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First evidence of an underwater Final Pleistocene terrestrial extinct faunal bone assemblage from Central Chile (South America): Taxonomic and taphonomic analyses

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ABSTRACT

Site GNL Quintero 1 (GNLQ1), located in Quintero Bay (32°S, Central Chile) constitutes the first evidence of a drowned terrestrial site on the continental West Coast of South America covered by sea-level rise after the Last Glacial Maximum. The site currently lies 650 m offshore and 13 m underwater, covers an area of ~64 m^2 and contains several discrete exposed and shallow-buried bone deposits. Through underwater archaeology survey and test excavations, a significant amount of animal bone assigned to the Late Pleistocene was successfully recovered and analyzed. After recovery and prior to the analyses, the bones were subjected to conservation and stabilization treatments, resulting in good preservation of the material. Taxonomic analyses (NISP 224) revealed high taxonomic diversity of extinct fauna (Camelidae, Cervidae, Artiodactyla, Equidae, Mylodontidae, Canidae, Rodentia and Xenarthra). The sample represents a continental faunal assemblage belonging to a drowned terrestrial context, probably related to an estuarine-lagoon environment. Taphonomic analysis allowed macroscopic identification of natural marks (punctures) associated with large and small size carnivores. The bones also show abrasion related to the action of marine sands along with colour alterations. By applying Scanning Electron Microscope (SEM) micrographs and Energy-Dispersive Spectroscopy (EDS) to fossil bones, marks and colour alterations were identified. Marks indicated rodent gnawing and trampling, while colour alterations were attributed to diagenesis processes, discarding thermal treatment. Site GNLQ1 is identified as having very high potential, for it provides the first evidence for a submerged palaeolandscape viable for human occupation and movement along the Pacific Coast of South America during the Late Pleistocene.

1. Introduction

The increasing interest in the study of submerged prehistoric sites has been driven in part by accumulating evidence demonstrating the preservation of archaeological sites and landscapes underwater. Another motive for this is a growing recognition of the potential importance of coastal environments for prehistoric adaptations, subsistence and migration pathways (Cliquet et al., 2011; Faught and Gusik et al., 2011). The search for terrestrial sites covered by marine transgression during the Late Pleistocene has become particularly relevant in the light of the models used to explain the initial peopling of the continent. Recent projects in North America have focused on locating evidence to support a hypothesized Pleistocene coastal migration along the Pacific coast (Goebel et al., 2008; Dillehay, 2009). So far, research on the eastern coast of the Americas has been successful in the identification of inundated sites, as the eastern coast of North, Central and South America exhibits large areas of low slope continental shelf. In particular, diagnostic artefacts of Late Pleistocene to mid-Holocene human occupations have been found in drowned sites located in Florida (Dunbar et al., 1991, 1992; Faught, 2002, 2004; Faught and Gusik et al., 2011). In addition, recent work in the karst caves of Yucatán have identified human remains dated 9000 cal BC (González et al., 2008; Faught and Gusik et al., 2011).

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However, the western coast of the Americas exhibits narrower continental shelves, active volcanism and tectonism and high-energy marine conditions, with fewer situations favourable to preservation, except in bays, inlets and island clusters (Faught and Gusik et al., 2011). Successive research undertaken in British Columbia demonstrated that the exposed shelf edge was available for human occupation and may have served as a migration route during time of lowered sea levels between 13,500 and 9500 BP (Josenhans et al., 1997). A single basalt flake tool was discovered, recovered from a drowned delta flood plain, providing tangible evidence that the exposed continental shelf encompassed a landscape viable for human occupation and movement before 12,200 BP (Fedje and Johansen, 2000).

The majority of the evidence is currently submerged by the rise in sea level which inundated coastal landscapes. These now covered by the sea were available for human occupation by early coastal adapted groups or by terrestrial hunter-gatherers that used valleys and estuaries (Richardson, 1981; Sandweiss, 2003; Bonnichsen and Sorg, 1989).

In the study area, the early known occupations of Central Chile correspond to terrestrial hunter-gatherers sites, mainly distributed in two large regions: one in the southern extreme of the semi-arid north of Chile (~31°S) and the other, in the basin of Tagua Tagua in Central (~34°S). Both the Santa Julia site (13,156–11,046 cal BP, Méndez, 2011: Table III.1) and Tagua–Tagua 1 and 2 (13,260–12,890 cal BP and 11,731–11,090 cal BP respectively, Méndez, 2011: Table III.1) contain extinct faunal remains associated with a rich artifact assemblage. However, in the semi-arid northern region substantial recovered evidence suggests a rather discrete but recurrent human occupation of a well-delimited area during the Late Pleistocene (Méndez, 2011).

The recovered extinct faunal assemblage constitutes the first evidence of a drowned terrestrial site on the Pacific continental shelf of South America. In this context, site GNLQ1 is identified as having very high potential, for it provides the first evidence for a submerged palaeolandscape viable for human occupation and movement along the Pacific Coast of South America during the Late Pleistocene. However, one common problem in investigating Late Pleistocene archaeological sites which frequently produce few artefacts is the absence of diagnostic evidence of cultural modification of animal bone material, making the issue of identifying natural and/or cultural formation processes affecting bone assemblages difficult. Moreover, this particular case is drowned terrestrial site where assemblages had been exposed to other sources of modification such as post-depositional disturbance related to the effects of sea-level transgression.

2. Site GNLQ1

Site GNLQ1 is located in Quintero Bay, located ~50 km north of Valparaíso (Fig. 1). This is a shallow bay, roughly oriented NE with a maximum recorded depth of 55–60 m. The nearshore bathymetric profile shows a steeper slope in the first ~250 m from the coastline and then a decreasing inclination to 1600 m (Fig. 1). There are some streams that drain into the bay, with permanent to perennial flow, which generate lagoons and/or wetlands trapped by sandbars resulting from coastal hydrodynamic activity (Vargas and Ortega, 2008). The resulting structural context is a shallow bay with gentle sloping nearshore bathymetry with little sediment yield from rivers.

The site, located 650 m offshore and 13 m underwater, was discovered in 2005 during archaeological diver surveys conducted as part of a Cultural Resource Management (CRM) project. Several discrete exposed and shallow-buried bone deposits were identified by hand fanning that extended ~5 cm below the seafloor.

In this context, a series of subsurface test excavations and mechanical coring samples were conducted in 2007 at several targeted points distributed across transects within an area of 40 × 25 m (ARKA Consultores, 2008). In particular, one well-delimited bone concentration barely visible on the sea bed was selected and sampled through a test excavation 1 × 1 m unit (Unit K8) (Fig. 2). The excavation was carried out using a 7.5 cm water dredge, and sediments sifted. Skeletal remains were exposed by careful excavation and recovered with their sedimentary matrix in order to be micro-excavated in laboratory, thereby minimizing loss of information and physical deterioration potentially caused by extraction.

A total of 224 bone specimens were recovered (Cartajena and López, 2008; Cartajena et al., 2011) (Table 1). The remains belong mainly to excavation unit K8_2 (Level 1, Concentrations 1, 3 and 6) (Fig. 2).

Table 1
Distribution of recovered bones in survey and excavation units.

Survey and excavation unit	Level	Bone concentration	NISP	%NISP
K8_2	1 (0–10 cm)	1	175	78,1
K8_2	1 (0–10 cm)	2	5	2,2
K8_2	1 (0–10 cm)	3	13	5,8
K8_2	1 (0–10 cm)	5	1	0,4
K8_2	1 (0–10 cm)	6	17	7,6
K8_2	1 (0–10 cm)	7	2	0,9
K8_2/K8_1	1 (0–10 cm)	1	5	2,2
K8_2	Cleaning	–	1	0,4
K4-Surface	Surface	–	2	0,9
K7-Surface	Surface	–	2	0,9
Core	Surface	–	1	0,4
Total	–	–	224	100

In particular, one core (T1) was selected for sediment analyses and recorded a complete stratigraphic sequence for the site, with three stratigraphic units exhibiting clearly different sedimentological features: Units 1, 2 and 3, from younger to older. Unit 1 contains brown well-sorted fine sand. Unit 2 is formed by an orange and grey clayish gravel clast-supported conglomerate with microcrystalline quartz (chalcedony), some exhibiting a charcoal patina, in a fine sand-silt matrix. In the higher and lower parts of this unit milimetric charcoal lenses are present. Unit 3 consists of brown and orange fine clayey sand. The animal bones were recorded in Unit 2, horizontally distributed over an extensive area and in both clear and direct association with charcoal lenses present within the upper 5 cm of Unit 2 (Vargas and Ortega, 2008) (Fig. 3).

Once micro-excavated at the laboratory, the structurally sound recovered bones underwent a conservation treatment aimed to remove the soluble salts in order to make the material stable. The salts were diffused out by rinsing in successive baths of water, starting with 100% sea water and increasingly incorporating fresh water (local tap water) until pure fresh water was attained. Distilled water was then substituted for the fresh water until the soluble salts were removed. Soft wooden tools and brushes were used to prevent surface damage (ARKA Consultores, 2008).

Unfortunately, two selected taxon samples for radiocarbon analyses could not be dated due to the lack of collagen. For this reason the sedimentary matrix containing the bones was ^{14}C dated (Fig. 3) at 13,640 ± 40 BP (UGAMS#9194, $\delta^{13}C$, ‰ −25,4) (16,716–16,878 cal. BP). Jackson et al. (2003) obtained a similar date for a surface deposited *Mylodon* sacrum associated with lithic

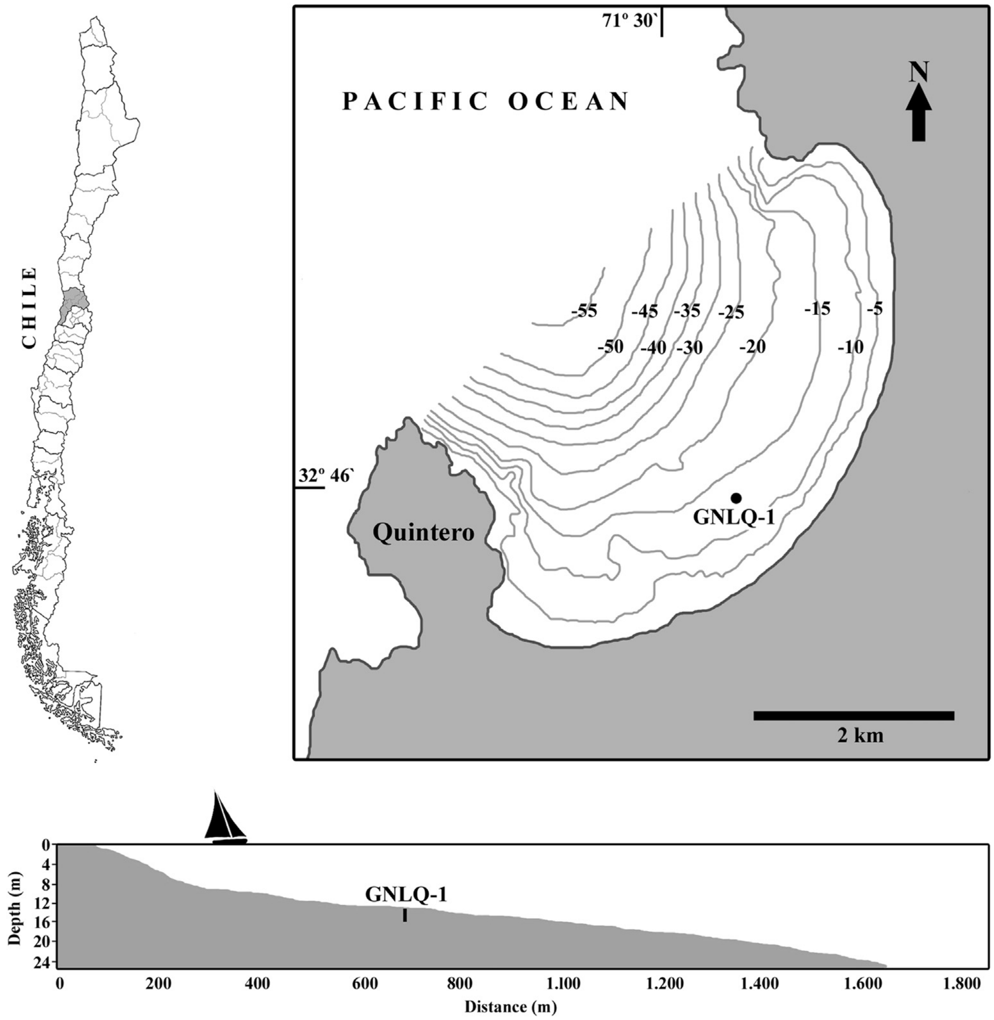

Fig. 1. Location of site GNLQ1 in Quintero Bay and bathymetric contour map. The bathymetric profile of the site can be seen below. (Figure taken and modified from Vargas and Ortega, 2008.)

remains in a nearby area (Los Vilos, LV 105): 16,677 cal BP (Méndez, 2011).

3. Taphonomy, Scanning Electron Microscope (SEM) and Energy-Dispersive Spectroscopy (EDS) analysis

In general, very little is known about taphonomic processes in the aquatic media (Bishop, 1980; Hanson, 1980). Taphonomic processes affecting terrestrial contexts is better understood (Behrensmeyer, 1978; Behrensmeyer and Hill, 1980; Binford, 1981; Haynes, 1983a,b; Bunn et al., 1988; Blumenschine, 1995; Borrero and Martin, 1996; Domínguez-Rodrigo, 1999; De Ruiter and Berger, 2000). On the other hand, very few studies have addressed these issues in drowned sites (Waters, 1992; Stright, 1995; Stewart, 1999). In order to study submerged late Pleistocene fauna, Dunbar et al. (1989) suggest considering (i) the cultural modifications in fresh bones synchronous with the death of the animal, (ii) natural modifications prior to deposition, (iii) natural post-depositional modifications such as the natural modifications within the sediment–water interface, and (iv) post-excavation alterations due to changes in the bone's environment.

Although cultural associations were not observed within the extinct fauna assemblage, charcoal particles were found in the sedimentary matrix. Several recovered skeletal remains showed a dark staining similar to that resulting from fire exposure (Shipman et al., 1984; Stiner et al., 1995; Shahack-Gross, 1997; Hanson and Cain, 2007). However, very little is known about colour alterations on bones in submerged settings (Bell and Elkerton, 2007).

In order to determine the modification agents of the fossil assemblage, microscopic analyses were performed using a scanning electron microscope (SEM). These enabled the observation of the micromorphology of marks and the possible structural and morphological damage to the surface and osseous matrix of the bones. In addition, Energy-Dispersive Spectroscopy (EDS) was used to identify diagenetic alterations on the fossil sample based on X-ray analysis. The use of EDS in GNLQ attempted to identify external elements to the original composition of bones (see López et al., 2011). Microscopic analysis was performed using scanning electron microscope (Jeol 5410©), X-ray spectrometer and the software Anamaker © for the spectrometric images.

Bones exhibiting macroscopical marks, fine parallel grooves, transversal or diagonally oriented, whose distribution and location could be related to cut marks were selected. Moulds of a Canidae calcaneus, an undetermined mammalian rib, and an apophysis of a cervical vertebra were made by using dental silicon (C type

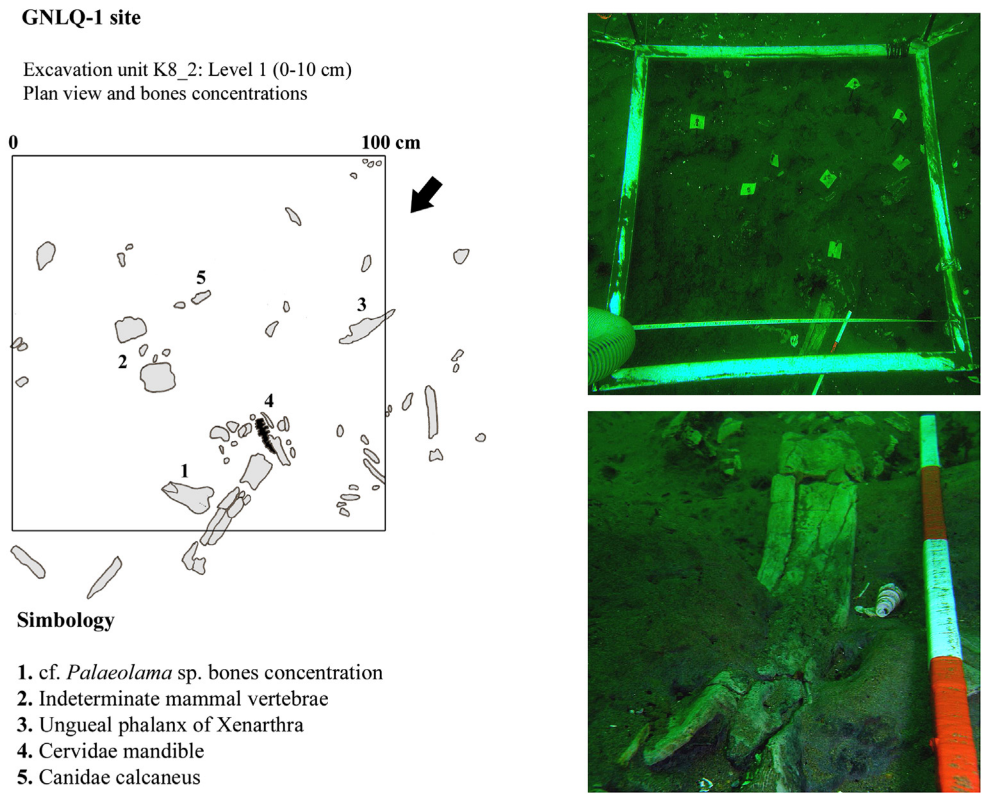

Fig. 2. View of site GNLQ1. Excavation unit K8_2 with bones *in situ*. Plan view and bone concentrations of excavation unit K8_2, level 1 (0–10 cm).

silicone) moulds, and selected marks were replicated by using epoxy resin.

To observe the structural and morphological modifications on the bone surface and the osseous matrix due to heat effect, bones of the fossil assemblage that showed no colour alterations or a light grey colour were contrasted with burned bone patterns obtained by controlled experiments (Bonucci and Graciani, 1975; Shipman et al., 1984; Nicholson, 1993; Pijoan et al., 2007; López et al., 2011). Samples of a cf. *Palaeolama* sp. humerus were selected which when observed underwater exhibited a dark colour, associated with charcoal particles. In addition, a fragment of a non-determined mammal diaphysis, with no macroscopically visible colour alterations was selected. The samples were covered with a gold film to avoid conduction problems and were studied at ×100, ×500 and ×2000. EDS was used to identify exogenous elements which are not part of the original structure of the bones resulting from diagenetic processes.

4. Taxonomic composition of the faunal assemblage

In order to establish the taxonomic determination of the remains, both modern and paleontological reference collections were used (Department of Anthropology at Universidad de Chile, Laboratorio de Estudios de Arqueología y Patrimonio (LEAP), Universidad Internacional SEK-Chile and Quereo site colletion, Archaeological Museum of La Serena city). Finally, in the case of the Xenarthra remains, the paleontological material available in Chile for comparative purposes is scarce. However, material corresponding to *Megatherium medinae* y *Glossotherium* at the Museo Nacional de Historia Natural of Santiago was used for the anatomical identification of the remains.

The preservation of the bone assemblage is very good. Nevertheless, some specimens show signs of initial states of weathering such as longitudinal cracks in diaphysis fragments, which could have affected the fragmentation of the assemblage, particularly splinters (27% of the whole sample) and flat bone fragments (17% of the whole sample) (Table 2). A significant percentage of the assemblage was reassembled, despite the erosion of the bone edges due to the constant action of water and abrasive sediments characteristic of the site's depositional environment (Fig. 4A).

Table 2
Taxonomical and Anatomical unit representation, expressed in NISP and MNI.

Anatomical unit	NISP	%NISP	MNI
Mammalia indet.			
Bone splinters	61	27,2	–
Flat bones	40	17,9	–
Minimal fragments	31	13,8	–
Fragments of long bones	2	0,9	–
Identified bones	14	6,3	–
Artiodactyla			
Skull fragment	1	0,4	1
Deciduous molar	1	0,4	1
cf. Palaeolama sp.			
Distal humerus	1	0,4	1
Radius-ulna	17	7,6	1
Fourth carpal	1	0,4	1
Tibia	4	1,8	1
Cervidae			
Left mandible	13	5,8	1
Mandible fragments	20	8,9	1
Right I_3	1	0,4	1

Table 2 (*continued*)

Anatomical unit	NISP	%NISP	MNI
Right Pm_2	1	0,4	1
Right Pm_3	1	0,4	1
Right Pm_4	1	0,4	1
Equidad			
Right P^2	1	0,4	1
Right P^3	1	0,4	1
Xenarhtra			
Right molariform	1	0,4	1
Right molariform	1	0,4	1
Right molariform	1	0,4	1
Ungueal phalanx	3	1,3	1
Dermal bone	1	0,4	1
Canidae			
Calcaneus	1	0,4	1
Canine	1	0,4	1
Cricetidae			
Incisor	1	0,4	1
Ave			
Tibia	1	0,4	
Femur	1	0,4	
Total	224	100	–

Most of the fragments belong to Mammalia indet., which correspond to adult and juvenile large mammals. The identified bones showed a high diversity of terrestrial extinct fauna, including Camelidae, Cervidae, Equidae, Mylodontidae, and Xenarthra. Other remains, such as a selenodont type deciduous molar, have been assigned to Artiodactyla, due to the lack of other diagnostic traits.

The Camelidae family (cf. *Palaeolama* sp.) presents large specimens. The size of the anterior superior extremity (distal humerus and radius-ulna) is similar to *Palaeolama* specimens from the Late Pleistocene Quereo site, located in an area near Los Vilos (31° S) (López et al., 2004) (Fig. 4A and B).

The equidae (Equidae gen. *et* sp. indet.) are represented by a P^2 and a P^3 from a juvenile animal (Fig. 4C). The protocone tends to be oval shaped. However, the juvenile tooth is scarcely developed, preventing assignment to the genus *Hippidion*.

The Cervidae remains belong to a large size cervid comparable to *Antifer* and *Blastocerus* genus. As there is very little information on the systematics of extinct cervidae in Chilean territory (Casamiquela, 1969, 1984, 1999; Labarca and Alcaraz, 2011), the remains are assigned to Cervidae gen. *et* sp. indet. (Fig. 4D).

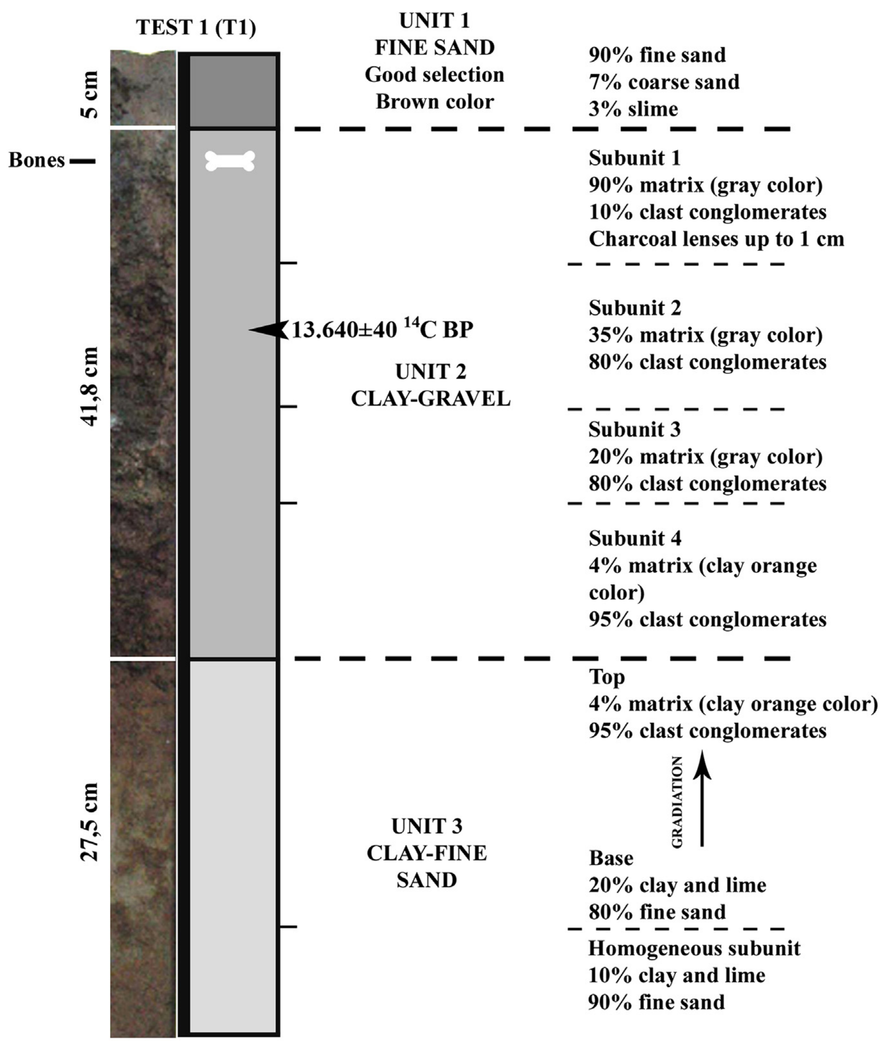

Fig. 3. Core sample T1 showing main stratigraphic units. The location of the bone assemblage and the dating obtained from the sedimentary matrix is shown in profile. (Figure taken and modified from Vargas and Ortega, 2008.)

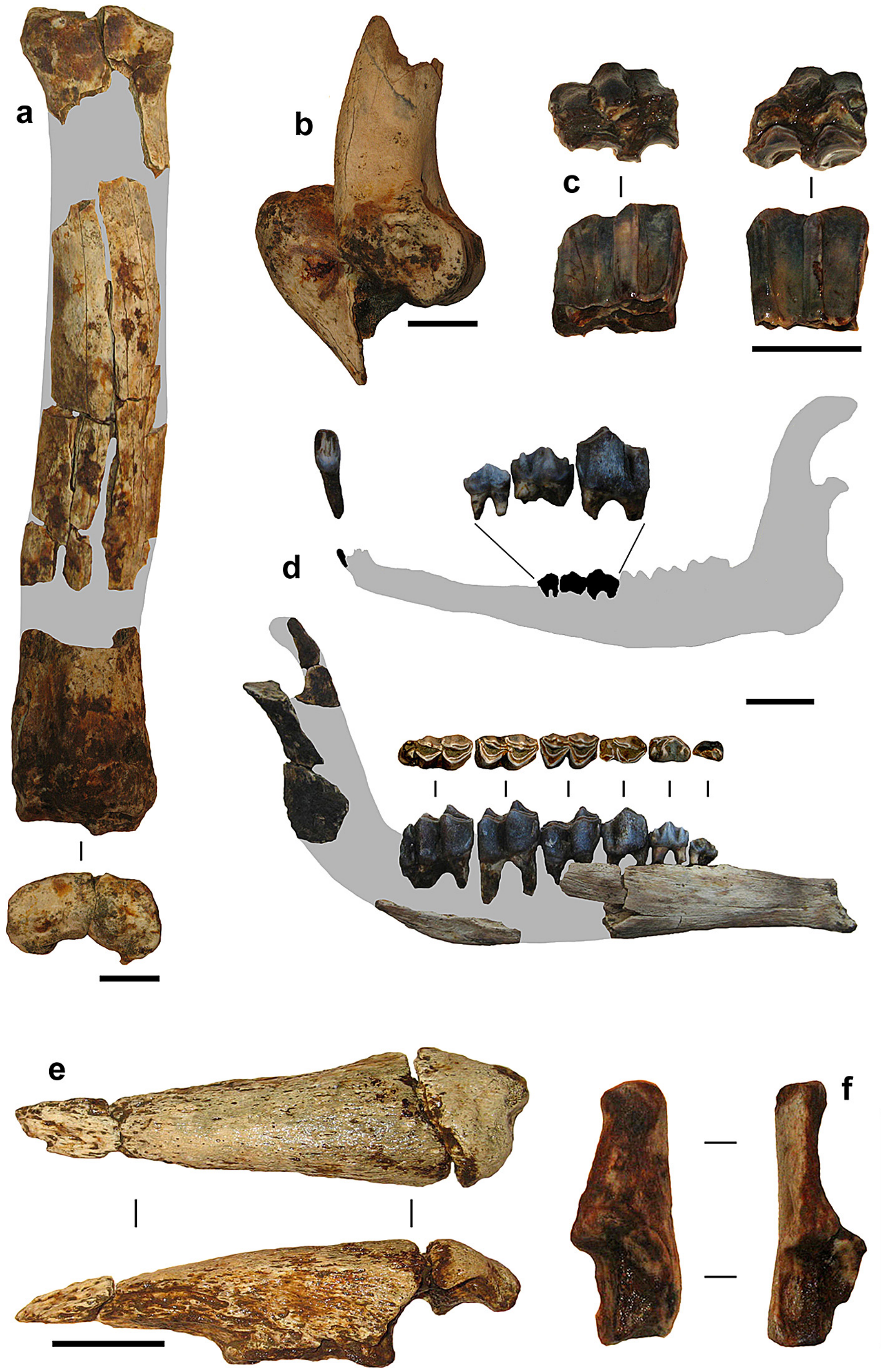

Fig. 4. Skeletal remains recovered from the site GNLQ1: A. radius-ulna fragment from a camelid; B. articulated distal humerus and proximal radius-ulna from a camelid; C. premolars from a young equidae; D. Mandible from a cervidae; E. ungueal phalanx from a xanarthra; F. a Canidae calcaneous (3 cm scale).

The xenarthra bones (Xenarthra gen. *et* sp. indet.) correspond to an osteoderm, the complete sequence of molariforms of the right mandible, and an ungueal phalanx (Fig. 4E). The shape of the occlusal surfaces is similar to species of the subfamily Scelidotheriinae. The absence of diagnostic traits of the ungueal phalanx prevents assignment to a specific family.

A calcaneus and a canine tooth were recovered, whose morphology and size are similar to the present day *Lycalopex culpaeus*. However, due to the scarcity of material, they have been assigned as Canidae gen. *et* sp. indet. (Fig. 4F). In addition, an incisor from a Cricetidae rodent of insufficient taxonomic diagnosis was recovered.

Finally, two bird remains from another excavation unit (K7) were registered. The morphology and size is compatible with specimens from the Phasanidae family.

The extinct faunal records of GNLQ1, cf. *Palaeolama* sp. (Camelidae), Cervidae, Equidad and Xenarthra are similar to those registered in other areas of the coast of the semi-arid North (Los Vilos) and the valley of Central Chile (Núñez et al., 1994a,b; Jackson et al., 2005, 2007; López et al., 2005; Méndez et al., 2005–2006; Labarca and López, 2006; López, 2007) (Table 3). Some of these remains have taxon dates or are associated with ^{14}C dates of organic remains from the Late Pleistocene or the Lujanense Mammal Age (Marshall et al., 1984). The faunal assemblages suggest similar environmental conditions, which favoured the congregation of diverse species around resource concentrated areas such as streams, lagoons, estuaries, fertile plains and wetlands, as seen in the Los Vilos and Tagua–Tagua areas (Núñez et al., 1994a,b; Jackson et al., 2007) (Table 3).

Another alteration common to all the remains is the presence of oxidation stains (99%) due to the interaction of the bones with an interface of gravelly clay sediments and water. This type of alteration is frequent in environments similar to the GNLQ1 site (Dunbar et al., 1989; Noakes et al., 2009; Lowery and Wagner, 2012).

The action of carnivores can be observed in 5.8% of the sample. Despite the low incidence of carnivores on the bone assemblage, they are significant for the understanding of the formation processes of the site. The specimens of cf. *Palaeolama* sp. show the largest quantity of marks caused by carnivores. The distal humerus epiphysis presents two circular perforations which could be attributed to the action of a big sized carnivore (Fig. 5), which show similar characteristics to those observed in extinct mammal remains from various sites recorded on the coast of the area near to Los Vilos (López, 2007). A transversal fracture can be seen on the distal radius-ulna diaphysis which appears to be related also to the action of a carnivore, as two notches are observed on the dorsal surface, similar to the perforations recorded on the epiphysis, with similar distance apart (*ca.* 35 mm) (Fig. 5).

The specific agent has not been clearly identified, although it could be associated with a large carnivore (Borrero and Martin, 1996). Among other damage caused by carnivores, punctures can be seen on the bone fragments and vertebral bodies which are considerable smaller than those described for the cf. *Palaeolama* sp. remains, suggesting the action of small carnivores.

The distal humerus of the cf. *Palaeolama* sp. presents a spiral fracture on the fresh bone. Although this type of fracture can be considered to be typical of that of human activity, diverse analyses determined the degree of ambiguity of this trait, as it can also be the result of natural agents (Myers et al., 1980; Haynes, 1983a,b; Borrero and Martin, 1996). It is important to note the similarity of this specimen to a distal humerus from the nearby site of Quereo interpreted as cultural (López et al., 2004). However, the humerus from GNLQ1 does not show any signs of notches or negatives characteristic of human modifications.

Table 3
Distribution of taxa in Late Pleistocene sites of the coast of Central Chile, the coast of the semi-arid North and the valley of Central Chile. ▲ Presence, ○ Absence. Data taken from: Núñez et al. (1994a,b), Jackson et al. (2005, 2007), López et al. (2005), Méndez et al. (2005–2006), Labarca and López (2006), López (2007).

		Palaeolama sp	*Lama* sp.	Cervidae	Equidae	*Equus (Amerhippus)* sp.	*Hippidion* sp.	Gomphotheriidae	Xenarthra	Canidae	Felidae
Coast of central Chile	GNLQ1	▲	○	▲	▲			○	▲	▲	○
Coast of semi-arid north (Los Vilos)	Quereo	▲	▲	▲	–	▲	○	▲	▲	▲	▲
	Las Monedas	▲	○	○	○	▲	○	○	▲	▲	○
	Santa Julia	▲	○	○	▲	○	○	○	▲	○	○
	Quebrada El Boldo	○	○	○	○	○	○	○	▲	○	○
	Quebrada Lazareto	▲	▲	○	○	○	○	○	▲	○	○
	El Avistadero	▲	○	○	○	▲	○	○	▲	▲	○
	El Membrillo	▲	○	○	○	▲	○	○	▲	▲	○
	Valle de los Caballos-D	▲	○	○	○	▲	○	○	○	▲	○
Central valley	Tagua–Tagua	○	○	▲	▲	▲	▲	▲	○	○	○

The Quintero assemblage shows high taxonomic diversity, mostly similar to that of the Quereo and other sites around Los Vilos. High faunal diversity is found in sites with weakly human evidence (*sensu* Méndez, 2011) like Quereo. On the other hand, sites which exhibit an archaeological context with clear associations and abundant cultural material, such as Santa Julia and Tagua Tagua, produce lower taxonomic diversity.

5. Taphonomic analyses

Among the most common taphonomic alterations of the assemblage is a slight degree of abrasion on the bone surface (99%). Abrasion is homogenous and observed in polish edges and the flat surfaces of the bones. This alteration is to be expected, due in an aqueous environment with abrasive sediment. Weathering affected 87.5% of the sample. This alteration is slight and is concentrated on stages 1 and 2, according to the Behrensmeyer scale (1978). The remains were exposed to terrestrial conditions before they were buried and subsequently flooded. The cf. *Palaeolama* remains showed a more advanced stage of weathering than the rest of the sample, which not only indicates longer periods of exposure, but also suggests that the GNLQ1 site was formed by different depositional events.

The majority of the osseous records show evidence of root marks on the surface (98%). The presence of these marks not only indicates the growth of a vegetation cover over the fossil deposits previous to the marine transgression, but is also a good indicator of the fact that the site was fairly stable. In this regard, the marks are distributed on the upper surface of the bones and less so on the inferior surface, indicating that the bones did not move within the strata in which they were deposited, previous to the transgression of the site.

6. Microscopic analysis

The microscopically analyzed bone surfaces, in one the fossil bones, does not show any alterations (Fig. 6A). However, the other greyish stained sample shows a slightly altered surface (Fig. 6B). For

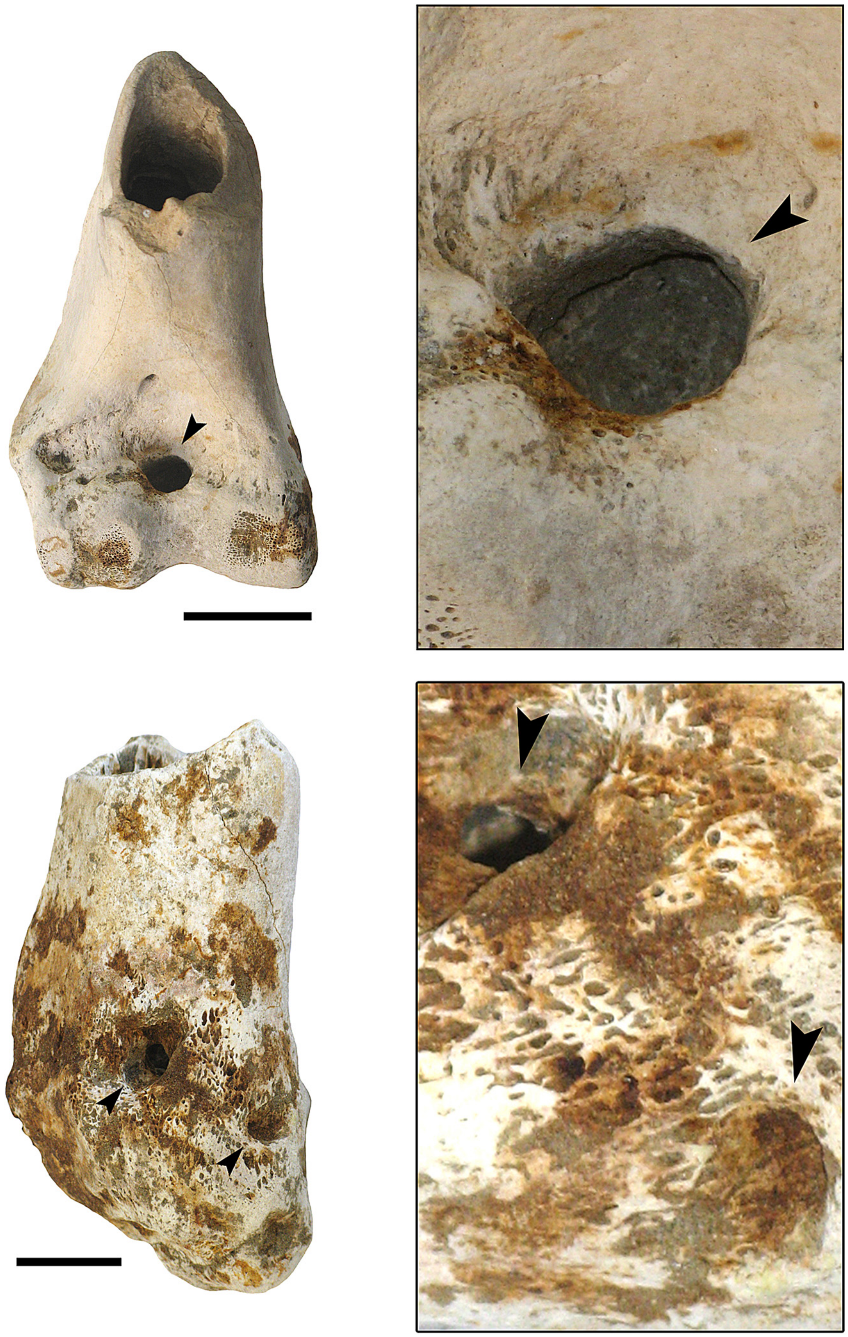

Fig. 5. Distal humerus and radius-ulna with arrow shaped punctures, caused by a big size carnivore (3 cm scale).

this reason, the osseous matrices of the two samples were explored and compared. Both bones have conserved the normal bone morphology and in both, ordered mineralized fibrils could be clearly observed (Fig. 6C and D), indicating that they were not exposed to fire (López et al., 2011).

EDS analysis was also applied to identify exogenous particles from the natural composition of the bone. It was possible to identify spheroidal bodies of pyrite in the osseous matrix of fragments of humerus from the cf. *Palaeolama* sp. (Fig. 6E). X-ray spectrometric images mainly indicate the presence of iron and sulphur (Fe 34%, S 61%). These bodies of pyrite are irregularly distributed in the internal structure of the bone and are located adjacent to the trabecular tissue. Pyrite formation is related to anoxic environments and to the action of sulphur reducing bacteria (Borrego et al., 2003; Saheb et al., 2008; Brown et al., 2010).

Lastly, the analysis of possible cut marks was developed. The micromorphology of the marks in the calcaneus was interpreted as damage due to rodent gnawing. Parallel flat grooves were evident at the micrometer level (Fig. 7A). Marks on the rib and the vertebra correspond to scratches on the surface related to trampling (Fig. 7B).

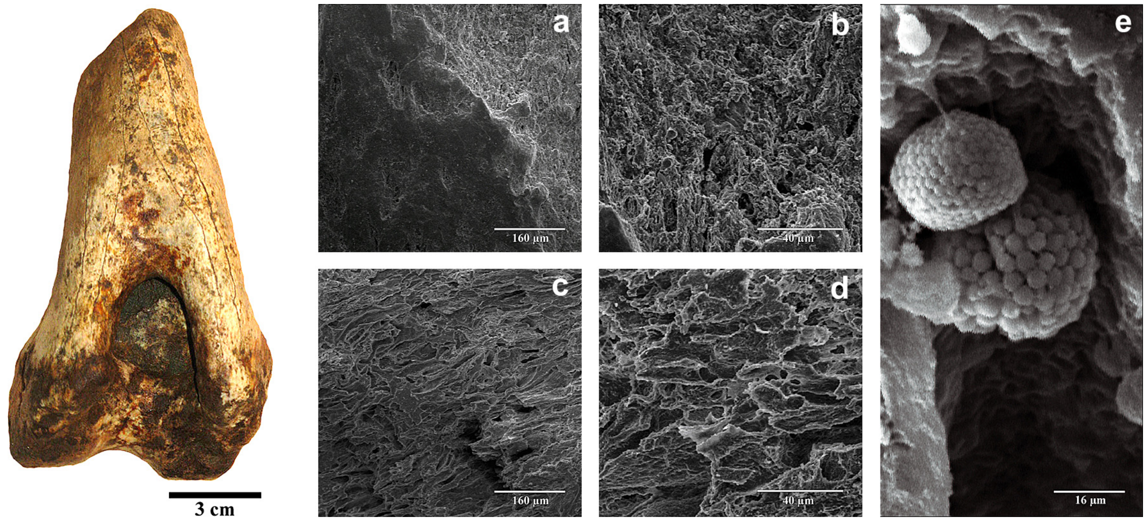

Fig. 6. SEM images of the internal and external structure, fragment of the humerus of cf. *Palaeolama* sp. from site GNLQ-1. A. and B. surface; C. and D. internal structure. Pyrite located in the osseous matrix of the humerus of the cf. *Palaeolama* sp.

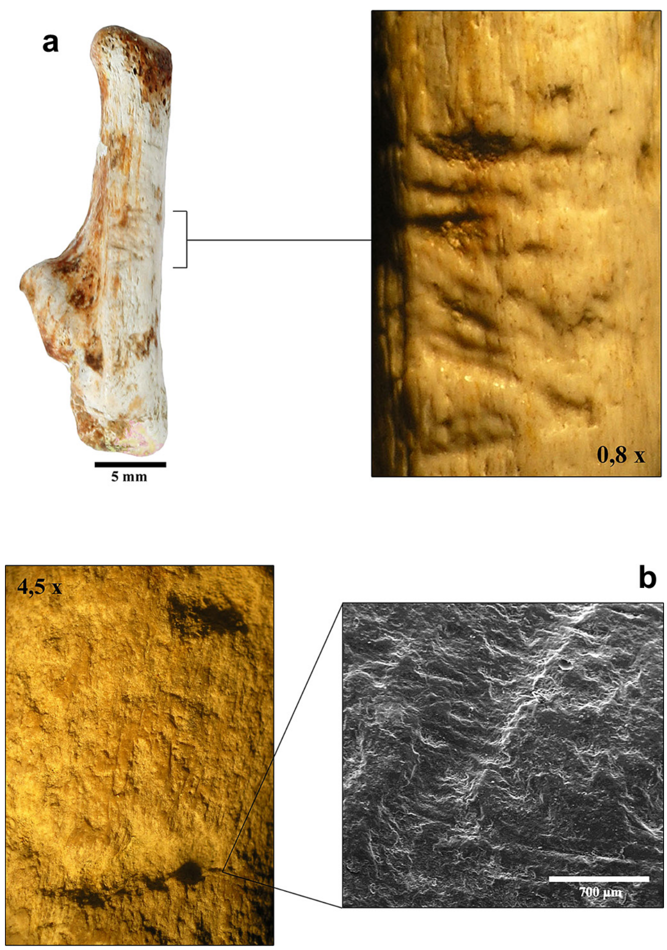

Fig. 7. A. Canidae calcaneus' showing rodent marks; B. Mammal rib showing trampling marks.

7. Conclusions

The geomorphological, sedimentary and paleontological information for the GNLQ1 site suggests the presence of an undisturbed context with scarce post-depositational alterations. The stratigraphic unit containing the fossil remains (Unit 2), suggests an estuarine-lagoon environment in the process of desiccation (Vargas and Ortega, 2008), consistent with other studies which suggest essentially a cold and wet environment, with a general tendency to desiccation around ca.13,000 cal. BP (Villagrán and Varela, 1990; Kim et al., 2002; Valero Garcés et al., 2005).

Around ca. 13,000 AP (ca 16 cal BP), the coast was situated at least 1 km away from the site, indicating that a substantial part of Quintero Bay was exposed and available for terrestrial fauna, which explains the taxonomical composition of the assemblage. The records of similar faunal assemblages in other sites indicate a wide distribution of grazers and browsers taxa, suggesting environments that combine pasture lands and woods.

Taphonomic analysis shows that different agents affected the record in their terrestrial and drowned depositional context. As for the accumulating agents, at least one large carnivore seems to have been involved, as indicated by the marks on the long bones of the cf. *Palaeolama* sp.

The remains appear to have accumulated at least in two differential depositional events, as suggested by the two states of weathering, which denotes that the remains were exposed to subaerial conditions. The presence of root marks indicates the growth of vegetation and sediment cover, which shows that whilst the remains were exposed, before the marine transgression, they were probably buried, which promoted the preservation and integrity of the record.

Oxidation staining is the result of the interaction of the bones with an interface of gravelly clay sediment and water, which is characteristic of the depositional environment of the GNLQ1 site. At the same time, this data is consistent with the presence of pyrite in the osseous matrix, characteristic of anoxic environments.

Finally, although neither cultural remains nor anthropic agents responsible for the accumulation of fauna were identified, there is no doubt that, these findings are unique due to their nature and state of conservation. Similarities with other terrestrial sites motivate further research, leading to evaluation of their possible association with human occupations. Without doubt, the site offers significant possibilities for future investigations on palaeolandscapes once available for early human occupations, now submerged.

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