



The far south: the Pleistocene–Holocene transition in Nerja Cave (Andalucía, Spain)

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Abstract

The archaeological site of Cueva de Nerja (Málaga, Spain) provides significant data about the bioclimatic conditions of one of the most southern European temperate regions. The bioclimatic and palaeogeographic changes that have occurred during the 20,000 years of human occupation of the site can be analysed by relating the geodynamic processes, the palaeobotany and the palaeofauna recovered from its archaeological deposits. © 2002 Published by Elsevier Science Ltd.

1. Introduction

Due to its location and bioclimatic conditions, the southern part of the Iberian Peninsula would have been an ideal refuge for some animal species during the last glacial maximum. The cave of Nerja (Malaga, Spain) is located within this territory and represents one of the most southern archaeological sites found in Europe. Today, the site is bioclimatically within the thermomediterranean zone; the warmest of the mediterranean region, characterised by annual temperatures between 17°C and 19°C, and with an absence of frost. The climate regime is defined as dry with an annual average rainfall of between 350 and 600 mm.

The bioclimatic and palaeogeographic changes that have occurred during the 20,000 years of human occupation of the cave can be analysed by relating the geodynamic processes, the palaeobotany and the palaeofauna recovered from the archaeological deposits of the cave. In addition to this, data regarding the characteristics and extension of the platform submerged due to isostatic variations are also available. Lithostratigraphic and palaeobiological data were also obtained during the excavations under the direction of Dr. Jordá Cerdá. Information relating to the coastal

palaeogeography and the geomorphology concerning the area surrounding the cave has been obtained from different authors (Hoffmann, 1988; Jordá Pardo, 1992; Hernández-Molina et al., 1994).

2. Location and description of the cave

The cave of Nerja is located on the south side of the Almirajara Mountain, in the area commonly known as Ladera del Aguila. The site rises some 158 m a.s.l (UTM: $x = 424.695$ and $y = 4.069.025$), and is approximately 1000 m from the nearest coastline (Fig. 1). Geologically, the Almirajara mountain is defined by a relief unit which extends to the NE of the Frigiliana fault (Jordá Pardo, 1992). The mountain which developed is characterised by highly recrystallised dolomitic marbles, which belong to the Triassic period and define the geological unit called the *Manto de la Herradura* (Alpujarride complex, Betic Mountain range) (García Dueñas and Avidad, 1981). Within a few metres distance from the cave entrance is a Pleistocene-dated alluvial fan, named after the village of Maro. The fan slopes gently towards the coastline, where it ends in a cliff with a small beach below which is cross-cut by the Maro ravine.

The old entrance to the cave (Torca, De la Mina and Vestíbulo rooms) is today partially filled with deep detritus and chemical deposits. These deposits have been interpreted as archaeological deposits with a chronology

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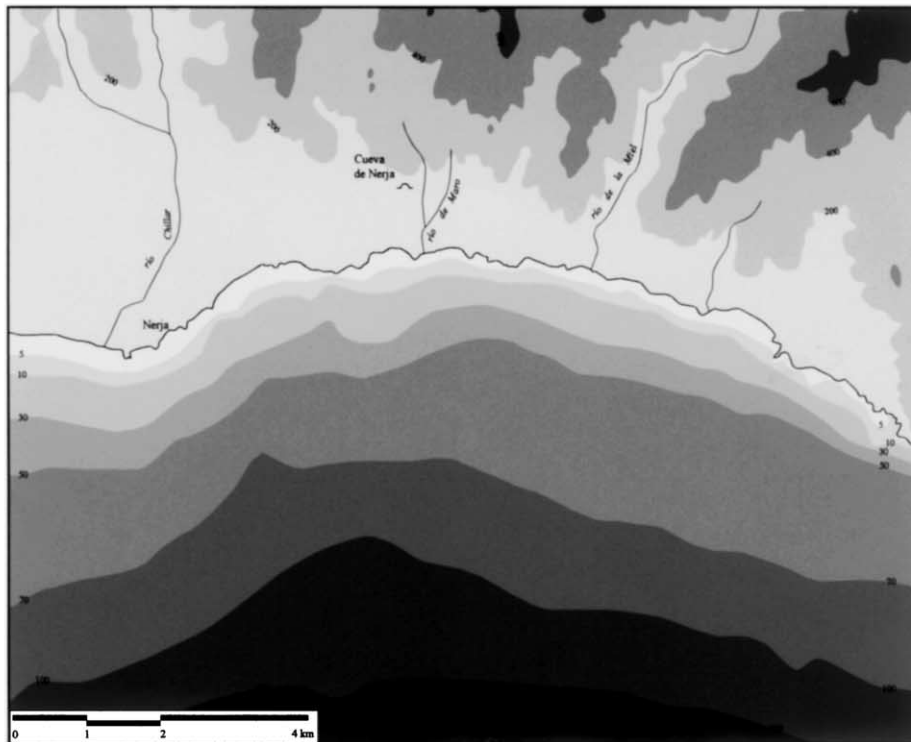
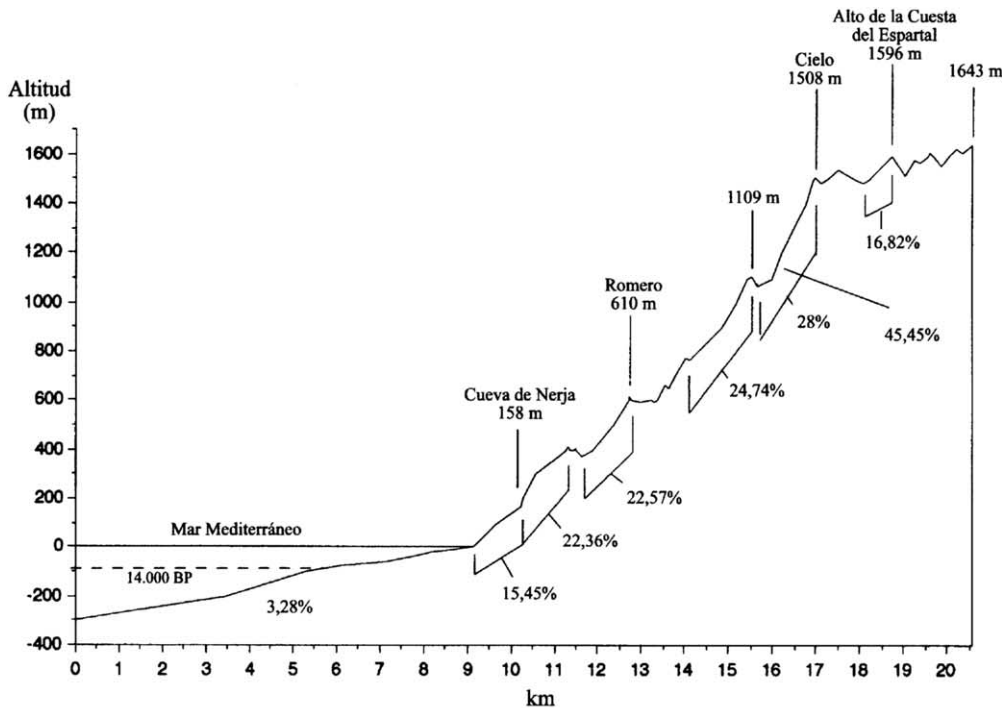


Fig. 1. Topographic section of the sea bottom of the Málaga coastline in the Nerja cave meridian (I.H.M., 1984).

covering the Upper Pleistocene and an important part of the Holocene (ca. 24,000–4000 BP), isotopic stages 2 and 1 (Shackleton and Opdyke, 1973).

The archaeological data analysed here belong to the Mina and Vestíbulo rooms of the cave. The Vestíbulo room offers a more complete archaeological sequence

relating to the period prior to the Pleistocene–Holocene transition. However, this archaeological sequence revealed a depositional hiatus of ca. 6 kya due to erosive processes. On the other hand, the Mina room deposits, with similar chronology, are less well represented. Here, disturbance caused by high-energy erosive processes

along with anthropic pits associated with the neolithic, which directly affect Magdalenian levels with Tardiglacial chronology. Sediments obtained from excavation were sieved with pressured water and floated using sieves of 10, 5, and 1 mm diameter.

3. Stratigraphy

The lithostratigraphic sequences obtained from the studied caverns show important correlative levels of formation. The differences which are observed can be explained by the variations in the orientation of the entrances and from the differences in their palaeotop-

graphy (Jordá Pardo, 1982, 1986a, b; Jordá Pardo et al., 1990; Aura et al., 1998). Upon comparison of the deposits, the following periods of sedimentation, divided by stratigraphic discontinuities, have been proposed (Fig. 2):

- First stage (Nerja, 1) corresponds to sediments dated ca. 24,000 and 20,000 BP. Characteristically, this stage is related with the last stage of the penultimate cold oscillation of the most recent Würm, in accordance with the last stage of the Mallaetes C phase (Fumanal García, 1986). It contains Gravettian industries, which decrease in frequency in the lower layers and occur along with hyena coprolites.

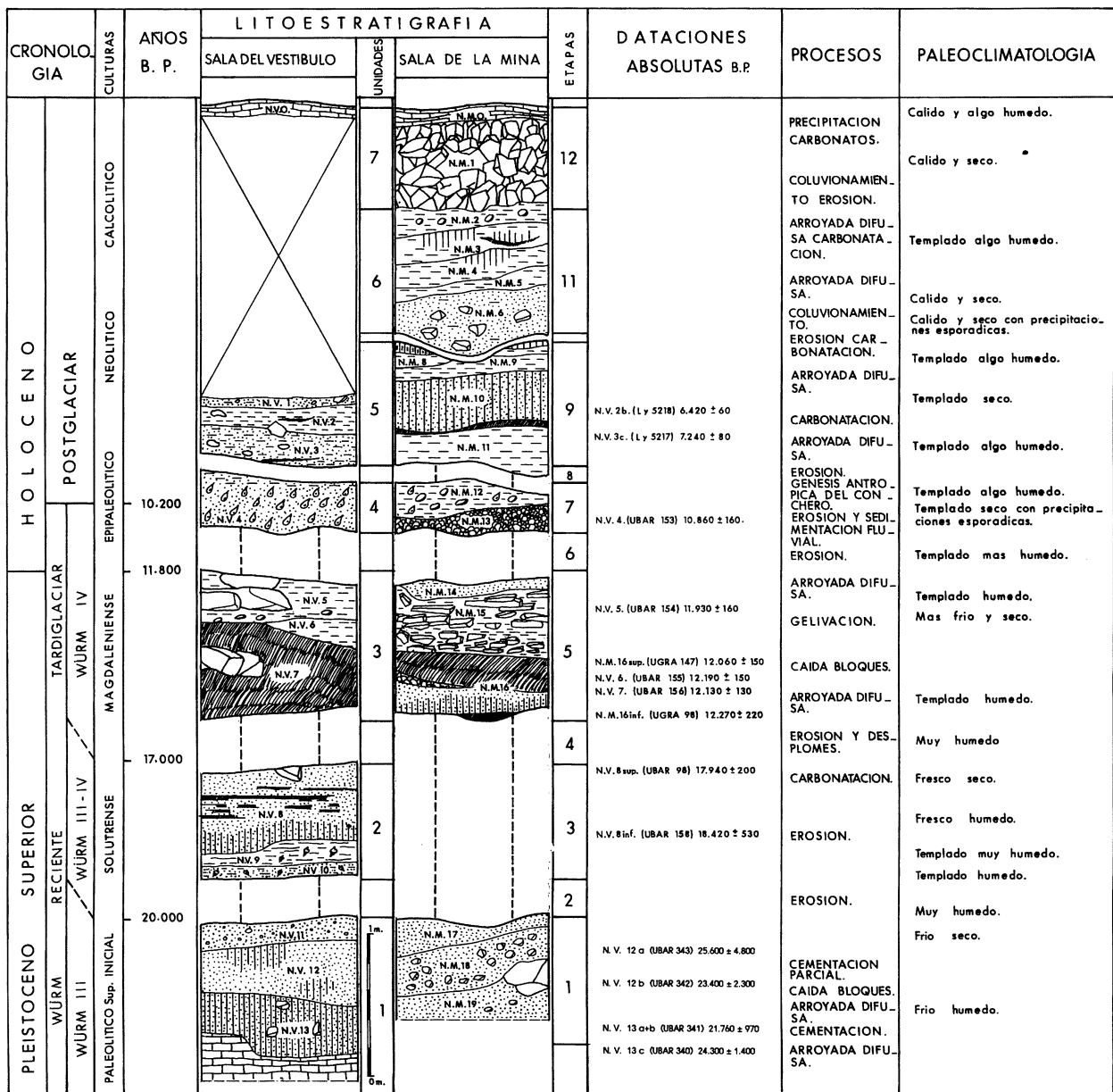


Fig. 2. Lithostratigraphic sequences correlation between sala de la Mina and Vestibulo, Cueva de Nerja (Andalucía, Spain).

- Second stage (Nerja, 2) is an erosional hiatus.
- Third stage (Nerja, 3) corresponds with the last interglacial phase of the most recent Würm, correlated to the Mallaetes D interphase (Fumanal García, 1986). This stage starts with two levels of sedimentation deposited during a period with a more temperate and humid climate than previously. The last level indicates a cooler climate with a progressive tendency towards aridity. The radiocarbon dates for this stage are $18,420 \pm 530$ and $17,940 \pm 200$ BP, which include Solutrean industries.
- Fourth stage (Nerja 4) represents a newer erosional hiatus in stratigraphy. In the Vestíbulo area the erosive processes have caused an absence of ca. 6 kya of deposits. In the Mina area, these processes created a gap of ca. 7 kya. It is in this area where an important amount of blocks fell due to intensification of neotectonic and seismic activity. This stage corresponds with the initial phases of the last glacial maximum.
- Fifth stage (Nerja 5) corresponds to the last phases of the Tardiglacial and is dated between $12,270 \pm 220$ and $11,930 \pm 160$ BP. One of the levels in this stage was deposited by frost shattering. It is possible that this level dates back to the coolest phase of the sequence. This phase is directly related with phase G of the Spanish mediterranean sequence (Fumanal García, 1986). Associated with these sedimentary characteristics was steppe vegetation, which indicates cooler climatic conditions than at present, although relatively warm when compared with the climatic conditions detected in other sites located further north (Badal, 1991). This is also coincident with the appearance of ornithological species characteristic of cold climates (Eastham, 1986). The archaeological levels include Magadalenian industries with harpoons from both areas, the Vestíbulo and the Mina rooms.
- Sixth stage (Nerja 6) represents another hiatus of the stratigraphy. Dates from the Vestíbulo area obtained for the end of the fifth stage ($11,930 \pm 160$ BP) and for the beginning of the seventh ($10,860 \pm 160$ BP) indicate the boundary between the Upper Pleistocene–Holocene. This period of stratigraphic erosion may be related to an increase of rainfall.
- Seventh stage (Nerja 7) is clearly located at the beginning of the Holocene, with a radiocarbon date of $10,860 \pm 160$ BP at the base. This level corresponds to the final phases of the Tardiglacial and the beginning of the postglacial. Palaeoclimatological data indicate warm temperatures and even traces of drought only broken by some intermittent rain storms, and indicate vegetation characterised by dry bush (Badal, 1991). Sedimentation in this stage has an anthropic origin (NV-4), including a shell-midden mainly formed of *Mytilus edulis* shells which infills

the erosive gap originating in Nerja 6. This anthropic occupation of the cave corresponds to epipalaeolithic industries, related with Epimagdalenian facies.

- Eighth stage (Nerja 8) is defined by erosion and introduces a new sedimentary phase.
- Ninth stage (Nerja 9) has two radiocarbon dates. The date for the initial level, containing mixed mesolithic and neolithic materials, is 7240 ± 80 BP. The date for the upper level, 6420 ± 60 BP, is associated with neolithic material. Between the initial and the upper levels, there is a small erosive scar. This stage had a warm and slightly humid climate at the beginning, which later evolved into a drier regime towards the end.
- From this point onwards there is no available information for the Vestíbulo area. However, there are some unexcavated sediments in this area that may produce more information. These sediments appear to be capped by a stalagmitic level which is directly related to the one covering the sediments of the Mina area.

In the Mina area, a 10th stage (Nerja 10) is detected. This is a stage with important traces of erosion, which deeply affects part of the archaeological sequence. Directly over the erosive gaps present in the 10th stage, a new phase of sedimentation occurred. This has been called the 11th stage (Nerja 11), and possesses an archaeological sequence that corresponds culturally with the mid-final neolithic and the calcolithic. The sequence ends with the 12th stage (Nerja 12), which dates to the recent Holocene phase, some 4000 years BP (Pellicer and Acosta, 1986). The stalagmitic level probably originated during a climatically warm and dry phase with subhumid conditions, and represents the culmination of this sequence.

4. Palaeobotanical record

The charcoal material analysed comes from the Vestíbulo area. Its distribution within the sequence is irregular and the sample quantities are locally small. However, there is a clear diachronic trend which acts as a pivotal point to establish comparisons with sedimentary and palaeofaunal data. The overall carbonised remains analysed add up to 13,383 of which 3444 are charcoal fragments, 9392 pine cone remains, and 547 pine kernel shells from *Pinus pinea* (Badal, 1990, 1995, 1998). The analysis of these remains allows the definition of five anthracological phases:

- First phase 1 (ca. 24,000–17,500 BP) corresponds to Nerja 1 and 3 of the stratigraphic sequence. It is characterised by the significant presence of *P. nigra* along with *Leguminosae*. Less well represented, but

present, are *Juniperus* sp., *Cistus* sp., *Rhamnus-Phyllyrea*, *Prunus* sp., *Sorbus-Crataegus* and *Quercus* sp. Current vegetal formations containing salgareño pine, juniper and *leguminosae* are found in the supra-mediterranean bioclimatic zone, which has dry and semiarid ombroclimatic conditions.

It is, however, important to highlight that towards the end of this phase, *Leguminosae* are more common than *P. nigra*, and there is a vegetation characteristic of warmer climatic conditions such as *P. halepensis*, *Olea europea sylvestris* (var.), *Quercus* (deciduous), *Pistacia terebinthus* and *Cneorum tricoccum*. This association is considered to represent a warmer and wetter climate than that previously.

- Anthracological phase 2 (ca. 12,500–11,500 BP) corresponds to Nerja 5. Samples from units NV6 and NV5 are small, and only NV7 offers a large enough sample that can be analysed. Results reveal a steppe-type vegetation, with few trees. There is a dominance of *Leguminosae*, but *P. nigra* is not very common. Other species identified are *P. halepensis*, *Juniperus* sp., *Quercus ilex-coccifera*, *Pistacia terebinthus*, *Cistus* sp., *Rhamnus-Phyllyrea*, *Prunus* cf. *amygdalus*, *Prunus* sp., *Cneorum tricoccum* and *Fraxinus oxyphylla*. The cold weather conditions suggested by sedimentary data for level NV7, which includes angular slabs, reinforce the anthracological analysis.
- Anthracological phase 3 (ca. 11,000–9500 BP) can be correlated to Nerja 7. Samples analysed suggest that there is a dominance of *Leguminosae*; but some diversification is present: *O. europaea Sylvestris* (var.), *Quercus* (deciduous), *Q. ilex-coccifera*, *Pistacia lentiscus*, *Rosmarinus* sp, *Arbustus unedo*, *Buxus* sp, *Lavandula*, among others. *O. europaea Sylvestris* (var.) are more common than the *Leguminosae* of the last sample.

The diversification of the vegetation with warm characteristics indicates, rather than more rain, higher temperatures, although *Quercus* continues to occur. This association is very similar to that described as Nerja 2, where *Leguminosae* were also dominant, though the decline of *P. nigra* presents certain differences. This phase has been related to the beginning of the Holocene.

- Anthracological phase 4 (ca. 7500–7000 BP): this phase coincides with unit NV3, and corresponds to the base of Nerja 9. The results show a decrease of *Leguminosae*, and an increase of *O. europaea sylvestris* (var.), which reach maximum values. There is also continuity in the presence of *Q. ilex-coccifera*, along with a progression for *Cistus* sp., *Rosmarinus* sp., and *Pistacia lentiscus*. These taxa and the values they present suggest the appearance of a vegetation

assemblage linked to thermo-mediterranean conditions. From a climatic point of view, a slight raise in temperatures can be identified in relation to the previous phase, although without complete certainty when referring to humidity.

- Anthracological phase 5 (ca. 7000–6000 BP) corresponds with the last level in this area of the cave (NV2). Along with the previous phase it can be related to Nerja 9 on a sedimentary basis. There is a clear decrease of *O. europaea sylvestris* (var.), whereas *Leguminosae* shows a certain stability with an increase among scrub species: *Rosmarinus* sp, *Cistus* sp., *Pistacia lentiscus*, *Rhamnus* sp. In contrast with what has been observed in other mediterranean sites, Nerja does not show the typical development of dense woodland or the progressive substitution by *P. halepensis* woodlands.

5. The faunal record

Palaeofaunal data obtained from Nerja cave provide an important amount of palaeoeconomic information when analysed through the perspective of anthropic selection (Aguirre, 1989). However, the good quality and biodiversity shown by the palaeontological data obtained in Nerja cave, representing about 100 species from all groups of vertebrate and invertebrates, minimise the impact of human selection of the faunal record (Palmqvist et al., 1999).

The data presented here refer mainly to the Vestíbulo area, for which the palaeofaunal study is almost completed. For the Mina area only preliminary data are available (Pérez Ripoll, 1986; Eastham, 1986). However, malacofaunal data used refer to both areas (Jordá Pardo, 1986c), whereas ichthyofaunal data come from two test-pits of 1 m² which were excavated in each of the areas.

There are about 20,000 mammal bones from the Vestíbulo area alone. These can be organised into four groups. The first group contains bones ca. 24,000–17,500 BP, which are directly related to levels of Gravettian and Solutrean industries. The second group refers to levels which contain Magadalenian (12,500–11,500 BP) and Epimagdalenian (11,000–9000 BP) industries. However, it is important to remember that lithostratigraphic data denote a clear break between both groups (Nerja 4), with a hiatus in the stratigraphy expressed by radiometric information dating of some 6000 yr (Jordá Pardo, 1986b; Jordá Pardo et al., 1990; Aura et al., 1998). The area excavated for each of the archaeological levels recognised and grouped from the criteria noted above, is not homogeneous due to the existence of baulks from previous excavations (Aura et al., 1998).

Table 1
Mammal bones from Cueva de Nerja, sala del Vestíbulo

Cueva de Nerja Sala del Vestíbulo	NV13–NV8 (ca. 24000–17500 BP)	<i>r</i> (%)	NV7–NV4 (ca. 12500–9000 BP)	<i>r</i> (%)
<i>Ovis aries</i>	0		2	
<i>Sus domesticus</i>	0		3	
<i>Equus</i> sp.	20	0.64	1	0.06
<i>Bos primigenius</i>	3	0.09	0	0
<i>Capra pyrenaica</i>	2756	88.96	1344	88.83
<i>Cervus elaphus</i>	293	9.45	50	3.3
<i>Capreolus capreolus</i>	1	0.03	0	0
<i>Sus scropha</i>	2	0.06	44	2.9
<i>Lynx</i>	9	0.29	16	1.05
<i>F. silvestris</i>	12	0.38	7	0.46
<i>Hyaena</i> sp.	2	0.06	0	0
<i>Delphinus delphis</i>	0	0	12	0.79
<i>Monachus monachus</i>	0	0	39	2.57
<i>Oryctolagus cuniculus</i>	5349		4361	
<i>Lepus</i> sp.	0		1	
Nonidentified	2885		843	
Total NR	11,335		6723	

Both groups show characteristics common to those of other mediterranean sites in Spain with palaeolithic and epipalaeolithic chronology. Thus, there is an important number of remains from *Oryctolagus cuniculus* with clear anthropic origin, and a concentration of the remains of one or two species of ungulates (Aura and Pérez Ripoll, 1992; Villaverde and Martínez, 1992; Villaverde et al., 1998). In Nerja cave, *Capra pyrenaica* appears along with a variety of other mammals which show some interesting diachronic variations (Table 1).

In the first group, there is an important concentration of remains from two species: *Capra pyrenaica* and *Cervus elaphus*. The remaining identified species show a presence with a percentage of <1% (within an index that excludes lagomorph bones). There are few remains of *Bos* sp. and *Equus* sp., but notably two *Hyaena* sp. coprolites were recovered. Another important aspect is the absence of marine mammals.

Within the assemblage corresponding to the end of the Pleistocene and Holocene levels are the remains of five domestic fauna from an intrusive upper neolithic pit. The faunal assemblage studied for this group shows an almost complete disappearance of *Bos* sp. and *Equus* sp. as well as a reduction in the number of *Cervus elaphus* in relation to lower levels. There is an increase of *Sus scropha* and *Lynx* and the first appearance of the mediterranean seal, *Monachus monachus*. The presence of marine mammals is significant and, above all, symptomatic of economic lines that will be analysed

later (Pérez Ripoll and Raga, 1998). As an indication, the addition of the number of remains of *Monachus* and *Delphinus* is superior to that of *Cervus elaphus*.

Micromammals, generally used to identify bioclimatic variations, in the case of Nerja cave are not entirely reliable because they did not come from systematic sampling but were picked directly from the sieve. Guillem Calatayud (1997) has identified *Apodemus flavicollis* in nearly all of the Upper Pleistocene deposits of the Vestíbulo area. This species is related to Eurosiberian conditions and is not documented in Nerja from the final Tardiglacial onwards.

With reference to the marine ichthyofauna, the total amount of remains recovered from the excavations directed by Jordá, constitutes a unique sample from the point of view of their chronology, number and diversity (Table 2). There are two important pieces of data to stress: first an almost total absence of ichthyofauna in the levels dated before ca. 12,500 BP. Secondly, the diachronic trajectory described by the assemblages, despite the differences of sample sizes. As the Holocene continues there is an increase of *Chupeidae* and *Labridae* and a decrease of *Scombridae* (Table 3). The biggest differences are found in the values between *Belonidae* and, particularly, *Gadidae* in the Vestíbulo area, and *Mugillidae* and *Sparidae* in the Mina area. The presence of *Accipenser sturio* in the Vestíbulo area levels with Magdalenian industries, is also documented in the Mina area, although not in this sample. This anomaly, along

Table 2
Fish species identified on Cueva de Nerja archaeological deposits

<i>Acipenseridae</i>	<i>Sciaenidae</i>	<i>Scombridae</i>
<i>Accipenser sturio</i>	<i>Argynosomus regius</i>	<i>Scomber scombrus</i> <i>S. japonicus</i>
<i>Chupeidae</i>	<i>Sparidae</i>	<i>Sphyraenidae</i>
<i>Sardinella aurita</i>	<i>Boops boops</i>	<i>Sphyraena</i> sp.
<i>Sardina pilchardus</i>	<i>Dentex</i> sp.	
	<i>Diplodus</i> sp.	
<i>Belonidae</i>	<i>Diplodus vulgaris</i>	<i>Mugilidae</i>
<i>Belone belone</i>	<i>D. sargus</i>	<i>Chelon labrosus</i> <i>Mugil</i> sp.
	<i>Lithognatus mormyrus</i>	
<i>Gadidae</i>	<i>Oblada melanura</i>	
<i>Merlangius merlangus</i>	<i>Pagellus eurythinus</i>	<i>Scorpaenidae</i>
<i>Pollachius pollachius</i>	<i>P. bogaraveo</i>	<i>Scorpaenidae</i> sp.
<i>Melanogrammus aeglefinus</i>	<i>Pagrus pagrus</i>	
<i>Phycis phycis</i>	<i>Pagrus</i> sp.	<i>Triglidae</i>
	<i>Sarpa salpa</i>	<i>Trygla</i> sp.
<i>Serranidae</i>	<i>Sparus aurata</i>	
<i>Serranus scriba</i>	<i>Spondylosoma cantharus</i>	
<i>Serranus cabrilla</i>	<i>Sparidae</i> sp.	
<i>Dicentrarchus labrax</i>		
	<i>Labridae</i>	
<i>Carangidae</i>	<i>Labrus merula</i>	
<i>Trachurus trachurus</i>	<i>L. bergylta</i>	

Table 3
Fish bone samples from Cueva de Nerja

Cueva de Nerja Sala del Vestíbulo	NV13–NV8 (ca. 24000–17500 BP)	NV7–NV5 (12500–11500 BP)	NV4 (ca. 10700–9000 BP)
<i>Accipenseridae</i>	0	1.03	0
<i>Chupeidae</i>	0	0	5.78
<i>Belonidae</i>	7.69	11.78	0.21
<i>Gadidae</i>	46.15	12.98	68.7
<i>Serranidae</i>	0	0.33	0
<i>Carangidae</i>	0	12.11	0.3
<i>Scienidae</i>	7.69	0	0
<i>Sparidae</i>	30.76	47.26	13.33
<i>Labridae</i>	0	6.34	10.47
<i>Scombridae</i>	0	7.27	1.05
<i>Sphyraenidae</i>	0	0.03	0
<i>Mugilidae</i>	7.69	0.8	0
<i>Scorpenidae</i>	0	0.03	0.07
Total NR: 7243	14	3831	3398
Cueva de Nerja Sala de la Mina	NM19–NM17 (before 17500 BP)	NM16–NM14 (12500–11500 BP)	NM13 (ca. 10500–7500 BP ?)
<i>Chupeidae</i>	0	0.18	3.51
<i>Belonidae</i>	0	0.61	0.65
<i>Gadidae</i>	0	0.06	0
<i>Serranidae</i>	0	2.83	3.05
<i>Carangidae</i>	0	8.18	10.98
<i>Scienidae</i>	0	0	0.43
<i>Sparidae</i>	0	45.5	47.83
<i>Labridae</i>	0	0.12	0.21
<i>Scombridae</i>	0	12.86	0
<i>Mugilidae</i>	0	28.87	33.81
<i>Triglidae</i>	0	0.73	0
Total NR: 2086	0	1631	455

with that of *Mugillidae* and some other species ca. 12,500–11,500 BP, is indicative of the existence of restrictive coastline areas, with estuaries and lagoons located at river mouths (Jordá Pardo, 1992).

The differences detected are based on a data obtained from sample pits dug in each area. A similar situation can be seen when analysing the malacofauna of the “archaeologically contemporary” occupations of the Mina and Vestíbulo areas. Undoubtedly, when incorporated into this discussion, a more detailed description of the habitat, ethology and size evolution of the different species, will provide a better understanding of the differences noted above.

Published studies dealing with ornitofauna from the Nerja cave agree in defining an important group of marine birds in the palaeolithic and epipalaeolithic levels (ca. 17,000–10,500 BP) of the Mina and Torca areas (Boessneck and Driesch, 1980; Eastham, 1986; Hernández Carrasquilla, 1995). As for the material excavated by Jordá, it has already been noted that data studied by Eastham (1986) for the Mina area is not completed (representing only half of the excavated area). The data obtained from the Vestíbulo could be used to describe diachronic sequences of this type of resources during the palaeolithic; however, these results are not yet available.

The malacofauna of both areas has provided an important number of remains, over 150,000. This will permit the establishment of a solid malacofauna sequence. The data have been summarised into three significative groups: continental malacofauna, marine fauna of sand substratum and marine fauna of rocky substratum. The data set can be seen in the original publications (Jordá Pardo, 1983, 1986c).

The available malacofauna samples are irregular. Firstly, because of the differences in surface area excavated and the thickness of the layers described for each area; and secondly, because of the differences in conservation between both areas. However, the diachronic trajectories of both sequences do show some interesting coincidences. Continental malacofauna show a contrasting evolution when compared with the marine malacofauna (Table 4). In the Vestíbulo area, without consideration of those examples used as ornaments (Cotino and Soler, 1998), marine malacofauna is present from the top of the Solutrean levels, ca. 18,000 BP. However, due to the existence of an erosive contact with the upper levels, some doubts about the dates of these malacofauna remain. Thus, it is not certain if they belong to upper levels, dated ca. 12,500–11,500 BP, or if they mark the beginning of the exploitation of the marine resources in Nerja (Aura, 1995). The marine malacofauna identified in the levels dated before 12,500 BP represent only 1.8% of the total.

Marine malacofauna is one of the most common faunal types, amounting to 75% of the total faunal

assemblage obtained from both the Vestíbulo and the Mina areas. The distribution of sand–mud substratum and rock substratum species shows a clear diachronic inversion. This trend has been related to sea level rise when the beach-line reached the palaeocliffs during the Pleistocene–Holocene transition (Aura et al., 1993).

In the first phase of Nerja 5 (ca. 12,500 BP), malacofauna is represented by the presence of the bivalves *Tapes decussatus*, *Cerastoderma edule* and *M. edulis*. In this phase, *T. Decussatus* represents more than 50% of the remains recovered in some of the levels of the Mina area. From this phase onwards, the *T. decussatus* and *M. edulis* frequencies show an inverse trend. Thus, the episode identified as being the onset of the Holocene, at the start of the stage Nerja 7 (ca. 11,000 BP), is defined by a significant increase of *M. edulis* which represents at points 90% of the total mollusc found in the Vestíbulo area (Table 4). This inversion between the number of remains of *M. edulis* and *T. decussatus* found may be explained by the differences in the ecological necessity of each species. *T. decussatus* is characteristically found at sandy, muddy depths located between 0 and 19 m. *M. edulis* is found among the epifauna of rocky areas of the mid-coastal territory, between 0 and 6 m.

6. Coastal palaeogeography

The topographic section of the bathymetry of the Málaga coastline in the Nerja cave meridian (I.H.M., 1984) suggests that the 120 m drop of sea level estimated by Hernández-Molina (1993) and Hernández-Molina et al. (1994) during the last glacial maximum, is geographically represented in the area as follows: a sandy–muddy littoral region, with estuaries in the mouth areas of rivers, extensive beaches and lagoons, with salted waters surrounding river mouths (Fig. 1).

The topographic profile of the sea bottom along the cave meridian and the seismic profiles obtained for the continental platform in the Málaga area, shows the existence of sandy beach deposits superimposed on the erosional surfaces of the platform. These deposits are related to the erosive terraces at depths of –90, –80, –73, –60, –47, –33, –20, –15 and –10 m (Hernández-Molina et al., 1994). The position of the sea level at –90 m in relation to the current coastline, at the beginning of the last transgression, ca. 14,000 BP (Hernández-Molina et al., 1994), signifies the existence of a emerged sandy–muddy coastal strip some 4 km wide and with a slope of about 4%. The cave was located, at this time, some 258 m a.s.l., at a distance of 5 km from the sea (Figs. 1 and 3).

An erosive terrace has been located at –73 m, dated ca. 12,500 BP (Hernández-Molina et al., 1994), coinciding with marine resource exploitation of

Table 4
Malacofaunal assemblages from Cueva de Nerja

Cueva de Nerja Sala del Vestíbulo (C-4)	NV13–NV8 (ca. 24000–17500)	%	NV7–NV5 (ca. 12.500–11.500)	%	NV4 (ca. 10700–9000)	%
<i>Patella</i> sp.	24	0.93	71	15,7	274	2.92
<i>Monodonta</i> sp.	0	0	0	0	13	0.13
<i>T. haemastoma</i>	0	0	0	0	0	0
<i>Mytilus edulis</i>	125	4.89	271	59.95	8577	91.47
Total rocky sustratum	149	5.83	342	75.66	8864	94.53
<i>Tapes decussatus</i>	33	1.29	14	3.09	3	0.03
<i>Pecten maximus</i>	1	0.03	1	0.22	36	0.38
<i>Cerastoderma edule</i>	32	1.25	64	14.15	16	0.17
Total sand sustratum	66	2.58	79	17.47	55	0.58
Marine malacofauna	214	8.37	421	93.14	8919	95.12
<i>Melanopsis</i> sp.	11	0.43	20	4.42	32	0.34
<i>Ruminna decollata</i>	12	0.46	2	0.44	2	0.21
<i>Iberus alonensis</i>	2316	90.68	7	1.54	408	4.35
<i>Helicella</i> sp.	0		2	0.44	15	0.15
Continental malacofauna	2339	91.58	31	6.85	457	4.87
Total	2554		452		9376	

Cueva de Nerja Sala de la Mina	NV19–NV17 (ante 17500 BP)	%	NM16–NM14 (ca. 12500–11500 BP)	%	NV13 (ca. 10500–7500 BP?)	%
<i>Patella</i> sp.	1	0.59	80	3.68	130	9.96
<i>Monodonta turbinata</i>	0	0	15	0.69	11	0.84
<i>T. haemastoma</i>	0	0	4	0.18	0	0
<i>Mytilus edulis</i>	0	0	282	12.98	737	56.47
Total rocky sustratum	1	0.59	381	17.54	878	67.27
<i>Tapes decussatus</i>	7	4.16	974	44.8	46	3.52
<i>Pecten maximus</i>	0	0	11	0.5	26	1.99
<i>Cerastoderma edule</i>	3	1.78	115	5.29	40	3.06
Total sand sustratum	10	5.95	1100	50.64	112	8.58
Marine malacofauna	11	6.54	1481	68.18	990	75.86
<i>Melanopsis</i> sp.	1	0.59	70	3.22	5	0.38
<i>Ruminna decollata</i>	12	7.14	66	3.03	42	3.21
<i>Iberus alonensis</i>	144	85.71	503	23.15	267	20.45
<i>Helicella unifasciata</i>	0	0	52	2.39	1	0.07
Continental malacofauna	157	93.45	691	31.81	315	24.13
Total	168		2172		1305	

the archaeological levels from Nerja. The emerged platform would have been some 3 km wide. Its sand–mud substratum would have allowed the gathering of species such as *T. decussatus* and *C. edule*, which are the most common (Jordá Pardo, 1986c; Aura et al., 1993).

Between ca. 10,000 and 7000 BP, the terraces indicate successive reductions of this mobile strip of land until the sea level raised to the level of the palaeocliffs. It is during this stage when a reshaping of the cliffs, related

to the Vélez river mouth, located to the west of Nerja (Hoffmann, 1988; Jordá Pardo, 1992), and the Burriana–Nerja beach occurred (Jordá Pardo, 1992). Equally, during this transgressive period, the erosive platforms of Nerja and Torrox developed over alluvial and fluvial materials of Pleistocene age (Jordá Pardo, 1992). Finally, the travertine cliffs of the Maro plain suffered a sea regression and the restricted, transitional environments located along the Upper Pleistocene coastline disappeared (Jordá Pardo, 1988).

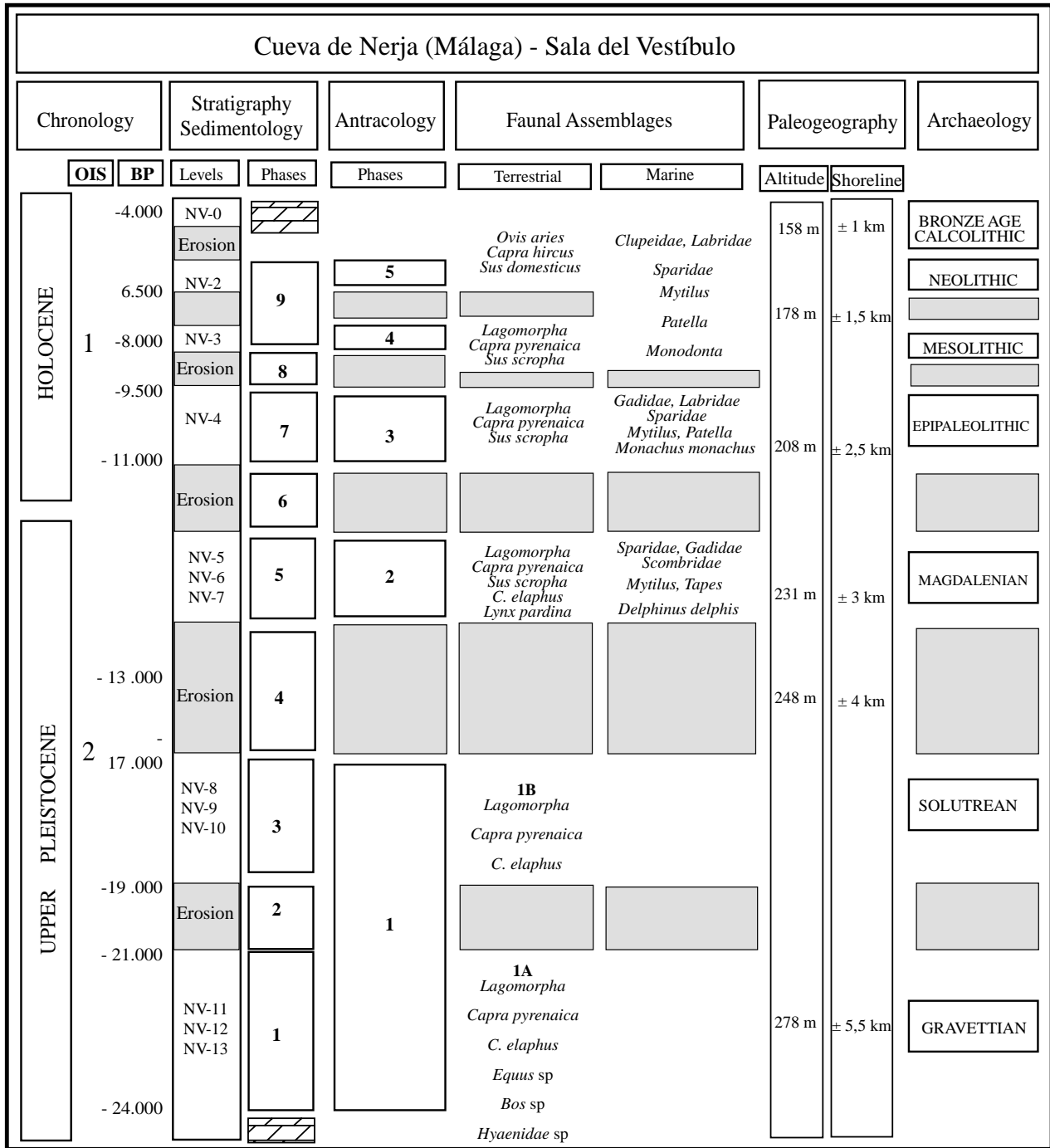


Fig. 3. Correlation between sedimentary phases, palaeobotanic and palaeofauna data with the paleogeographic coast.

Both the sedimentation and coastal palaeogeography during the Holocene show a great similarity with the current situation, with the biggest changes being observed around the areas of river mouths. It was a sinuous coastline, defined by the presence of estuaries, filled with sediments, located at the mouths of rivers which were often flooded by Holocene transgressive waters. It is thus quite possible that the coastline at the beginning of the Holocene was located more inland that

it nowadays coincides with the lowest terrace of the fluvial courses.

The transgression reduced in intensity during the Holocene, when the sea receded a few metres and allowed the development of beaches at the bottom of the cliffs, which are generally related to the mouths of small rivers. Towards the mid-Holocene, anthropic activity caused a period of deforestation, which triggered the destruction of the soil profile and the movement of

materials into riverbeds. The situation was maintained stable until ca. 2,700 BP. From this moment onwards there was a clear increase in the amount of material that moved into river courses from surrounding slopes, and as a consequence there was progressive silting of the estuaries (Hoffmann, 1988; Jordá Pardo, 1992).

7. Final comment

The site of Cueva de Nerja provides significant data about the bioclimatic conditions of one of the most southern European temperate regions. The correlation between the palaeogeographic coast, sedimentary phases, palaeobotanic data and palaeofauna allows an initial approximation in contrast with other models and deposits (Fig. 3).

The palaeobotanical results obtained through charcoal analysis reveal an altitudinal lowering of bioclimatic levels during the Upper Pleistocene (Badal, 1990, 1995, 1998). During the last glacial maximum the zone surrounding the cave experienced meso-mediterranean and supra-mediterranean conditions at altitudes between 500 and 1,000 m. Thermo-mediterranean conditions similar to those of the present day did not occur until the beginning of the epipalaeolithic–mesolithic (Badal, 1998).

The changes in the frequency of mammals exploited can be related more with palaeogeographic changes around the site rather than by alterations of temperature and humidity. The deposits of the ultimate glacial maximum include a majority of the *Equus* sp., *Bos* sp. and *Cervus elaphus* remains (ca. 24,000–17,500 BP). At this time, the coastal plain was more extensive with a more favourable habitat for these mammals (Pérez Ripoll, 1997). On the other hand, the marine fauna molluscs, fish and birds are found in high concentrations from ca. 12,500 to 7,000 BP, when the coastline occupied a central position, more or less, between that of the last glacial maximum and the probable position of the coastline of 6,000 BP (Hoffmann and Schulz, 1987).

The marine fauna recovered indicates that mediterranean waters were dominated by cooler temperatures. The presence of *Pinguinus impennis* (Boessneck and Driesch, 1980; Eastham, 1986; Hernández Carrasquilla, 1995), *Melanogrammus aeglefinus* and *Pollachius pollachius* affirms this fact (Rodrigo García, 1991). This situation is also observed in other archaeological sites along the Andalusian coast (Aura et al., 2001). This “colder Atlantic” of the Andalusia Tardiglacial coast could also be related with foraminifera data from the sea of Alborán, where a marked colder climate phase occurred between 12,000 and 10,000 BP (Pujol and Vergnaud Grazzini, 1989). From this phase onwards, the change of the type of molluscs exploited could be related to the palaeogeographical changes which took

place on the coast (Jordá Pardo, 1981, 1982, 1983, 1985, 1986c; González-Tablas et al., 1984; Jordá Cerdá et al., 1987; Aura et al., 1993).

Finally, the diversity of species that were found accumulated in the archaeological deposits of Nerja cave provides new perspectives concerning the palaeoeconomy of the last prehistoric hunters of southern Europe (Straus and Eriksen, 1998; Villaverde et al., 1998).

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