 from the south chamber (SC; Fig. 1e); and 3 assemblages are from the AEP-1 site. Their chronologies include the 3 main temporal stages of the settlement of Patagonia: colonization phase (ca. 13–7.5 ka BP), consolidation phase (ca. 7.5–3 ka BP), and the third phase corresponds to the last 3000 years (for further detail see Miotti and Salemme 1999; 2004).

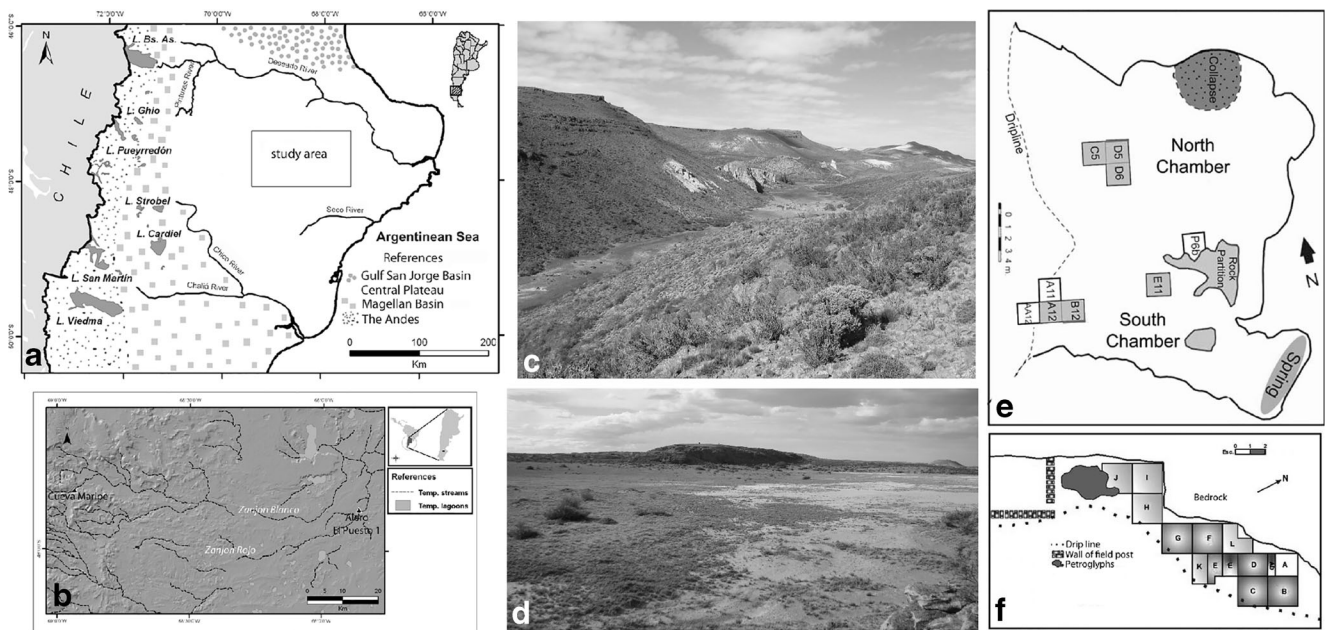


Fig. 1. **a** Study area in the northeast of the Central Plateau or Deseado Massif in Santa Cruz Province (Argentina). **b** Basin of Zanjones Rojo and Blanco and archeological sites studied here. **c** The upper sector of the

basin with Cueva Maripe site. **d** The lower level of the basin with AEP-1 site. **e** Cueva Maripe site with excavated squares in both chambers. **f** Alero El Puesto-1 (AEP-1) site with excavated squares

Cueva Maripe site

Cueva Maripe is a big external cave located at 560 masl in La Primavera archeological locality. The bedrock is formed by ignimbrites from the Chön Aike Formation (Panza 2001). The cave is divided into two chambers (north and south chambers) by a rock wall (Fig. 1e) and each one shows differences in terms of sun and wind incidence and humidity and shelter conditions (Miotti et al. 2007). Excavations were performed in both sectors between 2003 and 2010 (Fig. 1e).

Although the stratigraphic sequence consists of six layers in both chambers, it is highly complex as we could not correlate the north and south chamber profiles except for the current surface (Miotti et al. 2014; Mosquera 2014), and consequently, the assemblages from each chamber had to be analyzed separately. Collapsed rocks found in the inside of the cave suggest that some kind of leakage may have caused a low-energy drainage in the past in the NC, while in the SC, there is now a small intermittent spring at the back of this sector, which creates cycles of greater humidity (Marchionni et al.

Table 1 Radiocarbon dates from Cueva Maripe and AEP-1 sites. Information taken from Miotti et al. (1999, 2003, 2007, 2014)

	Cueva Maripe		AEP-1
	North chamber	South chamber	
Pleistocene-Holocene transition to Early Holocene	9177 ± 56 (AA95129)	9518 ± 64 (AA65175)	12,890 ± 90 (AA20125)
	8992 ± 65 (AA65179)	8333 ± 63 (AA65174)	11,000 ± 65 (AA27950)
	8827 ± 87 (AA9512)	7703 ± 47 (AA65177)	10,925 ± 65 (OxA8528)
	8012 ± 80 (AA95126)		10,390 ± 70 (OxA8527)
	8762 ± 50 (AA65178)		10,470 ± 60 (GRA9837)
	7153 ± 50 (AA99069)		10,470 ± 65 (OxA9242)
			10,400 ± 80 (AA8428)
Middle Holocene			9710 ± 105 (LP859)
			9230 ± 105 (LP105)
	5137 ± 45 (AA99070)	4113 ± 39 (AA65181)	7670 ± (LP450)
	5084 ± 49 (AA65173)		7470 ± 140 (NSRL11167)
Middle to Late Holocene	4002 ± 43 (AA99067)		
	3791 ± 42 (AA99068)		
	3210 ± 60 (LP-1497)	1078 ± 40 (AA65176)	

2012; Miotti et al. 2014). Furthermore, while both sequences have radiocarbon dates covering the Pleistocene-Holocene transition to the Late Holocene (Table 1), sequence depth is different: the NC sequence is about 2 m deep but the SC shows a compressed sequence that is less than 1 m. Sedimentation rates indicate that these were higher in the NC (1 cm = 103 years) than in the SC (1 cm = 250 years) (Miotti et al. 2007, 2014).

The occupational model generated for Cueva Maripe (Miotti et al. 2014) suggests the existence of three archeological components in both chambers. For the Pleistocene-Holocene transition to Early Holocene (between ca. 9500 and ca. 7200 years BP), the assemblages from layer 5 of the NC and the analytical unit (AU) 3 of the SC are component 1. Component 2 is integrated by layer 4 from the NC and AU2 from the SC and corresponds to Middle Holocene with dates between ca. 7700 and ca. 3500 years BP. Finally, component 3 registered occupations since the end of the Middle Holocene (between ca. 4100 and ca. 1100 years BP) and is included in layers 2 and 3 from de NC and AU1 from the SC.

The site was understood as a place where domestic activities were performed in the different moments of occupation (Miotti et al. 2014). However, the cave shows not only differential use as regards time scale but also in terms of space, since different activities were performed by hunter-gatherers in each chamber at different periods of time (Marchionni 2013; Miotti et al. 2007, 2014).

Alero El Puesto 1 (AEP-1) site

As regards AEP-1 site, located in the lower sector of the basin (Fig. 1b, d), this is a rock shelter of coquinooid sandstone (Zárate et al. 2000) located by a paleo-lake at 150 masl. The excavated surface varies across different layers in connection with the height of the bedrock which makes it smaller in the lower levels (Fig. 1f).

The stratigraphic sequence is composed of an upper eolian layer and five lower layers that represent different soil horizons (Zárate et al. 2000). Based on the massive roof shelter collapse, two archeological components were identified: the lower component, which spans between the Pleistocene-Holocene transition and Early Holocene (Table 1) includes layers 4 to 6 (Miotti et al. 1999, 2003) and was interpreted as a place where killing and primary processing activities took place. The upper component, on the other hand (layer 2) was used by hunter-gatherers for domestic activities during the Middle Holocene (Table 1; Marchionni 2012; Miotti and Marchionni 2011).

Methodology

The identification of different bone surface modification patterns allows us to infer, in some cases, the taphonomic agents

and processes that were involved in the formation of an assemblage (Gifford-Gonzalez 1991; Lyman 1994). This type of study serves as an analytical tool to understand the taphonomic history of the site and to discuss its integrity (Lyman 1994). By means of this, we can estimate the degree of incidence of the different processes in the formation of archeological deposits, and the role played by humans as well as to establish the preservation state of bone assemblages. For this analysis, we performed the standardized comparison across the assemblages that included natural modification patterns that were previously recorded in the assemblages (Marchionni 2013) to discuss variability at different depths.

At this point, we placed special attention on the traces that resulted from the agents involved in bone movement, such as trampling (Behrensmeyer 1978; Behrensmeyer et al. 1986; Borrero 2007; Lyman 1994; Marín-Monfort et al. 2014; Olsen and Shipman 1988), carnivores (Binford 1981; Borrero et al. 2005; Cleghorn and Marean 2007; Lyman 1994; Mondini 1995, 2004; Muñoz et al. 2008), roots (Andrews and Cook 1985; Behrensmeyer 1978; Binford 1981; Lyman 1994; Montalvo 2002), rodents (Binford 1981; Bocek 1986; Durán 1991; Frontini and Deschamps 2007; Lyman 1994), and weathering (Behrensmeyer 1978; Borrero 2007), which allowed us to discuss the associated taphonomic processes in greater depth. Then, we compared the assemblages across the sites for the different stages of the peopling of Patagonia (Miotti and Salemme 1999, 2004) used as temporal units of analysis.

The analysis was performed at the inter- and intra-site levels, where we used different taxonomic and anatomical abundance estimators like NISP, %NISP, MNE, MAU, and %MAU (Binford 1984; Grayson 1984; Lyman 1994) and different surface modification patterns that were recognized both by means of naked eye and magnifications from 10× to 60×. Likewise, we carried out refitting studies (Lyman 1994: 154–160) to evaluate the dispersion of bone assemblages in both sites.

Results

Given the NISP and %NISP value in both chambers of Cueva Maripe, *Lama guanicoe* (guanaco) was the most widely represented species in the three phases of human occupation (Table 2). We also found a small number of Rheidae specimens, which probably increased for the Middle Holocene given the presence of eggshell fragments. There were also a significant percentage of mammal specimens that could not be identified on a more specific level and a very small number of other taxa (Mollusca, birds, Dasipodidae, and carnivores).

The analysis of guanaco anatomical abundance was based on the %MAU value (Fig. 2), which showed a greater frequency of appendicular skeleton parts, with greater

Table 2 Taxonomic abundance in Cueva Maripé site

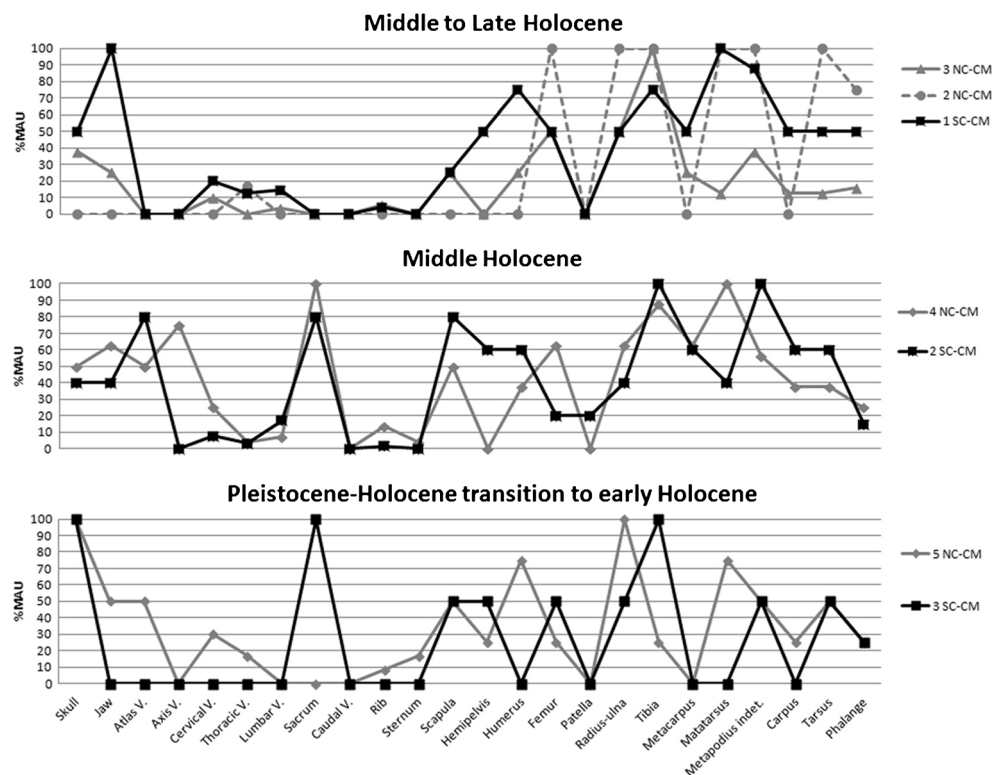
	Pleistocene-Holocene transition to Early Holocene				Middle Holocene				Middle Holocene to Late Holocene					
	Layer 5 NC		AU 3 SC		Layer 4 NC		AU 2 SC		Layer 3 NC		Layer 2 NC		AU 1 SC	
NSP	380		221		2630		1256		1320		262		2836	
	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP	NISP	%NISP
Mollusca	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5	2.06
Birds	4	3.33	0	0.00	0	0.00	0	0.00	4	1.51	0	0.00	1	0.41
Rheidae bones	1	0.83	1	3.70	1	0.21	1	0.64	0	0.00	0	0.00	7	2.88
Rheidae eggshells	0	0.00	2	7.40	131	27.69	1	0.64	116	43.77	4	20.00	12	4.93
Dasipodidae	1	0.83	0	0.00	2	0.42	0	0.00	1	0.38	0	0.00	0	0.00
<i>Felis concolor</i>	0	0.00	0	0.00	6	1.27	0	0.00	0	0.00	0	0.00	0	0.00
<i>Lama guanicoe</i>	114	95.00	24	88.89	333	70.40	152	98.70	144	54.34	16	80.00	190	78.19
<i>Ovis aries</i>	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	28	11.52
NISP total	120	100	27	100	473	100	154	100	265	100	20	100	243	100

representation of limb distal elements. The axial skeleton representation was lower but the most common units corresponded to head and sacrum elements. In the earliest assemblages, this trend was less evident since we found a greater variety of anatomical elements that included a low percentage of vertebral elements. However, sacrum elements were very well represented until the Middle Holocene but absent for the Late Holocene. Statistical correlations between %MAU and BMD values were performed in previous works

(Marchionni 2013; Marchionni and Miotti 2014; Marchionni et al. 2012, 2014), and the results do not indicate a significant bias in the anatomical representation of guanaco linked to the survival of each element.

Weathering profiles indicated low weathering (≤ 2 stage sensu Behrensmeier 1978) in all of the assemblages studied here (Fig. 3). We observed a trend towards a higher relative weathering of the assemblages from the SC, which suggests the presence of differential preservation between both

Fig. 2 Guanaco anatomical abundance in Cueva Maripé (CM) site



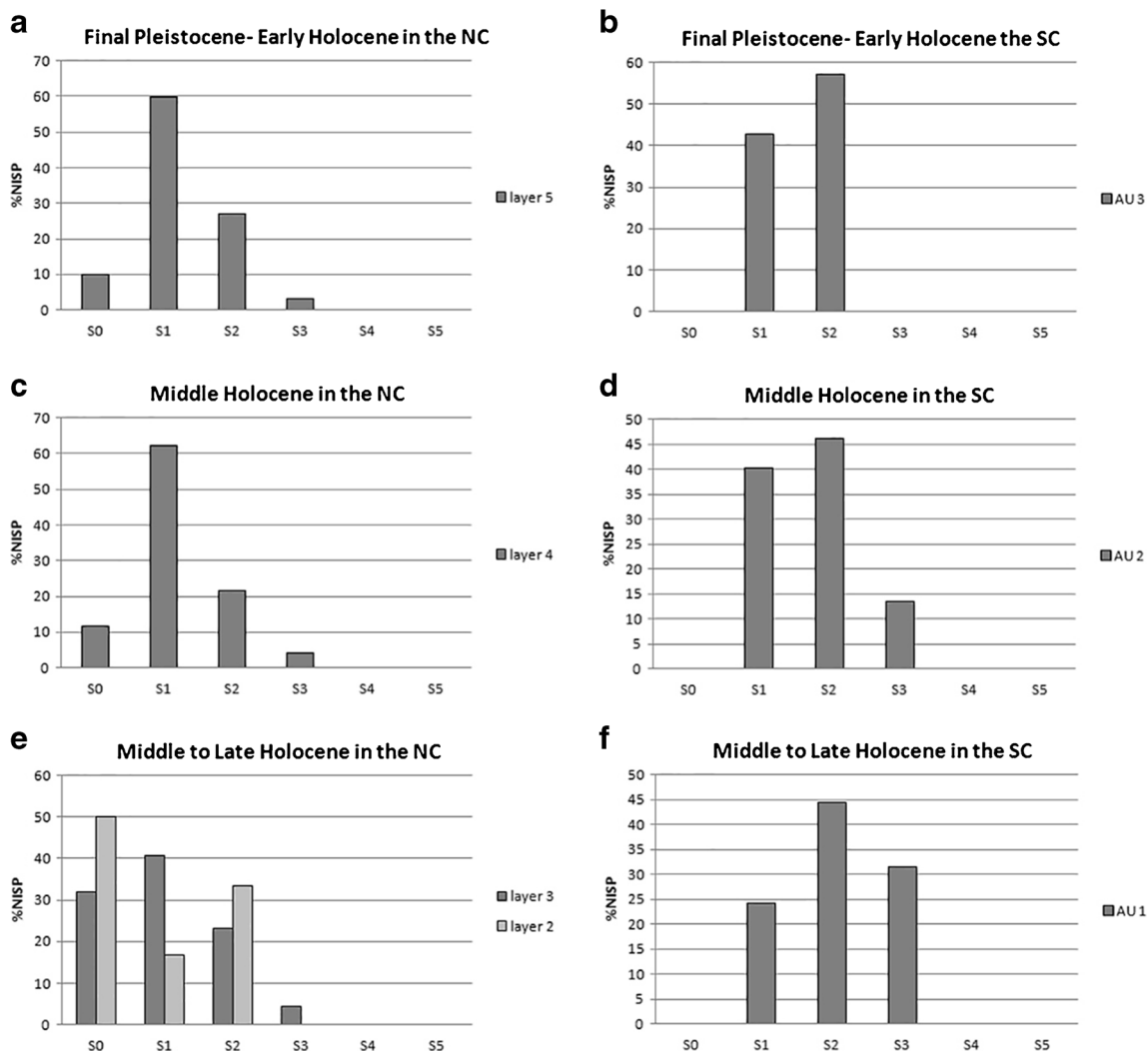


Fig. 3 Weathering stages (S) sensu Behresmeyer (1978) in Cueva Maripe site. **a** Layer 5 in the NC **b** Layer 4 in the NC. **c** Layers 2 and 3 in the NC. **d** AU 3 in the SC. **e** AU 2 in the SC. **f** AU 1 in the SC

chambers. When we considered the chronologies of the assemblages, those of the Middle to Late Holocene were mostly affected.

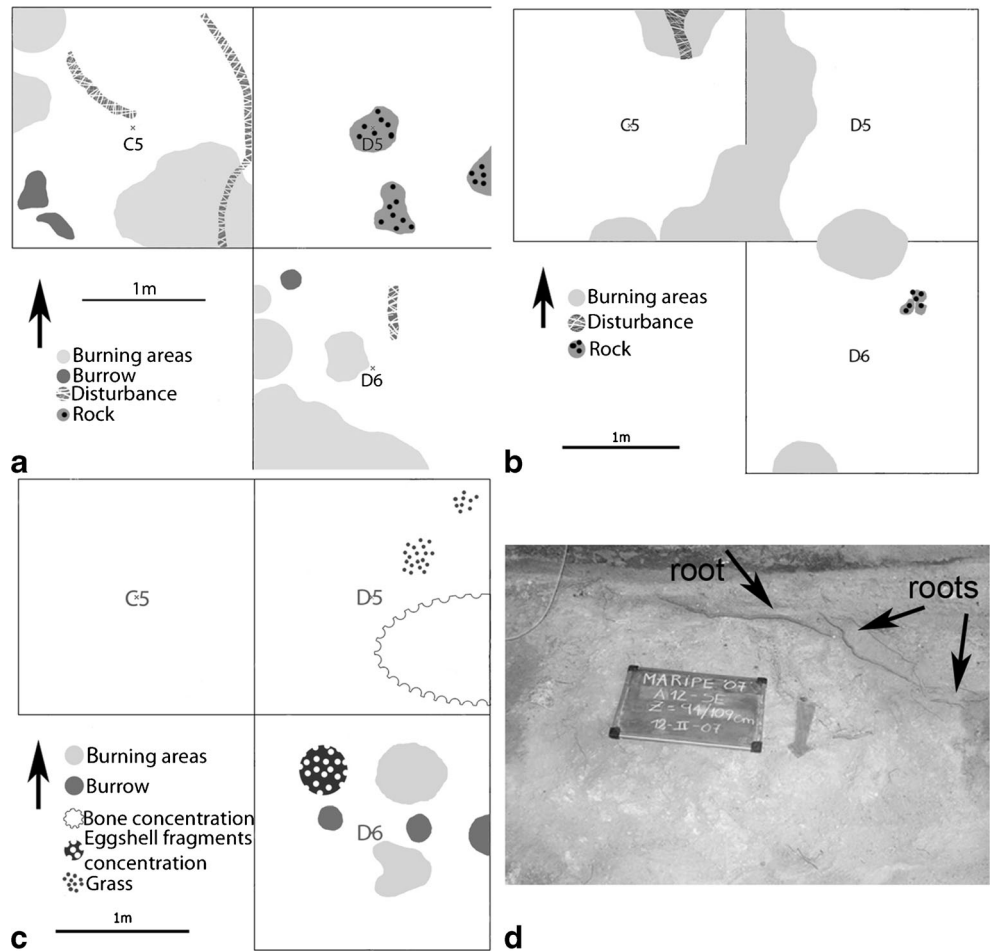
During the excavation, burrows were recorded in the different layers of the NC (Fig. 4a–c) and in AU 3 and 2 from the SC, which suggests the presence of small rodents or armadillos that may have caused the post-depositional movement of the materials. The presence of roots growing in the slope of the cave was only registered in the three levels of the SC (Fig. 4d).

The analysis of bone modification linked to the pre- and post-depositional processes that can move or scatter the specimens showed, for the Pleistocene-Holocene transition to Early Holocene in Cueva Maripe (Fig. 5), that only 0.8 % of the specimens from the NC registered marks produced by rodents, which may indicate a low incidence of such agents for this assemblage. Despite this, the presence of burrows does not rule out the post-depositional influence of this agent on both assemblages. None of the assemblages showed marks

produced by carnivores or trampling (Fig. 5). This apparent absence of damage by carnivores suggests, along with low weathering, a short period of exposure for these assemblages. While root etching in the NC was very low, this was not registered in the SC, although we found bush roots in the most external square of the SC during excavation (Fig. 5).

In the Middle Holocene, we found that less than 1 % of the specimens had been modified by carnivores in the NC while in the SC such modifications were not registered (Fig. 5). This suggests, as in the previous period, that the carnivore post-depositional action on the assemblages may have been of little significance. No trampling was observed, and although root etching in specimens from both chambers was rare, roots were found in a small sector of the SC (Fig. 5). Rodent marks were only found in the assemblages from the NC, though in small numbers, and these could be linked to the existence of burrows found during excavation (Fig. 4c).

Fig. 4. a–d Taphonomic signs registered during the excavation of Cueva Maripe site



As regards the assemblages from Middle to Late Holocene, among the recorded natural modifications, the presence of rodent marks in layers 2 and 3 from the NC was higher than in the lower levels (Fig. 5), which

suggests that this agent was more significant in the superficial levels. In relation to the SC assemblage, carnivore, rodent and root marks were identified in less than 1 % of the bone specimens (Fig. 5).

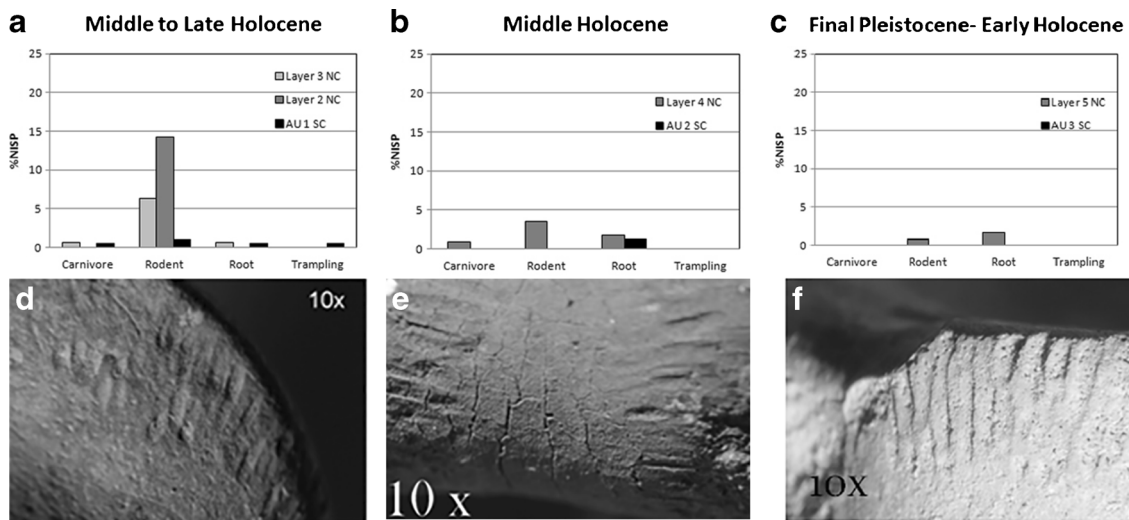


Fig. 5 Bone modification registered in Cueva Maripe site. **a** Middle to Late Holocene. **b** Middle Holocene. **c** Pleistocene-Holocene transition to Early Holocene. **d–f** Rodent marks registered in specimens of each temporal block, respectively

Table 3 Taxonomic abundance in AEP-1 site

	Pleistocene-Holocene transition to Early Holocene				Middle Holocene	
	Layer 6		Layer 4/5		Layer 2	
	NISP	%NISP	NISP	%NISP	NISP	%NISP
NSP	219		1038		2399	
Unionidae	0	0.00	0	0.00	1	0.16
Mollusca	0	0.00	0	0.00	3	0.48
Birds	5	6.58	39	4.21	67	10.77
Rheidae bones	4	5.26	57	6.15	55	7.91
Rheidae eggshells	0	0.00	0	0.00	68	9.85
<i>Zaedyus pichiy</i>	0	0.00	0	0.00	3	0.48
<i>Conepatus</i> sp.	0	0.00	0	0.00	1	0.16
<i>Canis</i> sp.	6	7.89	7	0.76	5	0.80
<i>Mylodon</i> sp.	6	7.89	0	0.00	0	0.00
<i>Hippidion saldiasi</i>	15	19.74	0	0.00	0	0.00
<i>Lama gracilis</i>	28	36.84	3	0.32	0	0.00
<i>Lama guanicoe</i>	12	15.79	821	88.57	487	78.30
NISP total	76	100	927	100	690	100

The refitting studies were performed on all assemblages from this site. We found mechanical and anatomical refitting within each assemblage, but we did not register refitting either between different assemblages from each chamber or among assemblages from different chambers.

In AEP-1 site, we found a similar trend as in Cueva Maripe regarding taxonomic abundance with guanaco being the most commonly represented species in the site over time (Table 3). However, here, we found a greater number of bone specimens and eggshell fragments of Rheidae than in all the other assemblages. Additionally, in the early assemblages, we registered the existence of extinct fauna, none of which was present in Cueva Maripe site. In AEP-1, there was also a significant

percentage of mammal specimens among which the presence of large mammals stood out.

The analysis of guanaco anatomical abundance based on the %MAU value showed a general trend towards a greater frequency of appendicular elements in the assemblages from layers 6 and 2 (Fig. 6) (Marchionni 2012, 2013; Marchionni et al. 2010; Miotti and Marchionni 2014; Miotti et al. 1999). In terms of axial skeleton representation, this was lower, with the exception of the assemblage from layer 4/5 that showed a greater representation of these anatomical parts, mainly thoracic and lumbar vertebrae (Fig. 6). Both within the Pleistocene-Holocene transition and between this first temporal phase and the Middle Holocene, we could observe a change in connection with the guanaco anatomical parts that

Fig. 6 Guanaco anatomical abundance in AEP-1 site

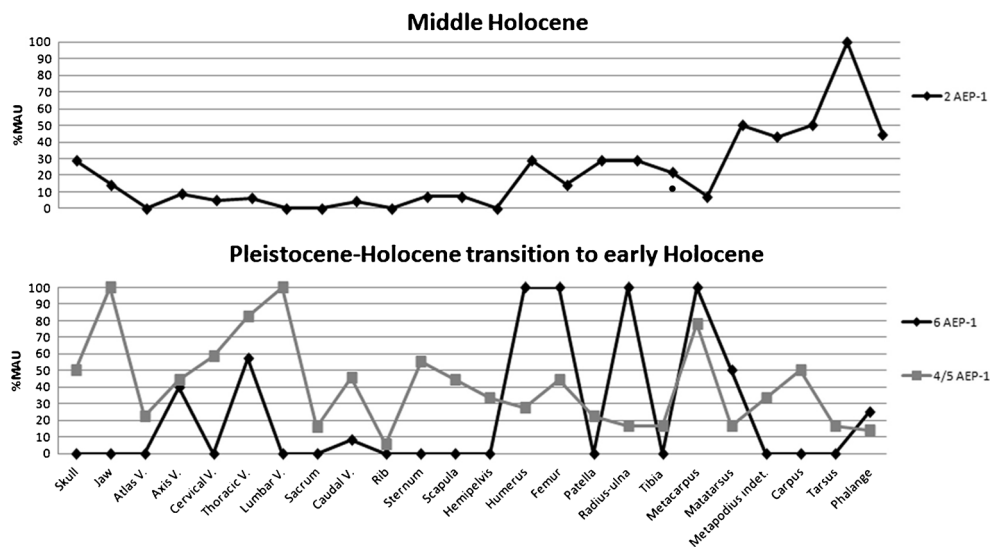
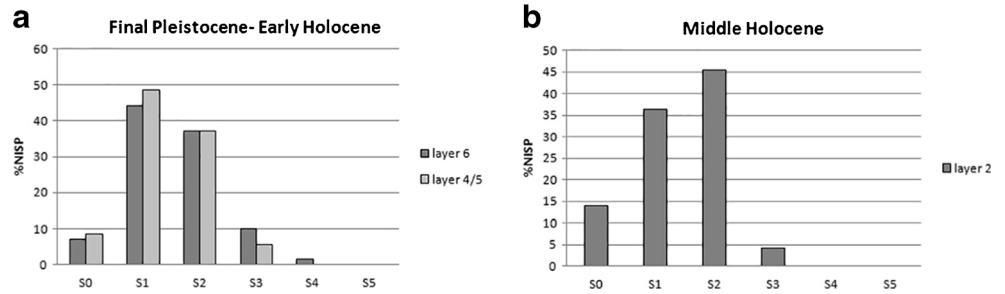


Fig. 7 a, b Weathering stages (S) sensu Behrensmeyer (1978) in AEP-1 site



were transported to the site and which could be clearly seen in layer 4/5.

We observed low weathering (≤ 2 stage sensu Behrensmeyer 1978) in the three assemblages from AEP-1 (Fig. 7), but among these, the assemblages from the lower component registered the highest weathering. This showed that the oldest and most affected assemblages had worse preservation but little bone loss, mainly in the assemblage from layer 6.

In the Pleistocene-Holocene transition to Early Holocene, the low frequency of carnivore marks observed (Fig. 8) may suggest that the pre-depositional action was not very significant, and layer 6 showed a slightly higher number of such marks than layer 4/5.

Although few rodent marks were recorded in bone specimens from layer 4/5 (Fig. 8), and despite the absence of burrows, we cannot rule out the possibility that these marks may have been made post-depositionally. Root etching was found in about 10 % of the specimens in both assemblages (Fig. 8). A key aspect linked to layer 4/5 is the presence of jointed

anatomical parts. Likewise, based on the different refitting performed in previous works between layers 4 and 5, these two layers were unified, as no specimens could be refitted with those in layer 6 (Miotti et al. 1999).

As regards the Middle Holocene, we found that while root etching was registered in about 20 % of the specimens, carnivore and rodent marks were observed on a very low number of specimens (Fig. 8). Layer 2 showed that mechanical refitting was the most common and no bone specimens were registered in this layer that could be refitted with bone specimens from other layers.

Comparison and discussion of inter-site variability

Upon integrating the standardized frequencies of bone modification linked to agents or processes that can re-deposit or move bones with other modifications involved in the taphonomic history of these assemblages (Marchionni 2013; Marchionni et al. 2012), we found

Fig. 8 Bone modification registered in the AEP-1 site. a In layer 2. b In layers 6 and 4/5. c, d Root etching in bone specimens from layer 2. e–g Damage by carnivores in layers 4/5 and 6

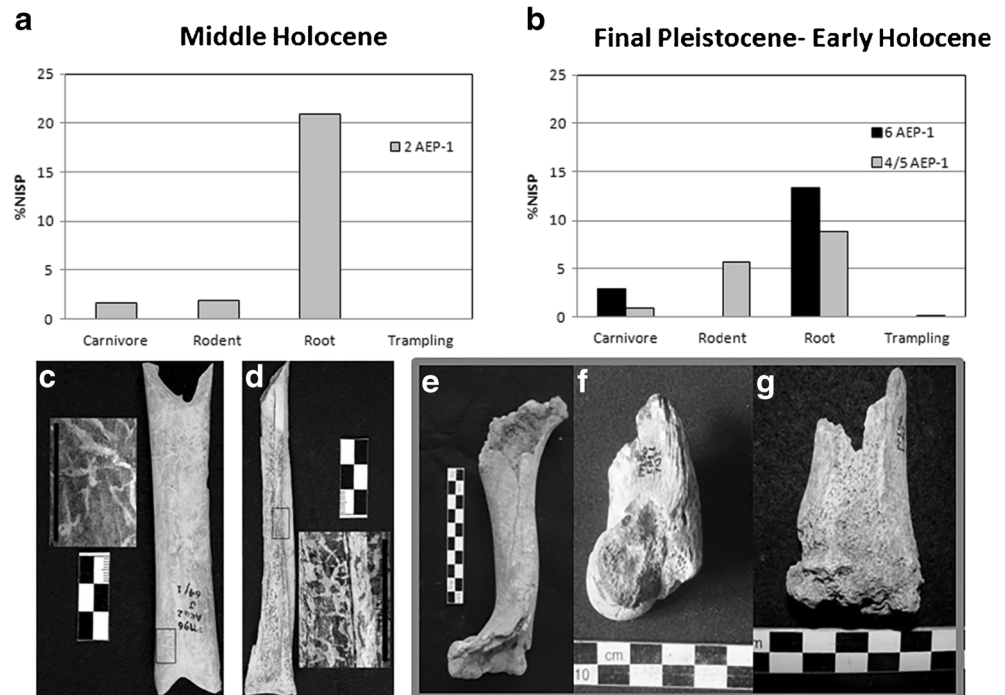
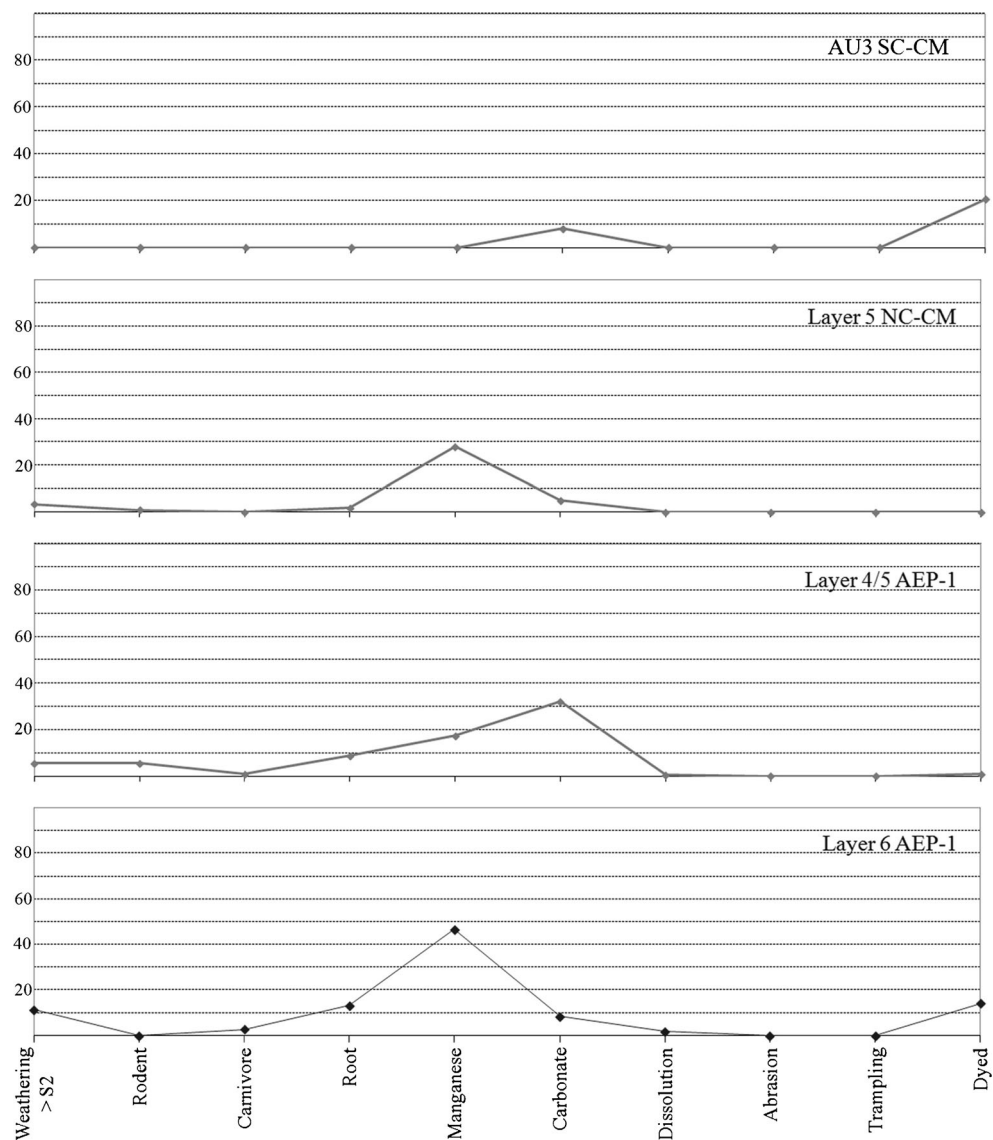


Fig. 9. Taphonomic variability in the Pleistocene-Holocene transition to Early Holocene from the Zanjones Rojo and Blanco Basin. The frequency is expressed in %NISP value



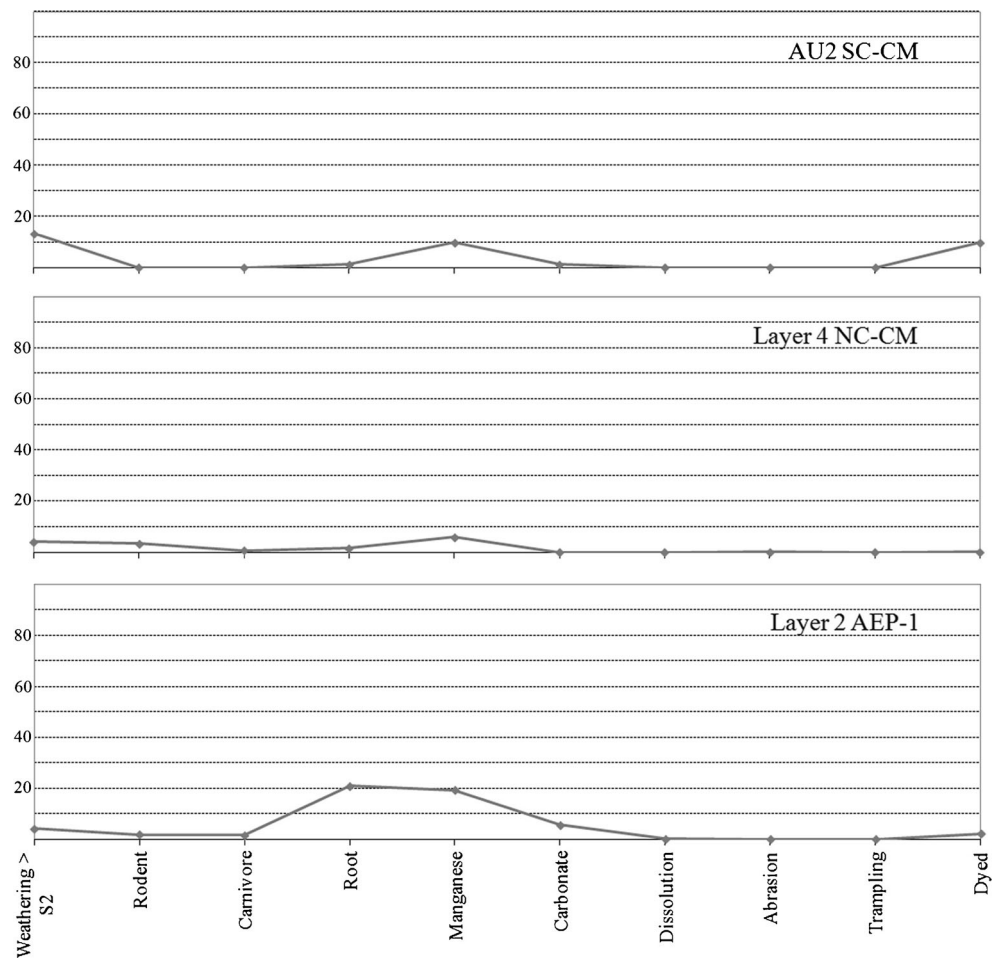
that the indicators of bone movement had little significance in both sectors of the basin (Figs. 9, 10, and 11). This suggests that while different agents could modify the assemblages affecting their preservation, the probability of having been redeposited is low.

In connection with weathering among the assemblages from Final Pleistocene to Early Holocene in the basin (Fig. 9), we registered the highest relative time of exposure in layer 6 from AEP-1, and therefore, taphonomic agents and processes are more likely to have been involved before the assemblage was buried.

For this period, the greater frequency of bone modifications corresponded to manganese and carbonate deposits (Fig. 9) and root etching, which were more represented in AEP-1 than in Cueva Maripe, with the exception of layer 5 of the NC where there was a high number of specimens with manganese (Fig. 9). These modifications suggest the existence of post-

depositional humidity. While in AEP-1, these can be associated with the recorded pedogenetic process, in layer 6, these may also have been the result of the variation of the water table. In the NC profile, the presence of open gravel and a collapse on the surface could indicate the possibility that shallow water has affected the NC bone assemblage in the past as a result of inside cave filtration. However, we did not register aligned bone specimens or bone concentrations which make us suspect that the bones may have been transported by water, and nor did we observe signs of abrasion on the bones. At both sites, the carbonate and manganese deposits could have partially obliterated other modifications. Despite the high occurrence of dense carbonate deposits in the assemblage from layer 4/5 from AEP-1, cut marks were still clearly identified (Marchionni 2013; Miotti et al. 1999). This carbonate can be related to the decomposition of the collapsed coquinoïd by pedogenesis. This collapse may have acted as sealing between

Fig. 10. Taphonomic variability in the Middle Holocene from the Zanjones Rojo and Blanco Basin. The frequency is expressed in %NISP value



both components and serves as evidence to rule out the possibility of vertical migration processes. This idea is supported by the absence of refitting between both levels (Miotti et al. 1999).

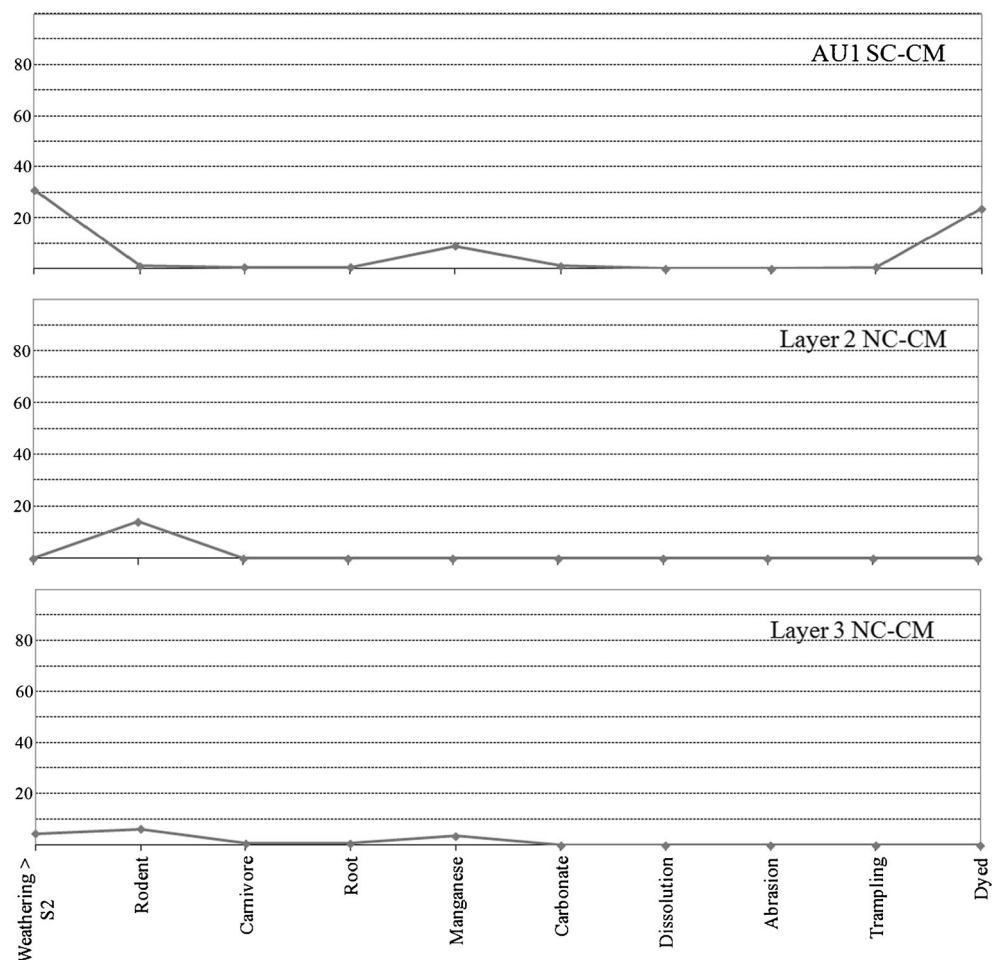
Although the representation of small roots is low (Fig. 9), they appear as the most likely agent in terms of redeposition. However, we cannot rule out the fact that they may have produced a slight alteration of the contexts or some taphonomic fragmentation of specimens. Even though we did not find any traces, other agents, for example rodents or carnivores, could also have modified the assemblages post-depositionally.

Among the cultural modifications registered for this temporal period, all assemblages showed the presence of cut marks, a high percentage of anthropogenic fractures with associated attributes such as impact points, percussion and scraping marks, as well as thermal alteration (for further details see Marchionni 2013; Marchionni and Vázquez 2012; Marchionni et al. 2012; Miotti and Marchionni 2013; Miotti et al. 1999). These were registered in greater frequency in Cueva Maripe, which suggests the existence of greater butchering activity in this site (Marchionni 2013).

This comparison allows us to recognize that the greater variety and number of natural modifications were registered in AEP-1, which indicates lower archeological integrity in AEP-1 than in Cueva Maripe for this temporal block. However, we believe that none of the modifications registered in both sites evidence significant problems in relation to archeological integrity. We think that the main difference registered in the formation history of both deposits is more closely related with the development of human activity, such as killing and primary processing in site AEP-1 and domestic activities in Cueva Maripe, and the specific features of each archeological site rather than with the differential survival of these assemblages.

In the Middle Holocene, weathering profiles showed the lowest preservation for the assemblage of AU2 from Cueva Maripe (Fig. 10). As in the previous temporal block, root etching and manganese and carbonate deposits are the most common natural modifications, which are most widely represented in the lower basin (Fig. 10). The higher presence of root etching in AEP-1 may be linked to the fact that the conditions of the lower basin may have been more stable, favoring the

Fig. 11 Taphonomic variability from Middle Holocene to Late Holocene in the ZanjonesRojo and Blanco Basin. The frequency is expressed in %NISP value



development of vegetation. The small number of carnivore and rodent marks could indicate that these agents would not have had substantial influence on the assemblages. The few marks produced by rodents in the NC of Cueva Maripe could have been post-depositional due to the presence of burrows, and therefore, we cannot rule out the existence of some minor bone displacement. While the greater number of processing marks shows the clear role of humans in the formation of these assemblages, these marks were more varied and frequent in the NC of Cueva Maripe (Marchionni 2012, 2013; Marchionni et al. 2012; Miotti and Marchionni 2009, 2011, 2013).

In the SC, we registered the highest weathering from Middle to Late Holocene (Fig. 11), which also showed the highest number of fragments affected by taphonomic processes. Taking this into account, we believe that this assemblage may have had the lowest archeological integrity.

In both sectors, an extensive record of butchery marks was described (Marchionni 2013; Marchionni et al. 2012; Miotti and Marchionni 2013) but the frequency was higher in the NC than in the SC, which shows the development of different stages of human processing of prey.

Final remarks

This work provides a first approach to studying “bone movement in space” in the Central Plateau and, in this sense, it offers new data for the region that should enable us to compare the taphonomic information from the northeast of Santa Cruz Province with neighboring regions where taphonomy is a well-developed discipline. Although much remains to be done in terms of the complexity of the formation history of these contexts, we can propose some ideas to be evaluated in the light of new research, such as the following:

Based on the indicators studied here, we found a very low probability of pre- and post-depositional movement of bones which may have been significant in the formation history of the context of the basin. It must be evaluated by new studies that include actualistic research, since the frequency of marks cannot be a good indicator of agent intensity on the assemblages.

Among the processes and agents studied here, the most relevant ones in connection with bone movement appear to be roots and rodents which may have taken part in the formation of assemblages during both bioestratinomy and

diagenesis. While the first was more significant in the site formation processes registered in the upper level of the basin, the last was more important in the lower level, where the presence of caves suggests action during diagenesis. Regarding the taphonomic history in the different sectors of the basin, we found that alterations like manganese and carbonate were the most important affecting the preservation during the diagenesis of the assemblages.

Both refitting and the presence of jointed anatomical parts suggest a low probability of bone redeposition and dispersion in both sites (Marchionni 2013; Marchionni et al. 2012; Miotti et al. 1999). The collapsed roof in AEP-1 may have acted as sealing, preventing migration between both components.

The compressed stratigraphic sequence in the SC in addition to a lack of clear limits between the strata, a constant variable condition of humidity that is evidenced by the spring and specimens with manganese, and the systematic presence of bones dyed by manganese or fire indicate that among all of the studied sectors, the SC from Cueva Maripe site registered the highest complexity of the basin, and it is where migration processes are more likely to have occurred.

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