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Gruta Nova da Columbeira, Gruta das Salemas and Gruta da Figueira Brava: Stratigraphy, and Chronology of the Pleistocene Deposits

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Gruta Nova da Columbeira, Gruta das Salemas and Gruta da Figueira Brava *

Stratigraphy, and Chronology of the Pleistocene deposits

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Abstract

The evidence concerning the most recent Neanderthals in Portugal and maybe in the world, comes from three basic sites: Gruta Nova da Columbeira, Gruta das Salemas and Gruta da Figueira Brava.

For Gruta Nova da Columbeira, two human occupation levels were ^{14}C dated: c. 7, 26400 ± 750 BP and c. 8, 28900 ± 950 BP. The industries (denticulates, rich in levallois facies scrapers) are exclusively late Mousterian; this, as well as the fauna and a neanderthalian tooth make this cave one of the reference Mousterian sites in the Iberian Peninsula.

Gruta das Salemas – at the bottom, sediment gliding suggests that most of the basal deposits (and bones for ^{14}C dating) came from the outside during a certain time span. Atypical implements have tentatively been ascribed to the Middle Palaeolithic. Bed 8 yielded a human decidual molar and was dated 24820 ± 550 BP, this being

* The recognized names of the sites are indicated (gruta, in Portuguese = *cave*).

apparently too late for the Mousterian. The concerned dating may be somewhat later than the lowermost c. 8 deposits.

The Gruta da Figueira Brava is especially important because of the wealth of data it provides. The site resulted from karst erosion that broadened vertical diaclases, and mainly from marine abrasion during Tyrrhenian III event. The surf excavated a broad and deep shelter. The consequent lowering of the sea level (until about – 60 meters) forstered the development of a littoral plain with dunes that was flooded again in the Holocene. Diagenetic $CaCO_3$ consolidated the external part of eolic sand with its fossil contents into a hard sandstone. That, in turn, converted the shelter into the extant cave. The upper part of C. 2 bed shows some evidence of human walking, excavating and (much later) the sticking of amphorae. A neanderthalian tooth was found in C. 2 along with mammal, bird and other faunal remnants. These objects include marine shells, coprolithes, human food garbage, bone and lithic late Mousterian implements, including denticulates (non-levallois facies owing to the scarcity of better raw material), and quartz pebbles brought in by man. Found in C. 3 were fired stones, ashes and charcoal, as well as what seems to be burnt animal fat and resin. These elements suggest the use of fire for lighting.

Much organic matter was eliminated. The accumulation of iron oxides may be the result of the cumulative effect of exposure and denudative processes. The sea (a few kilometers away from its present position) provided large quantities of molluscs and crabs. C. 2 was ^{14}C dated 30930 ± 700 BP, the value for the intermediate fraction being 30050 ± 550 BP. The dating may appear somewhat older than the real age. Th/U dating is 30561 + 11759 – 10725 BP. The homogenous lithic implements seem to indicate that the late Mousterian occupation was short and discontinuous: when temporarily abandoned by man, the shelter may have been frequented by bats and other animals such as hyenas and panther.

Resumo

Os dados acerca dos últimos neandertais em Portugal (e, talvez, no mundo) provêm da Gruta Nova da Columbeira, da Gruta das Salemas e da Gruta da Figueira Brava.

Dois níveis de ocupação humana da Gruta Nova da Columbeira foram datados ^{14}C: c. 7, 26400 ± 750 BP e c. 8, 28900 ± 950 BP. Excelentes indústrias (com denticulados, ricas de raspadores de *facies levallois*), só do final do Mustierense, fauna e um dente de neandertaliano fazem deste um sítio de referência do Mustierense ibérico.

Gruta das Salemas – escorregamento de sedimentos sugere que a maior parte dos depósitos basais (e os ossos para datação ^{14}C) provém do exterior. Indústrias atípicas foram atribuídas ao Paleolítico médio. A camada 8 deu um molar lacteal neandertaliano; foi datada de 24820 ± 550 BP, o que parece demasiado tardio para o Mustierense. Esta data pode ser algo mais moderna do que os depósitos iniciais da C. 8.

A Gruta da Figueira Brava é particularmente importante devido à riqueza da informação que deu, inclusive sobre a fauna marinha; é a jazida mais rica em Portugal neste domínio. Resultou do alargamento de fissuras e, principalmente, de abrasão marinha (Tirreniano III), que escavou amplo abrigo com tecto sobrejacente. O subsequente abaixamento do nível do mar até *ca.* de – 60 metros permitiu o desen-

volvimento de uma planície litoral com dunas (coberta pelo mar, no Holocénico). Precipitação de $CaCO_3$ veio consolidar a parte externa do enchimento de areias eólicas com fósseis e instrumentos líticos, convertendo o abrigo em gruta. A C. 2 é constituída por areias que, na parte superior, mostram evidência de pisoteio, escavação e implantação de ânforas romanas. Foram encontrados (sobretudo na C. 2, de onde provém um dente de neandertaliano) restos de mamíferos, aves e outros vertebrados, coprólitos, conchas marinhas, detritos alimentares humanos, bem como indústrias ósseas e líticas do Mustierense final, com denticulados). A presença (C. 3, em especial) de pedras submetidas a fogo, cinzas, carvão e o que parecem restos de gordura animal queimada e de resina indicam fogueiras e sugerem iluminação. Intensa oxidação eliminou a maior parte da matéria orgânica. A acumulação de óxidos de ferro pode ter resultado do efeito acumulativo da exposição e de processos de denudação. Não há evidência de ter havido perto algum rio. O mar, a poucos quilómetros, fornecia quantidades de moluscos e caranguejos. C. 2 foi datada ^{14}C a partir de valvas de *Patella* 30930 ± 700 BP, com 30050 ± 550 BP para a fracção intermédia. Não houve contaminação. A idade real pode ser algo mais moderna do que aqueles valores. A datação Th/U, 30561 + 11759 – 10725 BP, é compatível com a do ^{14}C. O conjunto de instrumentos líticos, homogéneo, parece indicar que a ocupação mustierense teve duração bastante limitada. Foi descontínua, com episódios de abandono pelo homem que permitiram a frequência por predadores (sobretudo hienas e panteras) e morcegos.

Introduction

The evidence concerning the most recent Neanderthals in Portugal, and maybe in the world, comes from three basic caves: the Gruta da Figueira Brava, on the coast near Portinho da Arrábida (J. Pais and P. Legoinha, 2000, this volume), directly excavated and exploited by the authors; Gruta Nova da Columbeira, near Bombarral; and Gruta das Salemas, near Lousa (Loures) (Fig. 1). For the last two, data about the geological setting have been contributed by G. Manuppella.

For Gruta Nova da Columbeira, stratigraphic evidence is good. An excellent collection of homogenous, often high-quality, exclusively late Mousterian lithic implements was obtained here. These flint implements (for the most part) includes denticulates and levallois scrapers. This cave also yielded an association of large mammals, whereas small ones are nearly unknown (for faunal data see Antunes, 2000 – faunal synthesis, this volume). ^{14}C dating is good. All this and the presence of a neanderthalian tooth make this cave one of the reference Mousterian sites in the Iberian Peninsula.

Gruta da Figueira Brava presents some similarities, especially in what concerns its relationship to the sea, with the well-known neanderthalian site of Devil's Cave, Gibraltar. From all data gathered, Gruta da Figueira Brava seems to be richer than the other mentioned sites in Portugal. Both large (including marine) and small mammals, a rich bird association, reptiles and amphibians, are well represented. Unlike the remaining portuguese sites,

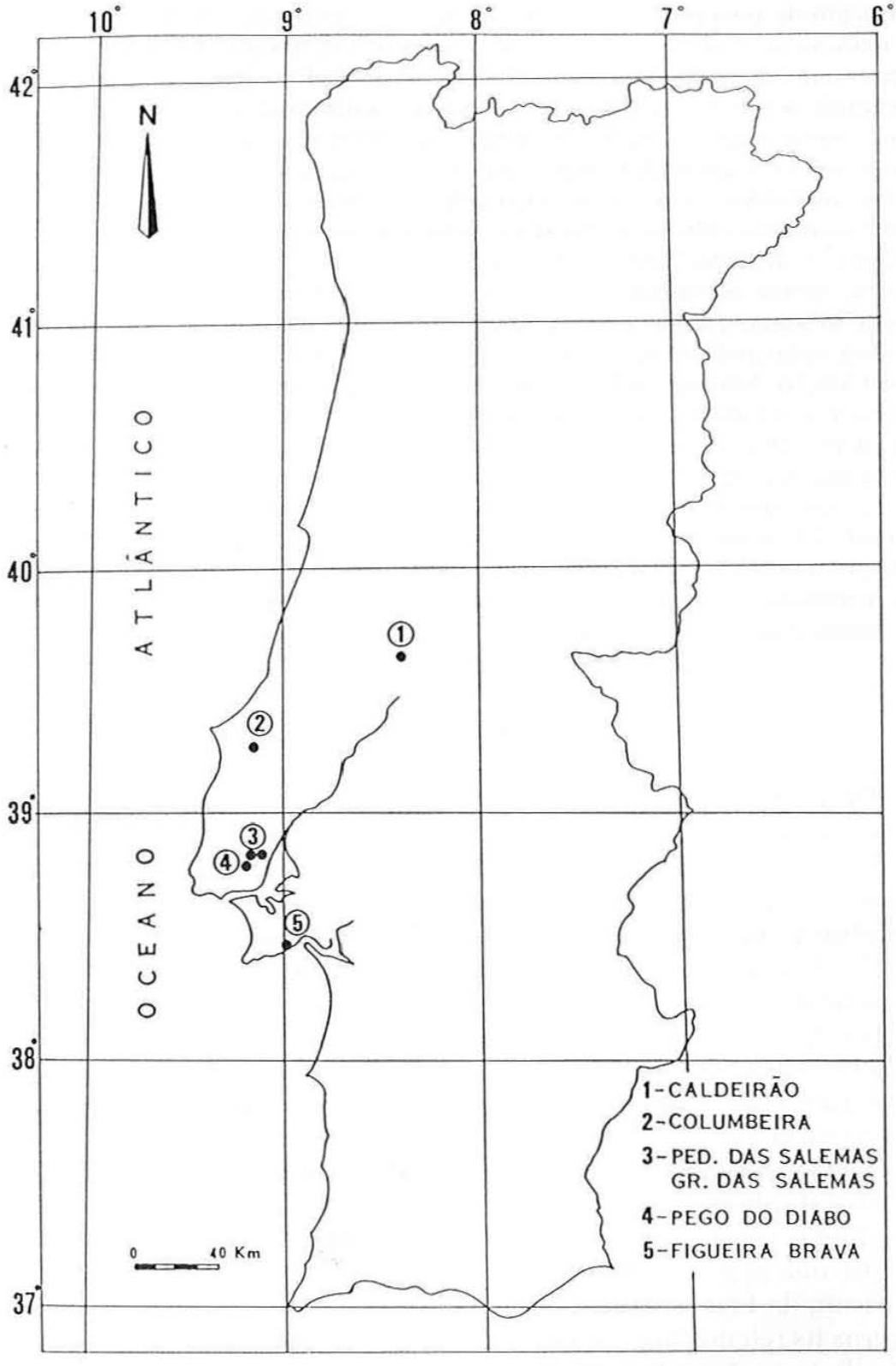

FIG. 1 - Portugal – a map indicating the position of the concerned localities (Gruta Nova da Columbeira, Gruta das Salemas, Gruta da Figueira Brava) and a few other more or less related sites.

data about marine molluscs and some other invertebrates is plentiful. Bone implements are common, in association with large numbers of lithic ones that correspond to a homogenous, late Mousterian association of denticulates and much less levallois scrapers than at Columbeira. That is a consequence of the worse quality of available raw materials, flint being rare; most of the specimens were made on quartz, less in quartzite, some even in limestone and flint. A neanderthalian pre-molar was found: it presents two sets of elsewhere unknown, man-made incised striae produced post mortem (with a cutting implement) and after the corpse was torn apart. This procedure is elsewhere unknown. ^{14}C dating is good and has been corroborated by U/Th series.

Much less can be said about the Gruta das Salemas. Stratigraphy poses some problems related to the gliding of sediments along fissures. The lower levels yielded scant, atypic lithic implements that have been tentatively ascribed to the Middle Palaeolithic. Evidence is rather good for large mammals but there is none as far as small ones are concerned. Nevertheless, the presence of a neanderthalian decidual tooth in the lower part of the cave's infillings and the ^{14}C dating of a somewhat later level are very interesting.

Gruta Nova da Columbeira

In the Serra da Cesareda, Upper Jurassic units occur in a large area. The main unit "Camadas de Alcobaça" comprises two formations with special interest, the "Calcários * de Moledo Fm" and the overlying "Reguengo Pequeno Fm". The "Calcários de Moledo Fm" has been dated Hypselocyclum – divisum Zone, Lower Kimmeridgian, by ammonites: *Orthosphinctes poligyratus* (Reinecke), *Phillopachyceras* sp., *Orthosphinctes* cf. *vandelli* (Choffat), *Lithacoceras subachiles* (Wegele), *Ataxioceras discobolum* (Fontannes) and *A. guentteri* (Oppel) (see Klingel, 1991).

Both Formations underwent karstic erosion. Several caves resulted, three of them on the left slope of the Vale ** de Frades. The cave known as Gruta Nova da Columbeira is situated at the uppermost part of the "Calcários de Moledo" Fm (Fig. 2 and 3). Coordinates: 39° 18′ 6″ N, 9° 11′ 58″ W.

The deep Vale Roto is a canyon. Its *ca*. 20 meters bottom is much below the highest surface, a platform at about 150 m. The western part of this platform is clearly divided by successive marine levels. The coastline was near until recent times. A fossil coastline is preserved along.

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* Calcários (in Portuguese) = limestones.

** Vale (in Portuguese) = valley.

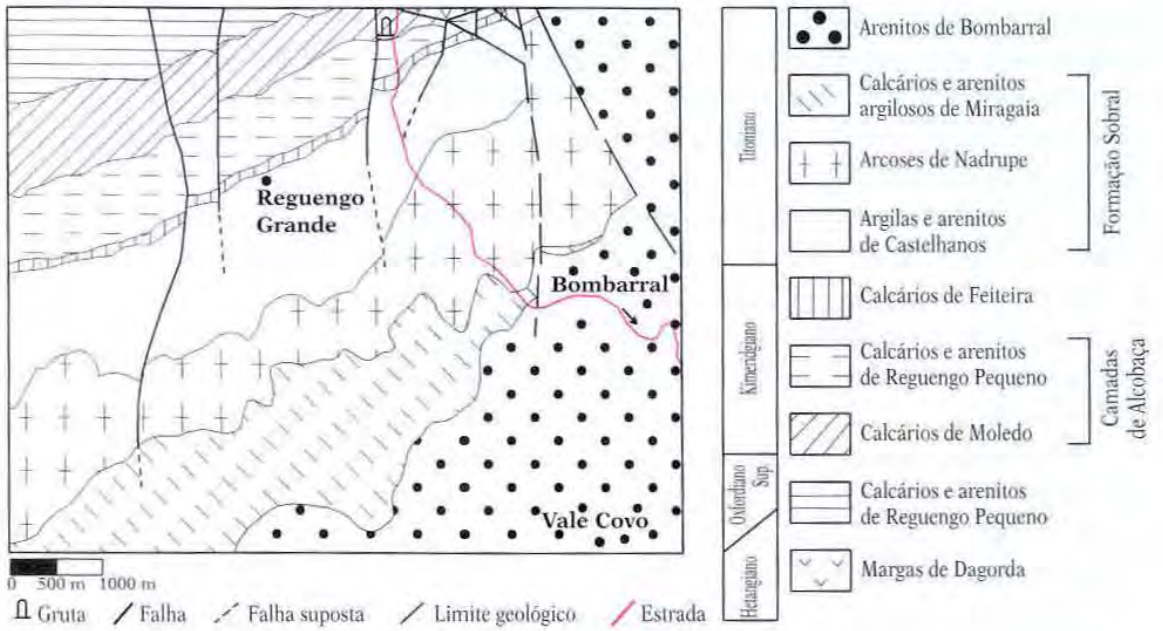


FIG. 2 - Geologic map – Columbeira area, showing Gruta Nova da Columbeira site (Manuppella *et al.*, 1999, *Carta Geológica de Portugal 1/50000*, Folha 30-A, Lourinhã (part). The "Calcários de Moledo Fm" is exposed.

Gruta Nova da Columbeira * owes its name to the fact that a few other caves were known in the same area since the last century. Its present entrance is located opposite of the cave's old one. It was exposed because of the limestone exploration of its surroundings. Some rhinoceros teeth attracted attention. Excavations were carried out by Octávio da Veiga Ferreira (August-October 1962) in collaboration with G. Zbyszewski and J. Camarate França (Serviços Geológicos de Portugal), and with the help of Jorge de Almeida Monteiro, Vasco Cortes, Antero Furtado and António da Silva Maurício from the Museum of Bombarral.

The cave comprises three main sectors: a broad, progressively narrower entrance gallery; a rather highly vaulted chamber; a narrow gallery that ends in an entirely filled chimney in the cave's innermost part. The old entrance corresponds to this chimney and leads to the spacious chamber where most human occupation occurred (Ferreira, 1984).

The cavity became closed by the end of the Pleistocene; no later human or animal presence has been detected. It corresponds to a narrow, high, irregular gallery about 20 meters long, 3 to 4 meters broad and *ca.* 10 meters

* Nova (in Portuguese) = new.

high. It contained (Zbyszewski, 1963; Ferreira, 1966) a succession of layers from top to bottom (thickness in meters):

C. 1 – Stalagmite level (0.01-0.12);

C. 2 – brown, somewhat sandy breccia with limestone fragments and concretions, animal bones and charcoal (0.40);

C. 3 – lenticular deposits containing carbonate concretions and animal bones (0.10);

C. 4 – grey to brownish clayey / sandy sediments with limestone fragments and carbonate concretions, animal bones and Mousterian implements (0.30);

C. 5 – silty layer (0.02-0.03);

C. 6 – compact breccia with many rock fragments, carbonate concretions, bones, charcoal and Mousterian implements (1.00);

FIG. 3 - View of the Vale Roto or Vale de Frades where the Ribeira da Columbeira flows. "Calcários de Moledo" Formation, Lower Kimmeridgian, uppermost part (passing into the "Reguengo Pequeno" Fm, Lower to Upper Kimmeridgian). The photo has been taken from near the Columbeira cross, on the Vale de Frades highway between Bombarral and Columbeira. The entrance of the Gruta Nova da Columbeira is seen to the left, lower part of the photo; at the center, the Lapa do Suão (a Neolithic site, a hole overlain by limestone beds) is shown. (Photo by G. Manuppella).

C. 7 – brown-greyish, bone-rich sandy layer with large numbers of Mousterian implements;

C. 8 – dark brown to black, more or less consolidated soil layer with ceinder accumulations (0.30);

C. 9 – stalagmite (unstated thickness);

C. 10 – yellow clayey, sterile sands on the cave's floor (unstated thickness).

Most levels were separated by a thin, lenticulat layer of stalagmite. That seems to indicate sedimentation hiatuses.

A more detailed stratigraphic description was carried out by J. Roche and O. da Veiga Ferreira in 1971. They recognized 20 levels that correspond to the previously published sedimentation events (Santos, 1972, p. 16). Charcoal for ^{14}C dating was collected between 12 and 13 meters from the entrance.

C. 8 corresponds to the most important human occupation level (Ferreira, 1984) (Fig. 4). C. 8 yielded the maximum concentration of implements

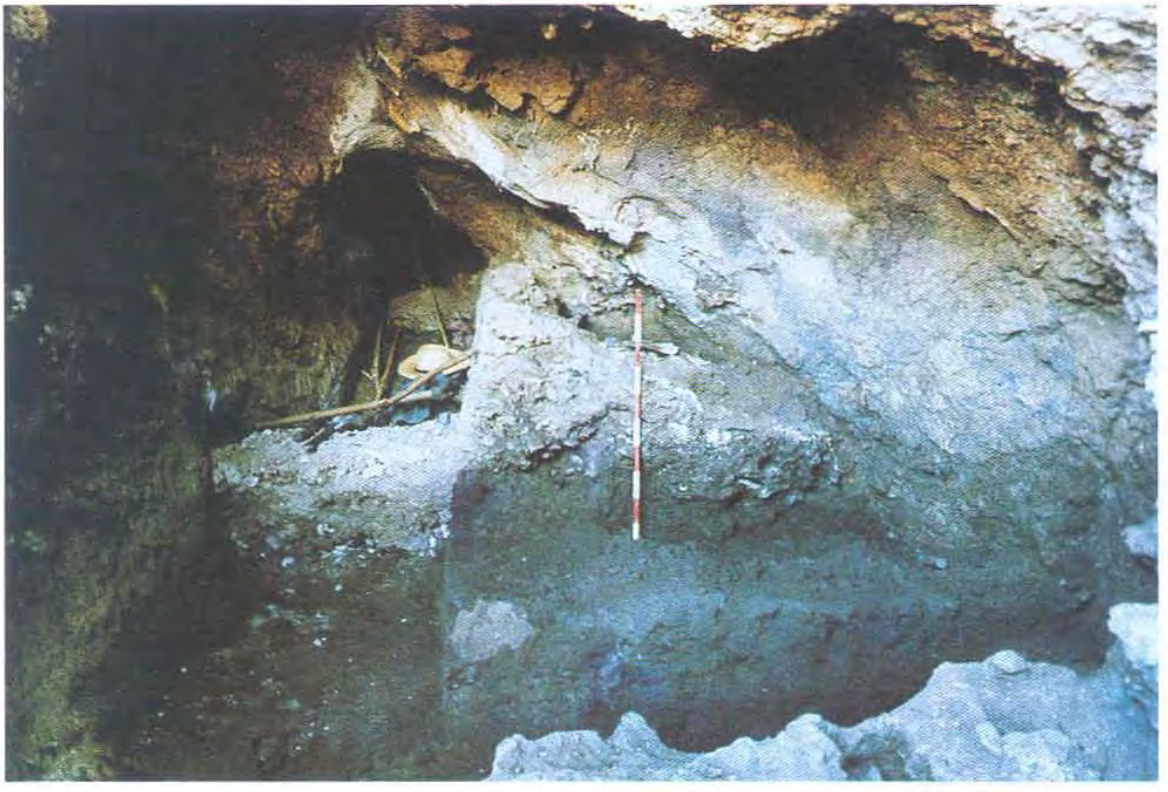
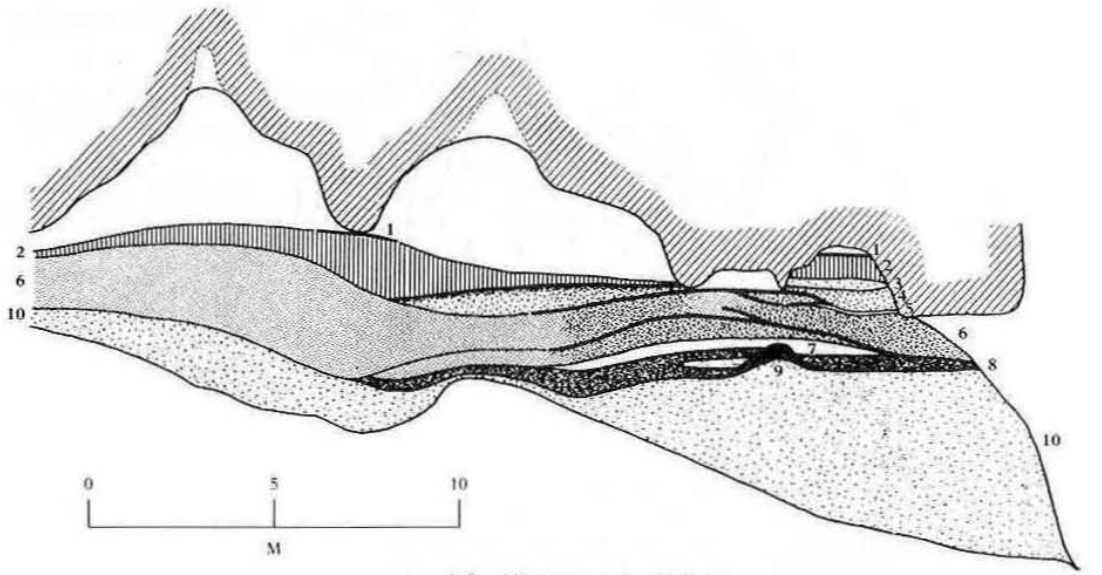


FIG. 4 - Gruta Nova da Columbeira site. View of part of the excavations in 1962, showing (at the center) the nearly black deposits of C. 8. In the foreground, there are parts of a stalagmite (C. 9) over which a neanderthalian tooth was found. G. Zbyszewski (straw hat) was inside. (Photo by O. da Veiga Ferreira).



1-9 – Niveaux moustériens;
8 - Niveau avec habitats de l'homme de Neanderthal;
10 - Sables stériles de la base.

FIG. 5 - Gruta Nova da Columbeira, stratigraphic section (Zbyszewski *et al.*, 1980-81, profil II, p. 10).

(2433); C. 7 follows up with 1880 (Raposo & Cardoso, 1998). The maximum incidence of carnivores was recognized in C. 6, which is poor in herbivorous mammals and industries in comparison to C. 7 and C. 8. We may conclude that the vast majority of herbivores found in C. 7 and C. 8 is a consequence of hunting.

^{14}C dating of two human occupation levels: C. 7, Gif 2703 sample, 26400 ± 750 BP; C. 8, Gif 2704, 28900 ± 950 BP. These place Gruta Nova da Columbeira among the about two dozen sites in Portugal and Southern Spain where the permanence of Neanderthals and Mousterian industries until *ca.* (or even after) 30000 BP has been ascertained (Raposo & Cardoso, 1998).

The industries (denticulates, numerous levallois scrapers) have been exclusively ascribed to the late Mousterian. This and the presence of a neanderthalian tooth at the top of C. 9 (in contact with C. 7 in a spot where C. 8 did not exist – Ferreira, 1966, 371) contributed to make Gruta Nova da Columbeira one of the reference localities for the study of the Mousterian in the Iberian Peninsula.

C. 6 and C. 8 yielded 255 identified mammal remnants (Cardoso, 1993). Their association is similar to other late Würm ones from several lower altitude caves in the portuguese province of Estremadura. The same association suggests temperate climate conditions, with some cold and dry seasons that favoured the existence of *Capra pyrenaica* – then a common species at the Serra dos Candeeiros.

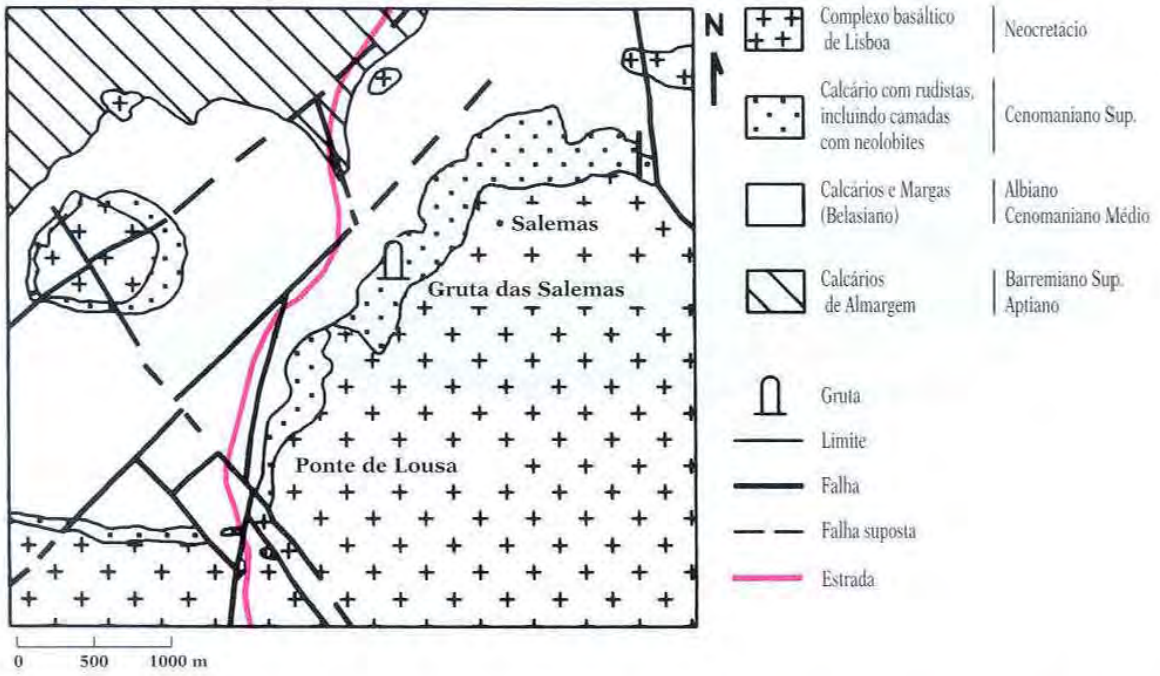


FIG. 6 - Geologic map - showing the site of Gruta das Salemas (Manuppella *et al.*, 1999, *Carta Geológica de Portugal 1/50000*, Folha 34-B, Loures (part). The upper Cenomanian limestones are exposed.

Gruta das Salemas

At the eastern side of the Rio de Lousa valley (between Lousa and Ponte de Lousa, about 24 kilometers Northeast from Lisbon), there is a scarp made up by Cenomanian (Upper Cretaceous), rudist-rich limestones (Berthou, 1973). The lowermost Upper Cenomanian is marked at its base by clayey, often nodular limestones with the ammonite *Neolobites vibrayeanus*, in association with gastropods (a few species of *Nerinea*), and foraminifers such as *Nummoloculina heimi*, *Praealveolina cretacea tenuis*. These nodular limestones are overlain by compact Upper Cenomanian limestones with Rudists (Berthou, 1973, 46, 138). Studies on the microfaunas of clay and carbonate beds allow a very fine datation.

Two caves exist near the summit of the scarp – A, the northermost one, and B. The former is located on top of the Middle Cenomanian beds. The B or Salemas cave (Fig. 6-9) is near the base of the Upper Cenomanian limestones. Coordinates: 38° 52′ 38″ N, 9° 11′ 58″ W, altitude 250 meters.

The Salemas cave resulted from a vertical, broadened diaclase in the Upper Cenomanian limestones. It is sinuous, about 30 meters long and *ca*. 1 meter wide. The cave was totally excavated by O. da Veiga Ferreira and J. Camarate França, with support from G. Zbyszewski. The first of two

campaigns was accomplished in November 1959, soon after a first prospection by L. de Albuquerque e Castro. The second campaign took place from October to December 1960.

The stratigraphic succession (Roche & Ferreira, 1962) comprises, from top to bottom (Zbyszewski, 1963; Ferreira, 1964, 1966; Zbyszewski *et al.*, 1980-81), the following "levels" (thickness in meters):

1 – Neolithic dark grey/black soils (0.50-1.00);

2 – grey soils (not as dark as C. 1); there has been sediment mixture as a result of the development of a Neolithic necropolis. Only the 4-5, 7-8 and 10-11 sections were observed; Solutrean (0.15 to 0.20);

3 – yellow, sometimes brown or reddish soils, deposited from the entrance to section 18; Perigordian (average thickness 0.25; at section 9, 0.35; at sections 6 and 7, 0.10);

4 – "terra rossa" at the base of the fissure (it was impossible to evaluate its thickness), containing large mammal remains and a few atypical, maybe Middle Palaeolithic artifacts.

FIG. 7 - General view of the Rio de Lousa valley seen from near the Gruta das Salemas (the cave is out of sight, to the left, upper part of the Upper Cenomanian rudist limestones, at about 275 meters level). The Fontelas hill, where the Cenomanian is capped by the Lisbon-Mafra Volcanic Formation, can be seen in the far-off center of the picture. (Photo J. L. Cardoso, 1987).

The only part of the cave where the stratigraphic succession was complete and well preserved was between sections 7 and 11 (Roche & Ferreira, 1970): "level" 4 corresponds to the C. 8 bed and "level" 3 to C. 7. The lowermost deposits are most interesting:

C. 7 – yellow-reddish soils with medium to small, angular detritical elements in large numbers. Sediments clearly glided along fissures on the floor. This layer yielded a few implements that have been regarded as Perigordian (0.10 to 0.35).

C. 8 – inside the fissures, there was a mixture of "terra rossa" and brown, clayey soil. These materials apparently glided along the fissures and are probably sediments from the two levels just above.

A more intense gliding of sediments along the vertical fissures that affect the whole cave was observed at the bottom. The primitive floor was entirely covered (Roche & Ferreira, 1970, 264). These phenomena were

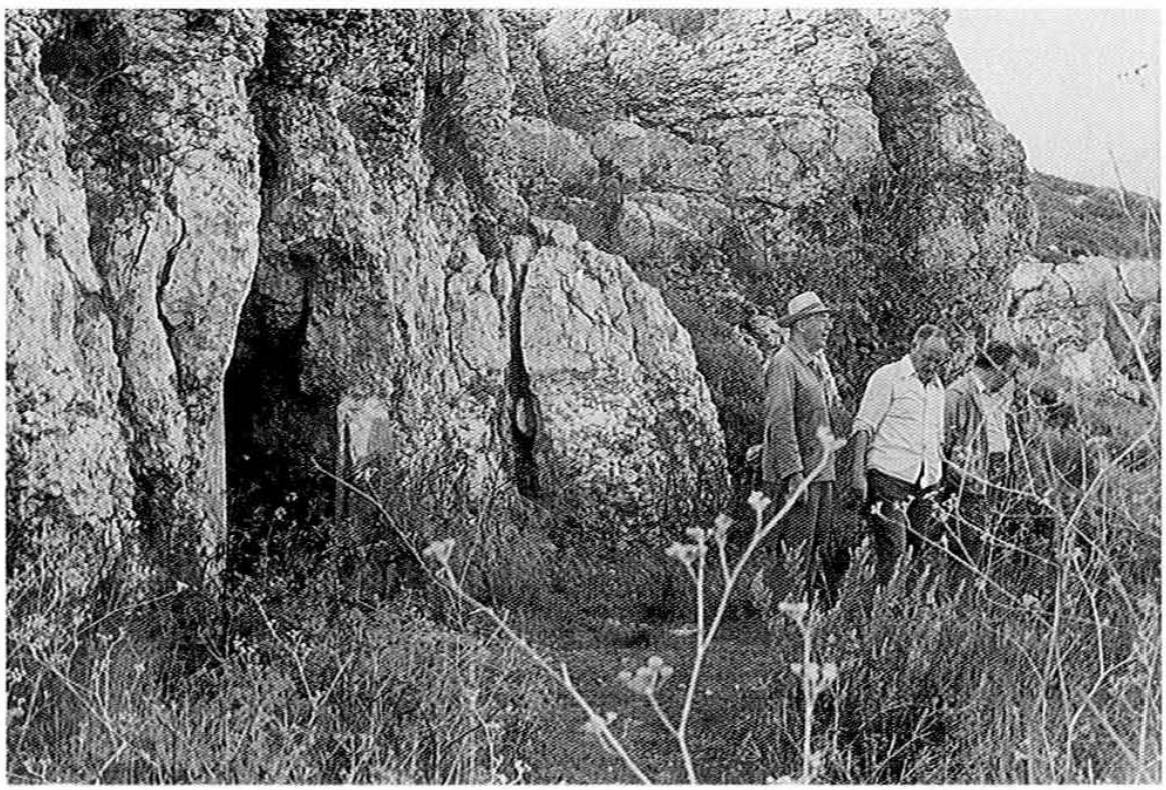


FIG. 8 - Gruta das Salemas, entrance. O. da Veiga Ferreira (center), accompanied by G. Zbyszewski (with hat), showing the site to M. T. Antunes. (Photo J. L. Cardoso, 1987).

important enough to suggest that most of the basal deposits came from the outside (Roche & Ferreira, 1970, 266).

The scarce and atypical lithic implements from "level" 4 (= C. 8) have been tentatively ascribed to the Middle Palaeolithic. Gliding of sediments has not been clearly observed here. Bed C. 8 (between the sectors 7 and 11) yielded a human decidual molar (Ferembach, 1962; Antunes *et al.*, 2000, this volume).

The C. 8 bed (TVb = Terras Vermelhas da base / Basal Red soils in English) was ^{14}C dated, sample ICEN-379, 24 820 ± 550 BP (Antunes *et al.*, 1989). This is apparently too late for the Mousterian and may justify some reserve about the atypical implements (Cardoso, 1993, 93; Cardoso, 1996). It is probable that the bone samples employed in ^{14}C dating came from the outside; bones could have glided into the bottom of the cave during a certain time span. The concerned dating may thus be somewhat later than the lowermost C. 8 deposits.

FIG. 9 - Gruta das Salemas, between Lousa and Ponte de Lousa. General view showing the upper Cenomanian, more or less concretionate limestones and the entrance of the cave. (Photo G. Manuppella, 1998).

FIG. 10 - Gruta das Salemas, entrance. (Photo G. Manuppella, 1998).

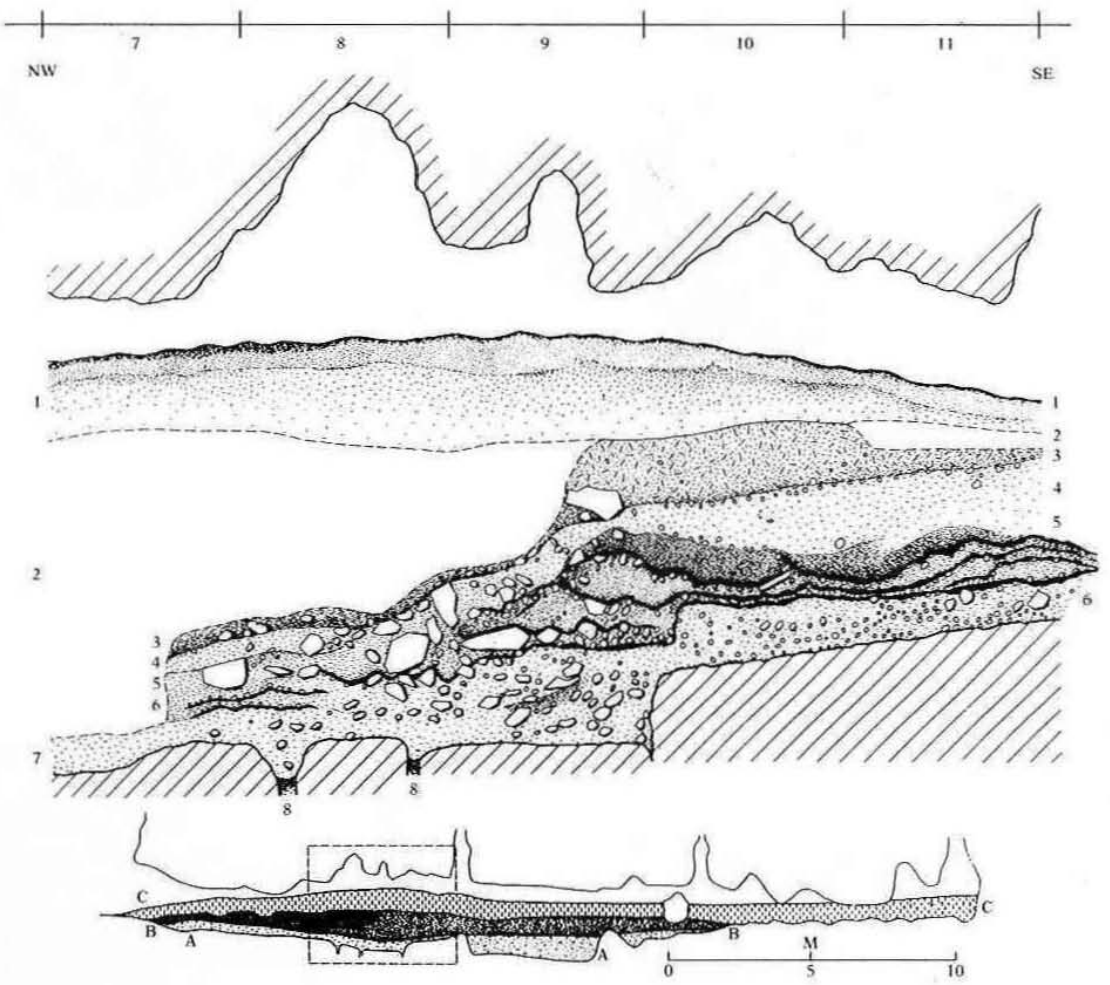


FIG. 11 - Gruta das Salemas, stratigraphic section (Roche & Ferreira, 1970, Fig. 1) enlarged from the longitudinal profile (Zbyszewski *et al.*, 1980-81, profil I). Each scale is in meters.

Gruta da Figueira Brava

The site and its origin

The Gruta da Figueira Brava (Fig. 12-34) is one of the main Portuguese late Mousterian sites. It yielded Portugal's richest evidence on marine fauna. It lies a few meters from the sea and less than 5 meters above the high tide level at the southern slope of the Serra da Arrábida, westwards of the Creiro small fortress (Fig. 12 and 17). Coordinates: 38° 28′ 23″N, 8° 59′ 42″ W. A detailed geologic account is provided (Pais & Legoinha, 2000, this volume).

Pliocénico		Areias feldspáticas de Fonte da Telha e de Coina	P_{TC}
Miocénico	Tortoniano	Depósitos de Ribeira da Lage (M_L)	M_L M_{An} M_{GM}
		Areias e margas de Qta. do Anjo (M_{An})	
		Conglomerados de Guarda-Mor (M_{GM})	
	Serravaliano-Langhiano	Depósitos glauconíticos de Penedo (M_{Pc})	M_{Pc} M_{Pi}
		Arenitos e calcoarenitos de Pinhal e Castelo de Palmela (M_{Pi})	
		Areias de Qta. da Torre	M_T
	Burdigaliano	Calcarenitos e margas de Foz da Fonte e de Penedo Sul (M_{FF})	M_{FF} M_{Az}
		Argilitos e margas de Azeitão (M_{Az})	
	Aquitaniano	Calcários margosos de Palhavã	M_{Pa}
Paleogénico		Calcários de Sra. das Necessidades	Φ_N
		Conglomerados, arenitos e margas de Picheleiros	Φ_P

FIG. 12 - Geologic map – showing the site of Gruta da Figueira Brava (Manuppella *et al.*, 1999, *Carta Geológica de Portugal 1/50000*, Folha 38-B, Setúbal (part)). The lower Miocene (Burdigalian) biocalcarenites outcrop West of Creiro (Fortaleza in the map), where the Lapa de Santa Margarida and the Gruta da Figueira Brava (*) developped.

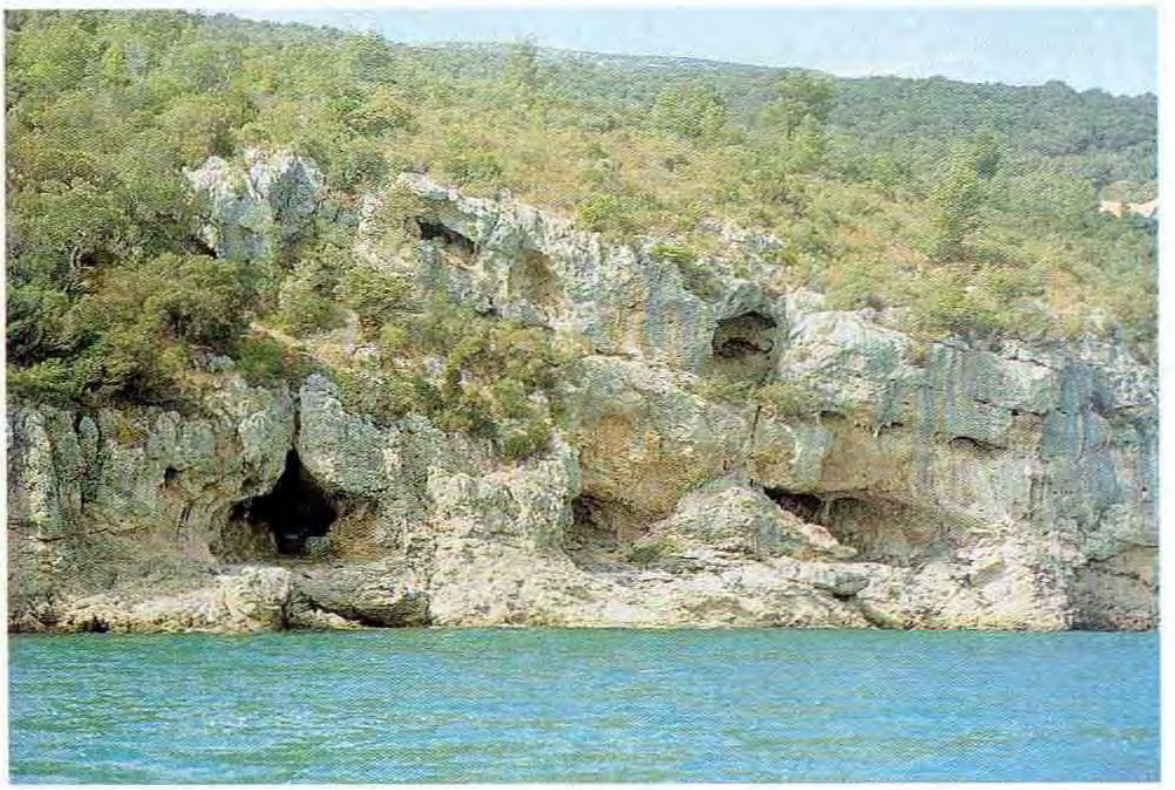


FIG. 13 - Entrance of Gruta da Figueira Brava and the 5-8 meters terrace covered by a conglomerate. Gruta da Figueira Brava and Lapa de Santa Margarida (nearby) are two caves excavated in the Miocene biocalcarenites of the Alpertuche-Creiro small fort outcrop. View from the sea. (Photo: M. Telles Antunes, July 20th, 1989).

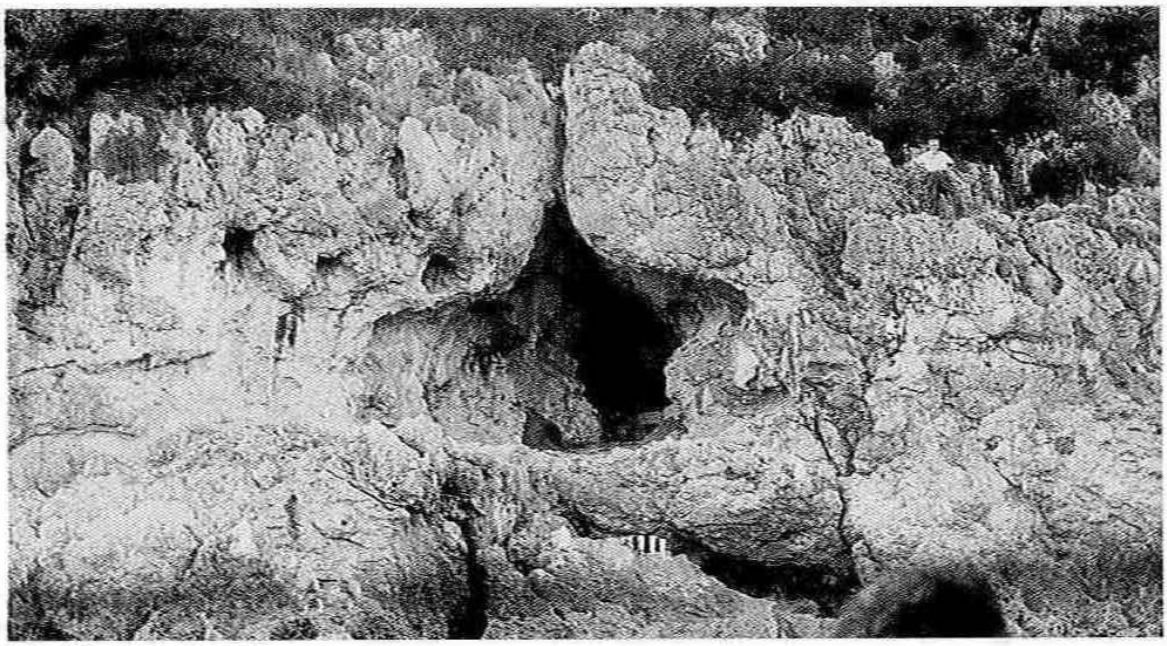


FIG. 14 - Gruta da Figueira Brava, entrance seen from the sea showing the enlargement of a main diaclase. At the lower part, the sea is excavating the Miocene biocalcarenites below the 5-8 meters terrace surface (i.e., the level of the floor at the entrance). The 5-8 meters terrace was similarly excavated during the Tyrrhenian III episode. July 20th, 1989. View from the sea. [Human figure to the upper right gives a scale].

FIG. 15 - Gruta da Figueira Brava – Northeastern foreground showing the Tyrrhenian III conglomerate on the 5-8 meters terrace surface. Scale: 1 meter. July 20th, 1989.

FIG. 16 - Gruta da Figueira Brava – The same as Fig. 15, detail: rolled cobbles and boulders, mostly of Jurassic limestones and dolomites, often much corroded.

Fig. 15

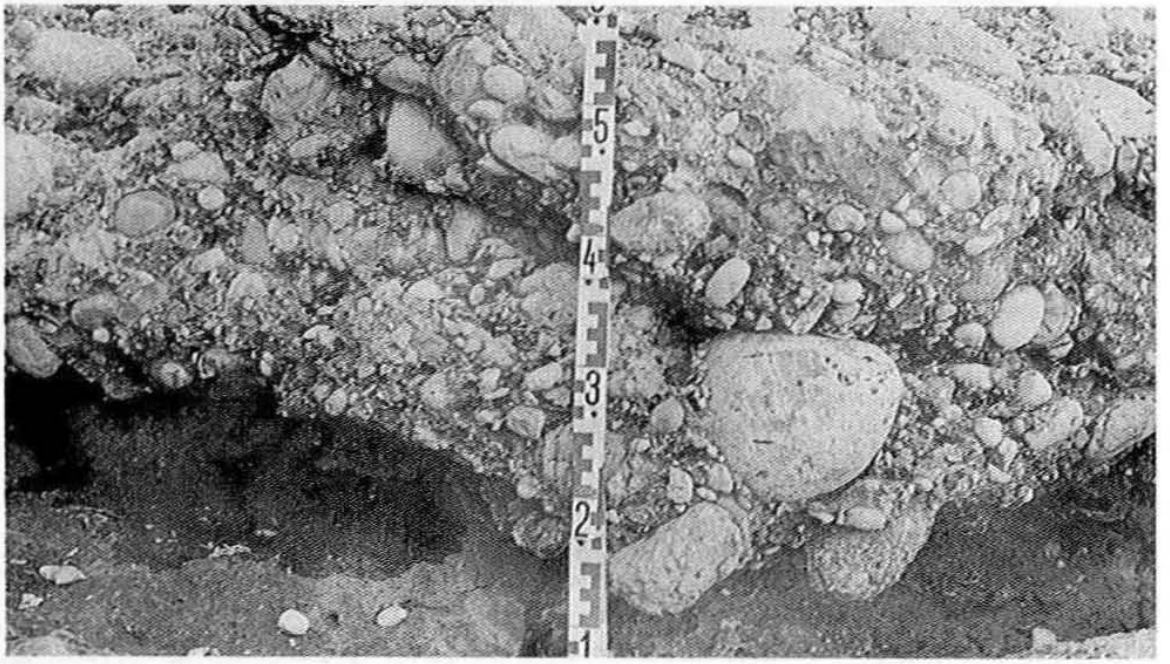


Fig. 16

The Gruta da Figueira Brava seems to have resulted from two kinds of phenomena: (a) karst erosion that broadened vertical diaclases (especially where they criss-cross) on Miocene biocalcarenites (Pais & Legoinha, 2000, this volume), and (b) marine abrasion during a Pleistocene event when the sea level was about 5 meters above its present position. The latter prevailed; the effects of the surf resulted into intensive excavation of the rocky coast, as it happens today at a lower level. As today, there is a tendency to develop some kind of shelter with an overhanging roof. A broad and deep chamber resulted, its floor being a sort of platform covered by the marine, Tyrrhenian III conglomerate (5-8 meters level terrace). As a consequence of the lowering of the sea level until about – 60 meters, a game-rich littoral plain appeared, only to be flooded again in the Holocene. Much later, diagenetic $CaCO_3$ consolidated the external part of eolic sand infillings into a hard sandstone that blocked the shelter and converted it into the extant cave.

FIG. 17 - The coast seen to NE from near the entrance to Gruta da Figueira Brava: in the rear part (at the center) the Creiro small fort, and (to the right) the Anixa islet.

Previous references, excavation campaigns, acknowledgements, general data

The first reference to the Figueira Brava cave is that by Breuil & Zbyszewski (1945, 326). After a second prospection (Silva & Soares, 1986), excavation campaigns were carried on by the Centro de Estratigrafia e Paleobiologia (later succeded by the Centro de Estudos Geológicos) of the Universidade Nova de Lisboa under the Direction of M. Telles Antunes and the participation of several persons, and especially that of J. L. Cardoso: September 1986; September 1987; April 1988; June 1988; June-July 1989; June 1990. Excavations were done with the agreement of the Direcção-Geral de Minas and the Instituto Português do Património Cultural, and with partial financial support of the Calouste Gulbenkian Foundation, and the Parque Natural da Arrábida. For a more detailed account, see Antunes (1991, 492-494, 498-499).

The cave presents an entrance gallery (*ca.* 12 meters long) that opens to the sea. This gallery communicates with a large interior room (about 10 meters high). The first researches were carried out in its western part,

FIG. 18 - The coast seen to the SW from near the entrance to the Gruta da Figueira Brava (where people stand). The 5-8 meters terrace (Tyrrhenian III) remains and conglomerate are well exposed. April 1988.

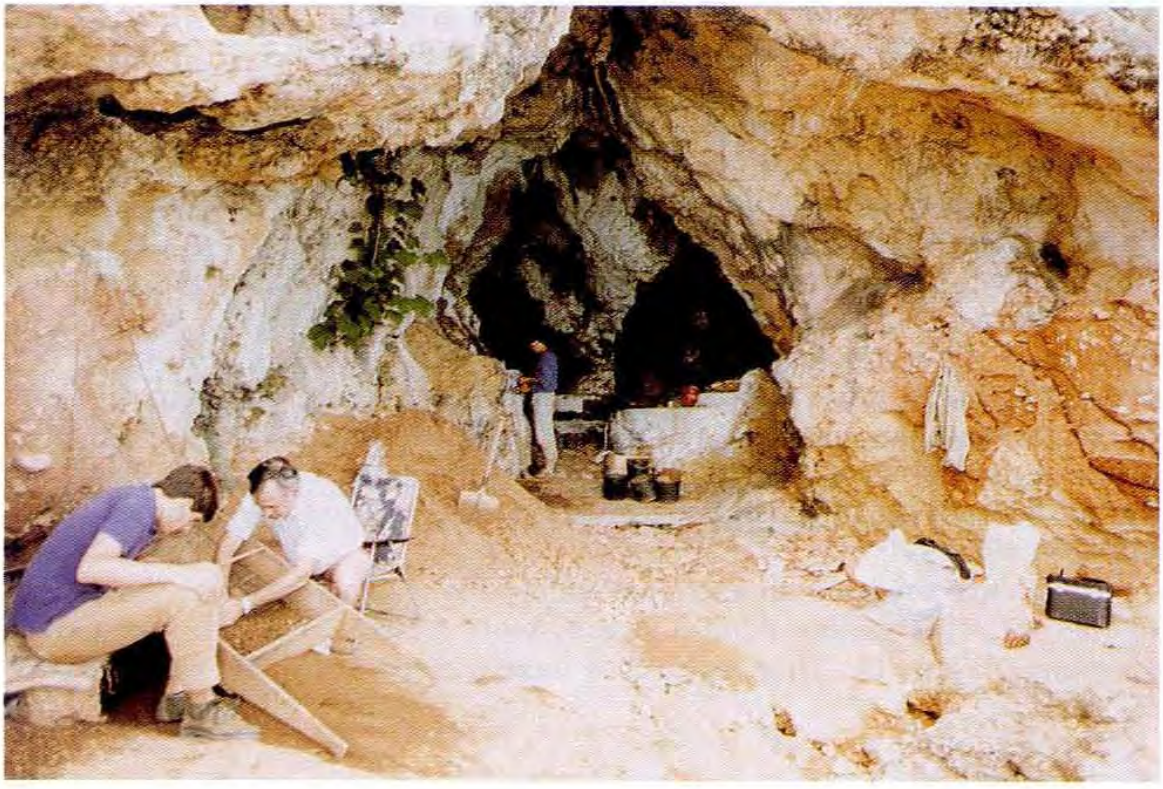


FIG. 19 - Gruta da Figueira Brava – The entrance, sieving activity. To the right, a red Mousterian "breccia" rich in iron oxides is apparent. It has been converted into hard stone by $CaCO_3$ diagenesis, and adheres to the Miocene biocalcarenites. April, 1988.

FIG. 20 - Gruta da Figueira Brava – Entrance to the main room. April, 1988.

FIG. 21 - Gruta da Figueira Brava – Main room (part) and its entrance. The first prospections were carried out on the unconsolidated brown/reddish sands to the right. April, 1988.

Fig. 20

Fig. 21

FIG. 22 - Gruta da Figueira Brava – Main room, right (NE) part; stalactites, stalagmites and the entrance of the gallery. September, 1987.

where the lack of stalagmite cover rendered the excavation of unconsolidated sands easier until the rocky bottom. In this particular spot there was no conglomerate. A rectangle of 1 by 2 meters was selected. Lithic implements and abundant microfaunal remains were collected.

Prospection and excavation went on in an eastern, progressively narrower gallery. A thick stalagmite cover suggested the preservation of intact deposits under it. This gallery became the main excavation ground for collecting materials and stratigraphic observations, especially on the vertical section cut on its southern side.

As the excavation went on, it became clear that this gallery is but the inner part of an extensive space that was formerly open to the outside. As of now, a wall of partly stalagmite-sealed, carbonate-consolidated sediments isolates it up until the roof. The eastern part of the gallery becames so narrow that it is nearly impossible to enter a still unexplored eastern room.

The excavation front was *ca.* 5 meters long; it was explored from 1 to more than 2 meters in depth. An estimated volume of 10 to 12 cubic meters

of sediments was extracted. All were sieved (5 mm sieve) at the cave entrance, most of the finer part being washed and sieved (0.5 mm sieve) later at the Faculdade de Ciências e Tecnologia Earth Sciences laboratory. Microvertebrate remnants were found in abundance. Many large mammal bones and teeth were collected. The former had been broken for extraction of the marrow. The Palaeolithic faunal remnants presented a strong patina and adherent sand grains. Some coprolithes were found, as well as one neanderthalian tooth, along with a very rich association of birds and reptiles, numerous shells, redeposited fossils, lithic and bone implements, and (in C. 3) fired stones, ashes, charcoal and other, undeterminated organic matters.

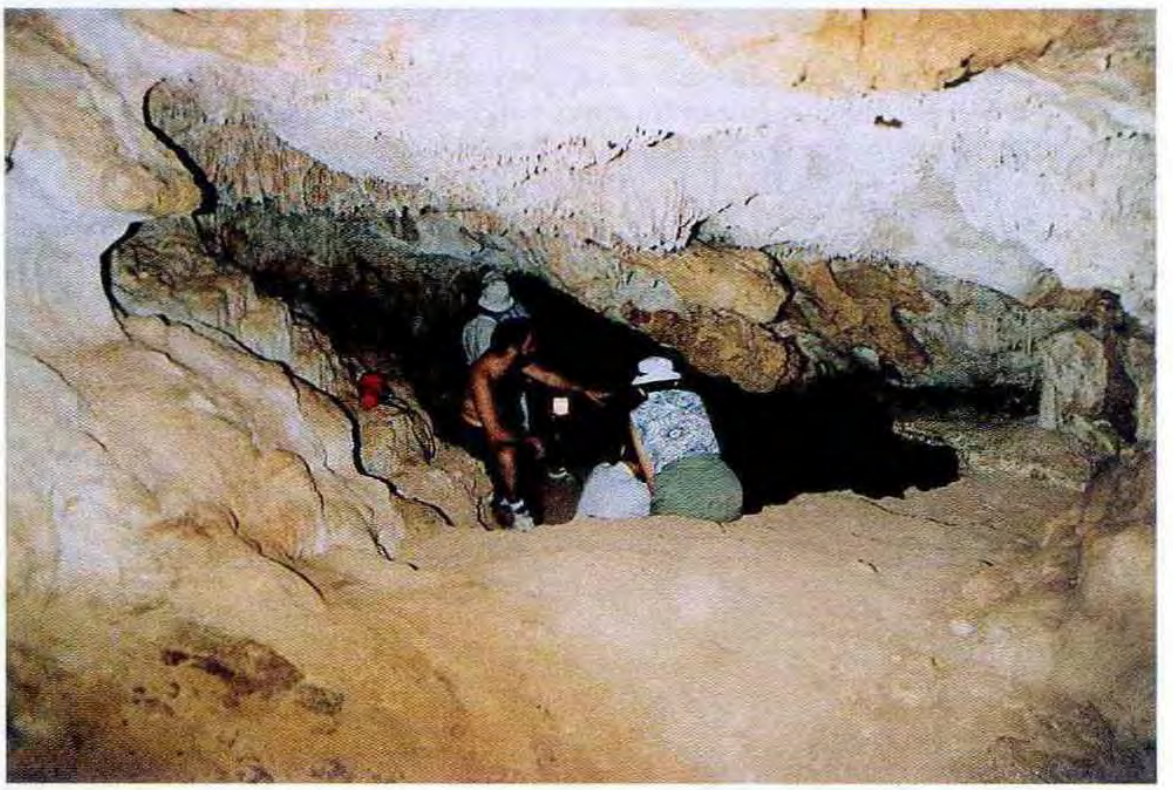


FIG. 23 - Gruta da Figueira Brava – The gallery entrance showing stalactites and the important stalagmite cover that seals the older, Middle Palaeolithic (late Mousterian) sediments under exploration. J. L. Cardoso (left), Pierre Mein (Université Lyon I) and Marie-Thérèse Mein. July 20th, 1989.

FIG. 24 - Gruta da Figueira Brava – Early excavations at the gallery (September, 1987); part of the stalagmite cover had been removed, allowing the exploration of the underlying mobile sands. No recent stirring up occurred. [Helena L. T. Antunes in the picture].

FIG. 25 - Gruta da Figueira Brava – Early excavations at the gallery near its entrance (September, 1987); mobile sediments under the stalagmite cover had partly been removed. Note (to the right of the scale) two downward pointed stalagmite cones that remained exposed after enclosing sands were removed. They may correspond to carbonate infillings of the bottom of roman amphorae previously sticked into the floor (a common practice by then). Scale: 1 meter.

FIG. 26 - Gruta da Figueira Brava – Early excavations in the gallery (September, 1987), near the entrance; detail showing much broken large mammal bone (probably from *Bos primigenius*) next to a quartz cobble that may have been used as a hammer. Also apparent is a section of a downward pointed cone sealed by stalagmite. Scale: bent in 0.5 meter halves.

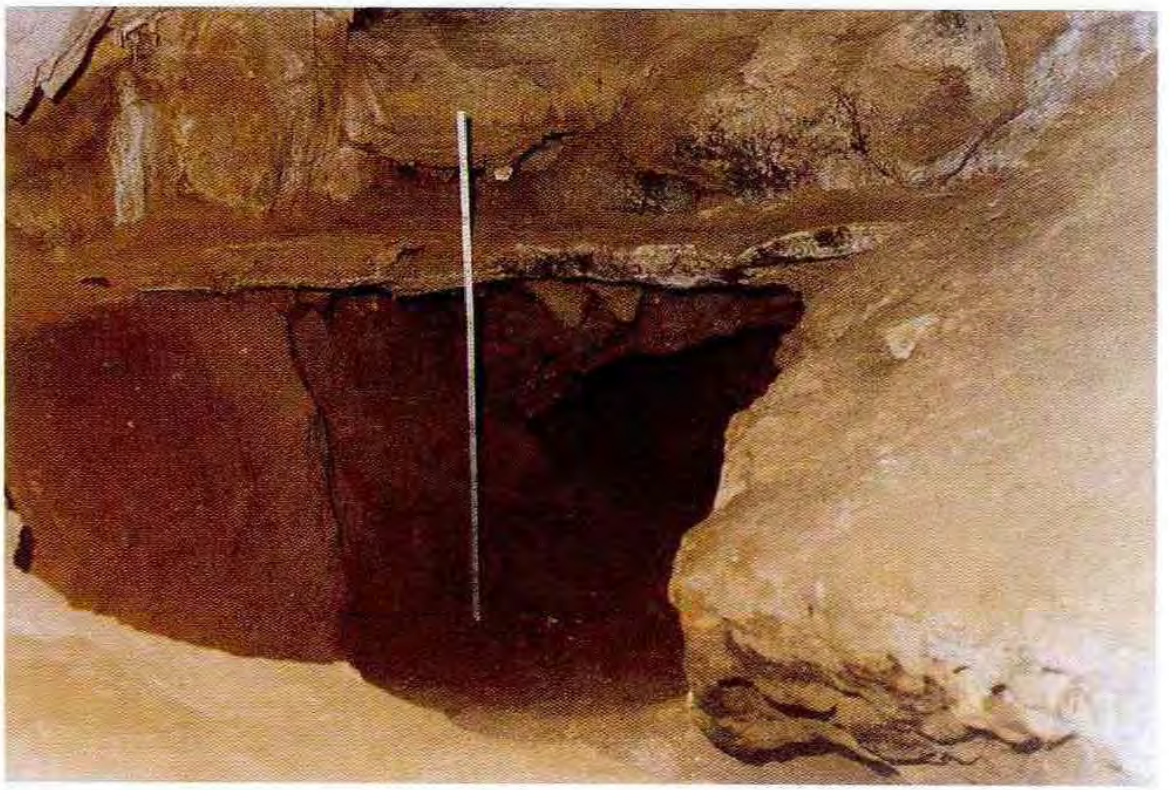


Fig. 25

Fig. 26

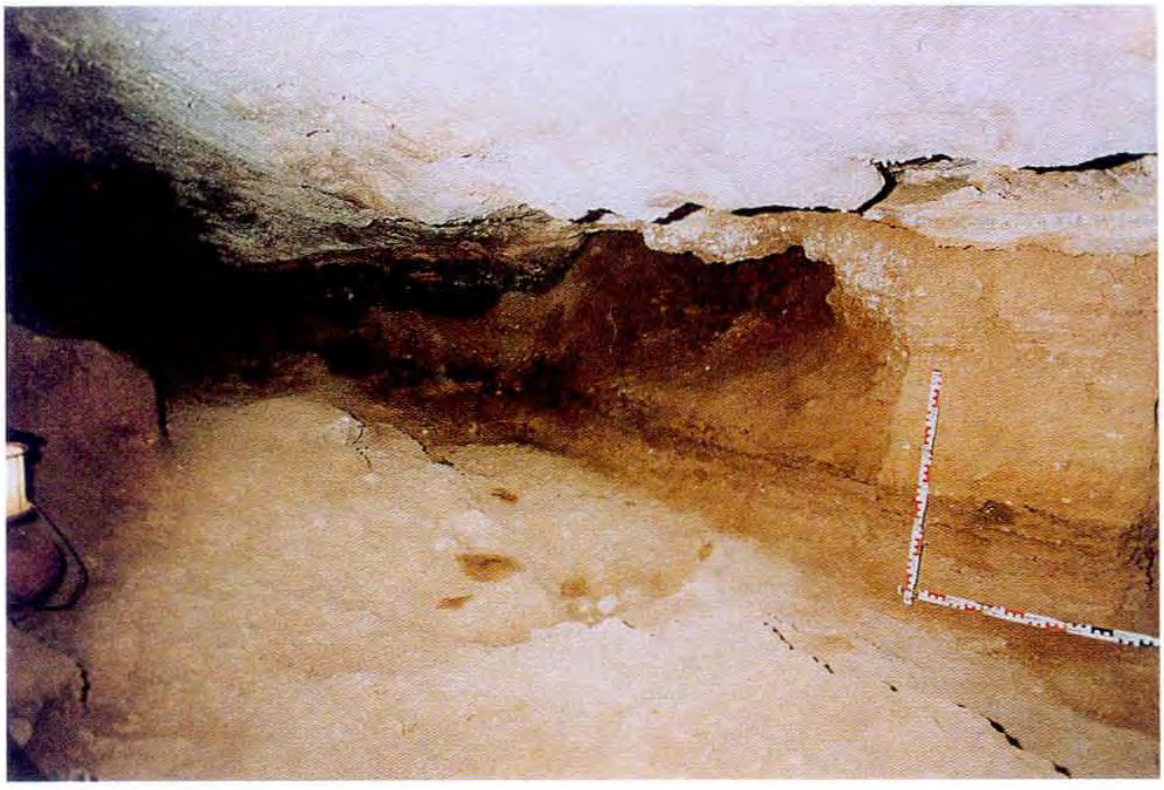


FIG. 27 - Gruta da Figueira Brava – General aspect by the end of excavations (July 20th, 1989). Northeastern end of the excavations showing (to the left) the narrowing gallery that communicates with a still unexplored room. A sedimentary section testimony was left, showing the beds under the stalagmite cover referred to as C. 1 (see Fig. 34): C. 2, fossil-rich sands with numerous Late Mousterian lithic (and bone) implements; the surface has been irregularly stirred up by walking on and the sticking of roman amphorae [Palaeolithic material is strongly patined, whereas the scant modern faunal and amphorae fragments are nearly without patina]; C. 3, darker layer with ashes, fired stones, less fauna and implements of the same type; C. 4, basal Palaeolithic deposits that overlie the Tyrrhenian III conglomerate.

FIG. 28 - Gruta da Figueira Brava – View of the main, ± southern front by the end of excavations (July 20th, 1989). The top of the conglomerate (C. 5 bed) is evident under the sedimentary testimony. The upper part shows some stirred up and (later on) more consolidated sediments covered by stalagmite layers. Scale (upright part), 0.6 meters.

FIG. 29 - Gruta da Figueira Brava – View of the main front by the end of excavations (July 20th, 1989). Detail showing beds C. 2 (including upper, more carbonated stirred up sediments), C. 3 (darker), and C. 4 (bottom). Scale minimal divisions, 1 centimeter.

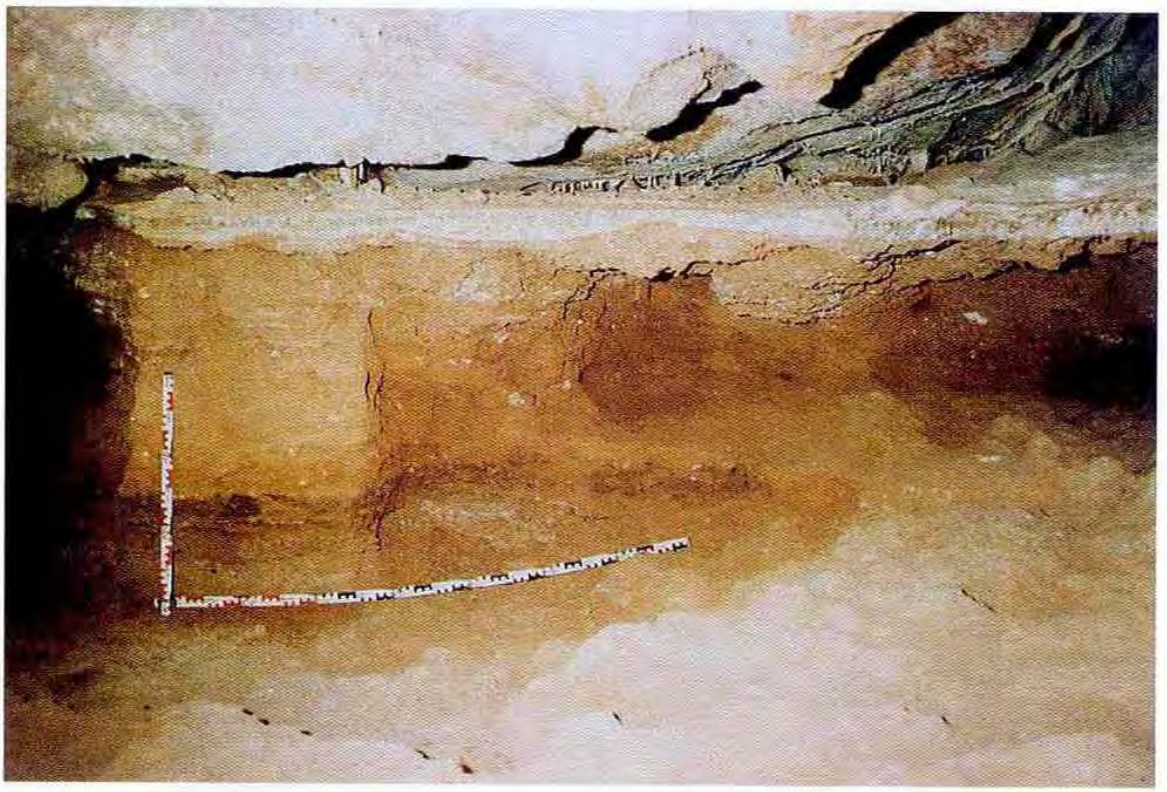


Fig. 28

Fig. 29

FIG. 30 - Gruta da Figueira Brava – A stratigraphic detail (April 1988). The succession of beds C. 2 to C. 4 is evident in between the stalagmite cover and the Tyrrhenian III conglomerate (C. 5), of which some boulders are exposed. Scale, 0.8 meters.

FIG. 31 - Gruta da Figueira Brava – A stratigraphic detail by the end of excavations (July 20th, 1989): upper part of the succession, bed C. 2 and the stalagmite cover, showing 3 (or 4) formation events. Scale minimal divisions, 1 centimeter.

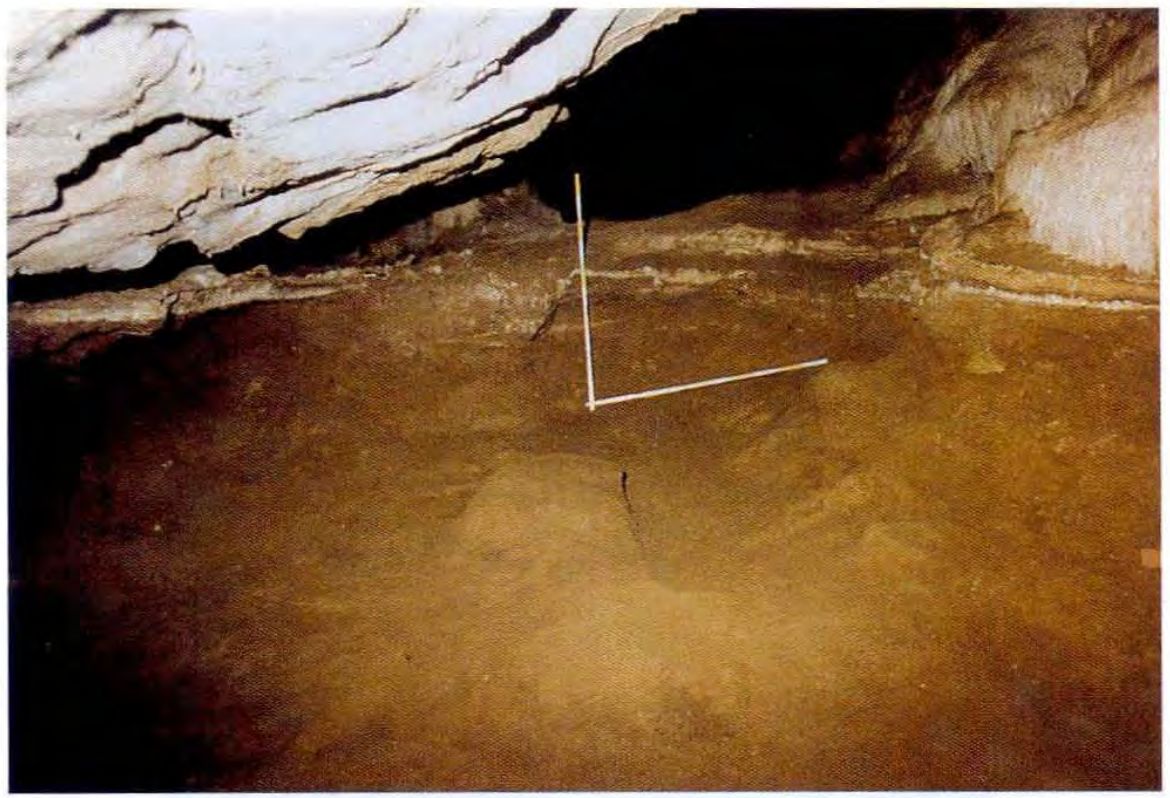


FIG. 32 - Gruta da Figueira Brava – View of the excavated part near the entrance of the gallery by the end of excavations (July 20th, 1989). The remaining part of the stalagmite cover and the excavated space can be seen. Scale: 1x1 meters.

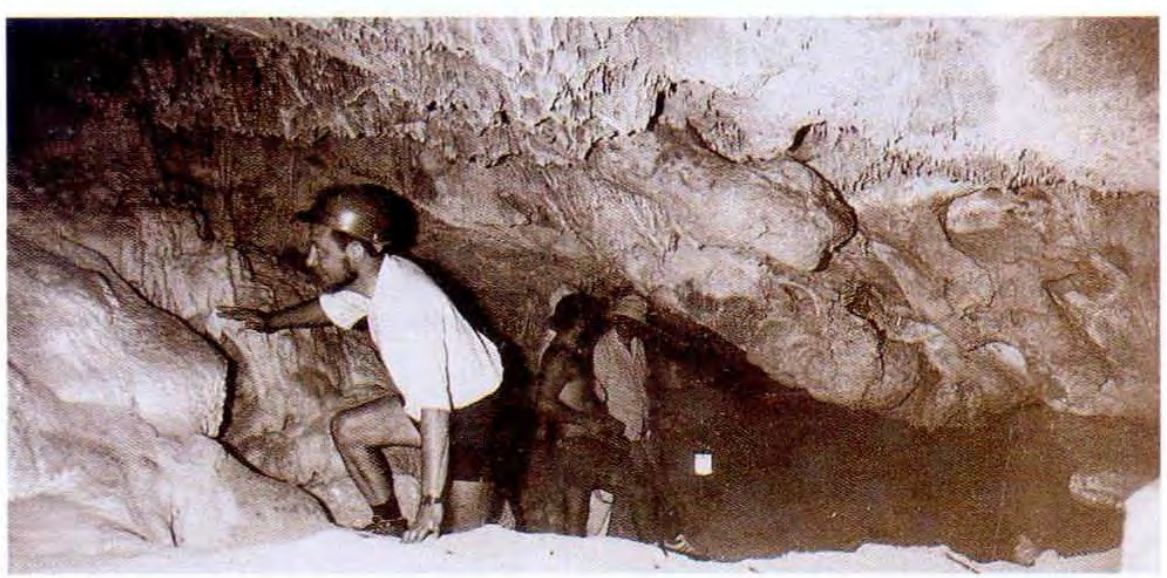


FIG. 33 - Gruta da Figueira Brava – Pierre Mein (Lyon 1 University) at the gallery entrance, July 20th, 1989.

Stratigraphy of the Quaternary deposits

Stratigraphic sections (for the geologic framing Miocene biocalcarenites see Pais & Legoinha, 2000, this volume) were described by Antunes and Cardoso (Antunes, 1991, 497, Fig. 1) (Fig. 34). The following Quaternary deposits were observed from top to bottom (thickness as a whole does not exceed 1 m; measurements in meters):

C. 1 – whitish stalagmite layers, containing scant fragments of Roman amphorae, and white, without patina domestic animals (*Ovis*), rabbit and small mammal, bird, reptile and marine fish remnants – Holocene (0.15 m, variable).

C. 2 – moderate to light brown fossil-rich sands, eventually consolidated by $CaCO_3$. The Mousterian sands are disturbed in some spots by mixing with more recent materials (0.80 m, variable).

C. 3 – is the darkest sandy bed, moderate brown (wet, dry), then grey to black (0.25 m). It yielded very scarce faunal remains, some lithic material and carbonaceous matters. There is evidence of fire structures, including fired, more or less rubefacted pebbles and cobbles.

C. 4 – sands that are moderate brown or moderate yellowish brown in the upper part and in the lower part dark yellowish brown or pale yellowish brown, sometimes darker (inside the cave); in the exterior, pale yellowish brown or greyish orange (maximum, 0.10 m).

C. 5 – the marine conglomerate that overlies the Miocene substractum. It is mostly composed of Jurassic calcareous or dolomitic cobbles and boulders (some of quartz and quartzite). These are often very much corroded and many times exceeding 0.20 m in size (thickness, 0.20 m).

In the upper part of C. 2 there is some disturbance of sediments, probably related to human activities, including as for other beds ancient walking on and excavating (and much later sticking of roman amphorae into the floor). Amphorae fragments were indeed collected in superficial part of C. 2. Prevailing pleistocene sediments are mixed with some Holocene materials, including marine bird bones. Most of the layer is made up of undisturbed pleistocene sands rich in faunal remnants and late Mousterian implements. C. 2 has resulted from the sedimentation of fine, sub-horizontal eolic sands added to human food garbage, implements, and quartz pebbles (most probably transported by man as raw material for implement producing). Beds C. 3 and C. 4, with ashes and carbonaceous matters, point out to firing in the shelter space inside and outside the present gallery. The conglomerate can be correlated to the transgression event that took place in the beginning of the Würm glaciation and originated the 5-8 meters terraces that are well represented near Arrábida (Zbyszewski & Teixeira, 1949; Antunes, 1991; Cardoso, 1994).

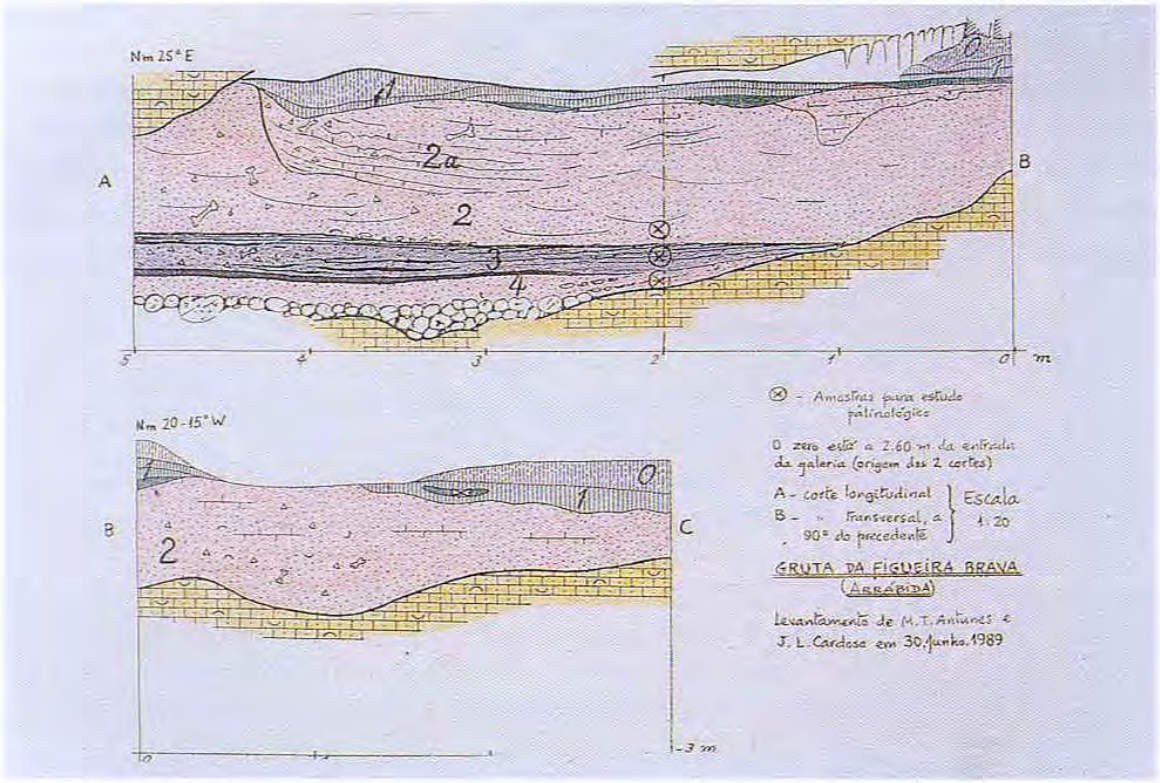


FIG. 34 - Gruta da Figueira Brava – Stratigraphic sections in the excavated gallery (Antunes, 1991, Fig. 1). [x in a circle - samples for palynologic analyses (all negative). Zero (starting point of the two sections) is at 2.60 meters from the gallery entrance. A - longitudinal section, B - transverse (90 degrees from A) section]. By M. Telles Antunes and J. L. Cardoso, June 30th, 1989; Antunes, 1991, 497, Fig. 1.

The sediments

a) Grain types

Most of the chamber was filled by sands whose primary origin is diverse (sedimentologic study made in part by Lisa Sheils, 1991). The majority of the sand sediments does not have a common original substrate. The most significant action seems to have been the transport by wind; this interpretation is enhanced by the presence of well rounded grains with numerous pit markings covering their surface. Most of the grains are classified into "Well pitted" and "Moderately pitted", features that directly refer to the effect of wind transport on grain surfaces. The sea swept out any ancient dunes, but it is nearly certain that dunes existed in the then existing broad littoral plain.

Other grain types are frequent. Some are "very angular" and "discoidal"; rounded sediments may have been subjected to breakage and fracturing.

This "breaking" process may have occurred because of the intensity of the mode of transportation or it may indicate human activity to some extent. Other evidence (see discussion in Antunes, faunal synthesis, this volume, especially for evidence concerning bats) indicates intensive trampling and other human activities on the spot. The hypothesis of grain breaking, often related to glacial environments, seems less probable; there is no other palaeoenvironmental evidence to corroborate it.

b) Sorting

All levels within the cave's stratigraphy (C. 4 and C. 3), including the exterior parts, are "extremely poorly sorted", "negatively skewed" and "leptokurtic". Only C. 2 is "poorly sorted". The extremely poorly sorted levels (and perhaps the attenuated C. 2 situation) may also indicate human activity and its effect on sediments by causing some disturbance and mixing.

Evidence indicates a mixed up, if not chaotic sediment population. Much of the sediments appear to have been transported by wind over a short time period, thereby not loosing their original features. Most of the sediments have been reworked or modified by aeolian action.

c) Colour

Another interesting point is colour. From the upper part of the sediments under the stalagmite cover to the bottom of the post-conglomerate succession:

- level C. 2 is 5YR 4/4 moderate brown (wet) and 5YR 5/6 light brown (dry);
- level C. 3 is the darkest – 5YR 3/4 moderate brown (wet) or 5YR 4/4 moderate brown (dry), then grey or even black - that may be due to the accumulation of ashes and charcoal resulting from human occupation;
- level C. 4 varies in the interior of the cave - the upper part is 5YR 4/4 moderate brown (wet) or 10YR 5/4 moderate yellowish brown (dry), the lower part is 10YR 4/2 dark yellowish brown (wet) or 10YR 6/2 pale yellowish brown (dry). In the exterior of the cave, 10YR 6/2 pale yellowish brown (wet) or 10YR 7/4 greyish orange (dry).

Conditions were very oxidating, but that tendency decreases as we move up through the stratigraphic column (colour lights gradually). Orange and yellowish colours are related to oxidation that eliminated much organic matter and to the accumulation of iron oxide. The accumulation of iron oxide may be the result of the cumulative effect of exposure and denudative processes.

d) Organic matter

Organic matter was analysed. The organic content (%) is as follows:

- C. 2, 1.11;
- C. 3, 0.79;
- C. 4 interior upper part, 0.36;
- C. 4 interior lower part, 0.42;
- C. 4 exterior, 3.35.

Except for a somewhat larger accumulation at the exterior (maybe because of later accumulation), it is obvious that (a) the content is always very low, (b) % values decrease from top to bottom of the pre-stalagmite sediments. This situation is probably related to oxidizing conditions and dry, exposed accumulation. The absence of pollen and spores corroborates this.

The loss of organic matter has also been detected in the bone samples used for ^{14}C dating; it was impossible to obtain the needed minimal amounts of collagen required for accelerating techniques at Groningen. Undeterminated organic matters may be burnt animal fat (M. Lemos de Sousa, personnal communication) and what seems to be small fragments of resin. At least the latter may have been used by neanderthals for light.

The dry environment and scant water circulation prevented the accumulation of Uranium; U/Th-series dating was consequently difficult. The cross-examination of the various results seems to be in close agreement.

e) Calcium carbonate

No clear pattern or trend in the $CaCO_3$ % was detected:

- C. 2, 39.19;
- C. 3, 18.52;
- C. 4 interior upper part, 35.66;
- C. 4 interior lower part, 19.35;
- C. 4 exterior, 8.45.

The situation is unclear, especially because several factors to be taken into account acted in proportions that cannot be estimated: (a) the circulation of carbonate contributed by the overlying Miocene rocks, which may account for the formation of stalagmites as well as for the highest content of carbonates in C. 2, the bed that lies just under, (b) carbonates from other sources, including mollusc shells, may have been chemically altered and partially deposited; that is a possible explanation for part of the accumula-

tion in C. 2, and (c) contributions from the carbonate rock pebbles and cobbles from the underlying terrace. All we can think is that the rather high C. 3 content results in part from the burning of carbonate-containing matters, and that a part of the $CaCO_3$ content may have been lost when exposed to external conditions; the rocks are sometimes reached by waves and always by salt water particles.

The contribution of carbonate from the overlying, sloping Miocene rocks was transported by descending waters (as shown by stalactite and stalagmite formation) and resulted into the conversion of the deposited loose sands into a hard, coherent rock with Mousterian implements. This process was most important in clogging the former Neanderthal shelter into the present cave.

Dating

Dating is available for bed C. 2 (that yielded a neanderthalian tooth) (Tables 1 and 2, Fig. 35).

^{14}C dating has not been obtained from bones. All the samples that were treated proved to be unsuitable as they had lost nearly all the collagen. This difficulty was overcome by using Neanderthalian-collected *Patella* shells. The choosing of shells was carefully made; the selected ones

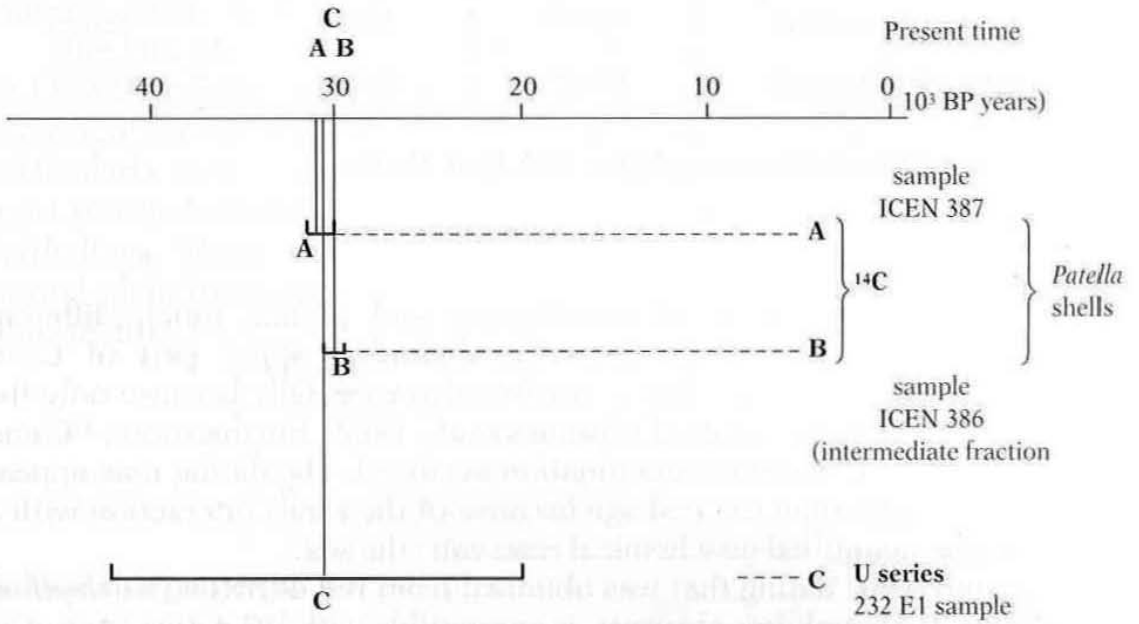


FIG. 35 - ^{14}C and U series dating from Figueira Brava (bed C. 2): dates and spans (±, + and –).

TABLE 1

Figueira Brava, Bed C. 2, ^{14}C dating on *Patella* shells (Late Mousterian)

ICEN 387: 30930 ± 700 BP
ICEN 386: 30050 ± 550 BP (statistically identical, intermediate fraction)

ICEN - Instituto de Ciências e Engenharia Nucleares (INETI), Sacavém, Portugal.
By J. M. Peixoto Cabral and A. Monge Soares.

TABLE 2

Figueira Brava, Bed C. 2, U series dating on *Cervus elaphus* teeth (Late Mousterian)

Samples	Am. 232 E1	Am. 233 E2	
U chemical yield (%)	55.83	17.82	
Th chemical yield (%)	36.21	15.98	
Inferred sample age (years)	30561	44806	Unreliable age
Upper age error (years)	11759	15889	" error
Lower age error (years)	10725	13958	" error

The Southern Methodist University, Dallas, USA. By A. Marks.

presented the same grade of fossilization and patina, much different from the rare modern shells from the disturbed upper part of C. 2. Results (Table 1) were regarded as trustworthy, especially because only the inner part of the shells was used (Antunes *et al.*, 1989). Furthermore, ^{13}C and ^{18}O tenors indicate that no contamination occurred. The dating may appear as somewhat older than the real age because of the shells interaction with a different, non quantified geochemical reservoir: the sea.

The only Th/U dating that was obtained from red deer (*Cervus elaphus*) teeth (Table 2), though less accurate, is compatible with ^{14}C dating (Antunes, 1991, 513).

Discussion and cross-information with other data

Most sediments have been blown by the wind, even if some redeposited grains show traces of previous transport and abrasion. These grains were taken from the Miocene biocalcarenites, that were also a source of quartz pebbles. These characteristics and the scarcity or absence of freshwater dwellers like most amphibians (Crespo *et al.*, 2000, this volume), the pond tortoise *Emys* (de Lapparent-de Broin & Antunes, 2000, this volume), and *Arvicola* (Jeannet, 2000, this volume) (see Antunes, 2000 – faunal synthesis, this volume) show that there was practically no sediment transportation by freshwaters. The minority of birds that could frequent or breed near freshwaters (nearly all edible ducks) (Mourer, 2000, this volume), may have been brought in by man. There is no evidence of a river close by. The sea may have been at a lower level a few kilometers away providing large quantities of marine molluscs and crabs.

On the other hand, descending waters that passed through calcareous rocks have contributed to diagenetic consolidation of the sands and to moderate stalactite/stalagmite genesis.

The lithic implements are homogenous; this justified their study as a whole (Cardoso & Raposo, 1995; Raposo & Cardoso, 2000, this volume) and seems to indicate a rather limited span for the late Mousterian occupation. When temporarily abandoned by man, the shelter may have been frequented by predators such as cave hyenas (that probably are the origin of some coprolithes) and panther, as well as by bats (Mein & Antunes, 2000, and Antunes, 2000 – faunal synthesis, both this volume).

The late Mousterian occupation of Arrábida's southern limb is related to littoral, mostly eolic sedimentation on conglomerates that had been deposited on the 5-8 meters terrace. The succession of terrace levels is particularly well exposed at Arrábida's southern limb in its westernmost coast (Forte da Baralha) (Fig. 36-37). This surface was frequented by Neanderthalians. There they dwelled in an elevated position on a game-rich coastal plain (now underwater) – a situation that may be briefly illustrated (Fig. 38-40).

Acknowledgements

Thanks are due to our Colleague Giuseppe Manuppella, who kindly suplied much information on the geological framing of Gruta Nova da Columbeira and Gruta das Salemas.

Fig. 36

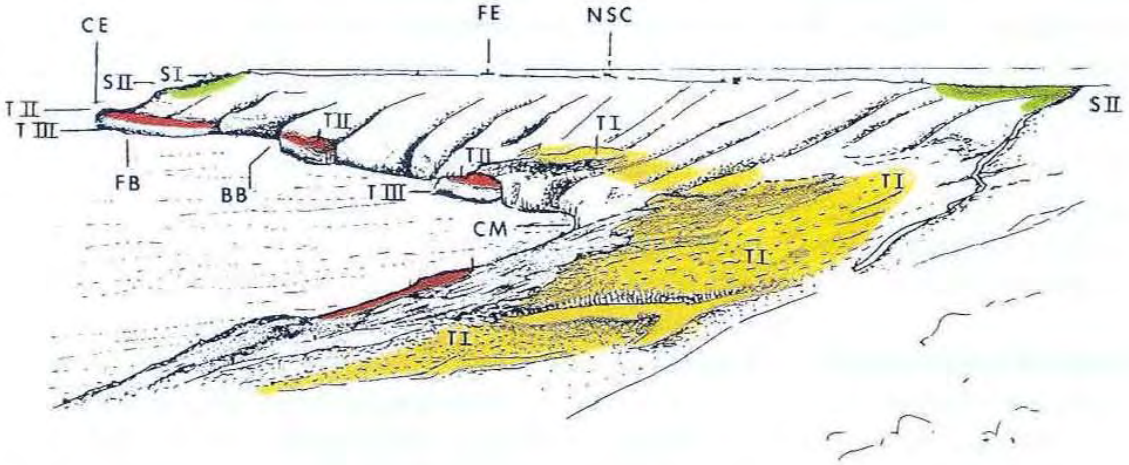


Fig. 37

FIG. 36 - The southern coast of the Arrábida chain (western part) seen from Serra do Burgau, view up to Forte da Baralha and Cabo [= cape] Espichel. (Photo M. T. Antunes, 1988.) This part of the littoral, 15 to 20 kilometers WSW from the Gruta da Figueira Brava, shows several Quaternary marine abrasion surfaces. They are westwards tilted, especially the highest ones, and have been cut on Jurassic limestones and dolomites: (a) the Cabo platform, *ca.* 75 to more than 110 meters high, assigned by authors to the Sicilian I; (b) the "cabeços" [= hills] level, *ca.* 45 to 90-100 meters level, Sicilian II; (c) the main level, about 30 to 40-50 meters, attaining 60 to 70 meters to the East, Tyrrhenian I; (d) the littoral level, *ca.* 15 meters (in general) but attaining 25 to 30 meters in this area, Tyrrhenian II; (e) the lowermost terrace at Figueira Brava's level (5 to 8 meters), Tyrrhenian III. See Zbyszewski in Ribeiro *et al.* (1979); Daveau & Azevedo (1980-81).

FIG. 37 - The same, explicative sketch (by M. T. Antunes).

FIG. 38 - Palaeogeographic sketch of the western and southern areas of Portugal at the time of the late Mousterian occupation of the Gruta da Figueira Brava, when the sea level was about – 60 meters below its present position. A broad littoral platform developped by then.

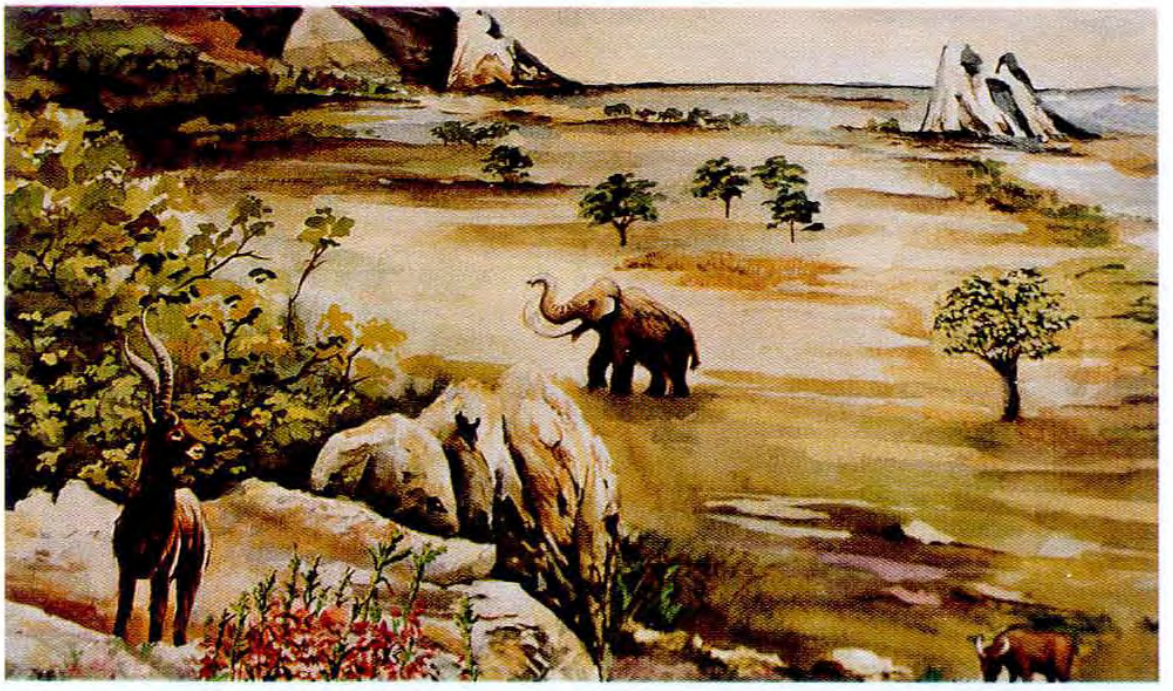


FIG. 39 - Eastwards view from the Figueira Brava area (environment reconstruction) to show the present Anixa islet, a *Mammuthus primigenius* (mammoth), *Capra pyrenaica* (foreground) and a female *Bos primigenius*. (Detail of a drawing by Martins Barata after a sketch by M. T. Antunes.)

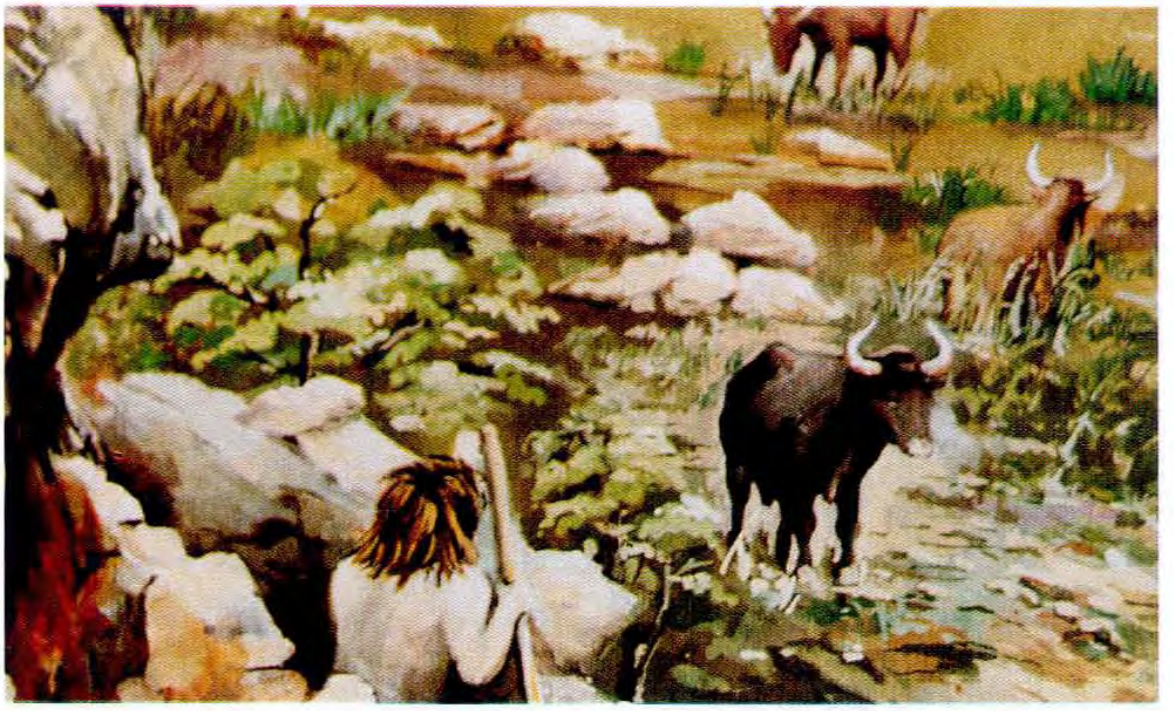


FIG. 40 - The same: a neanderthalian man watches one (black) *Bos primigenius* male and two (red) females.

References

ANTUNES, M. T. (1991) – O Homem da gruta da Figueira Brava (*ca.* 30 000 BP). Contexto ecológico, alimentação, canibalismo. *Memórias da Academia das Ciências de Lisboa, Classe de Ciências*, XXXI: 487-536, 6 fig., 6 tab., 3 pl.

ANTUNES, M. T. (2000) – The Pleistocene fauna from Gruta da Figueira Brava: a synthesis. *Memórias da Academia das Ciências de Lisboa, Classe de Ciências*, XXXVIII: 259-282, 10 tab.

ANTUNES, M. T., CABRAL, J. M. P., CARDOSO, J. L., PAIS, J. & SOARES, A. M. M. (1989) – Paleolítico Médio e Superior em Portugal. Datas ^{14}C, estado actual dos conhecimentos, síntese e discussão. *Ciências da Terra* (UNL), 10: 127-138, 2 tab.

BERTHIOU, P. Y. (1973) – Le Cénomanien de l'Estremadure Portugaise. Serviços Geológicos de Portugal, *Memória no. 23* (N.S.), 169 p., 13 fig., 67 pl., 1 map.

BREUIL, H. & ZBYSZEWSKI, G. (1945) – Contribution à l'étude des industries paléolithiques du Portugal et de leurs rapports avec la Géologie du Quaternaire. *Comunicações dos Serviços Geológicos de Portugal*, XXVI: 678 p., 8 fig., 7 tab., 142 pl.

CARDOSO, J. L. (1993) – *Contribuição para o conhecimento dos grandes mamíferos do Plistocénico Superior de Portugal*. Oeiras, Câmara Municipal de Oeiras, 567 p., 75 + 8 fig., 152 tab., 37 pl.

CARDOSO, J. L. (1994) – O litoral sesimbrense da Arrábida. Resenha dos conhecimentos da sua evolução quaternária e das ocupações humanas correlativas. *Sesimbra Cultural*, 4, 5-12, 10 fig.

CARDOSO, J. L. (1996) – Les grands mammifères du Pléistocène Supérieur du Portugal. Essai de Synthèse. *Geobios*, 29 (2): 235-250, 1 fig., 3 tab.

CARDOSO, J. L. & RAPOSO, L. (1995) – As indústrias paleolíticas da Gruta da Figueira Brava (Setúbal). *Actas da 3.ª Reunião do Quaternário Ibérico*, Coimbra, pp. 451-456, 1 tab.

CRESPO, L. G., PATRÍCIO, G. A. & ANTUNES, M. T. (2000) – Pleistocene Reptilia and Amphibia from Gruta da Figueira Brava (Arrábida, Portugal). *Memórias da Academia das Ciências de Lisboa, Classe de Ciências*, XXXVIII: 117-127, 13 fig., 1 tab.

DAVEAU, S. & AZEVEDO, T. M. (1980-81) – Aspectos e evolução do relevo da extremidade sudoeste da Arrábida (Portugal). *Bol. Soc. Geol. Portugal*, XXII: 163-180, 9 fig., 2 pl.

FEREMBACH, D. (1962) – La deuxième molaire déciduale inférieure de la grotte de Salemas (Portugal). *Comunicações dos Serviços Geológicos de Portugal*, XLVI: 177-186, 3 tab., 2 pl.

FERREIRA, O. da Veiga (1964) – Jazidas quaternárias com fauna de vertebrados encontradas em Portugal. *Arqueologia e História*, 11 (8): 39-53, 1 fig, 4 pl.

FERREIRA, O. da Veiga (1966) – Acerca dos primeiros restos de Homo neanderthalensis encontrados no Mustierense de Portugal. *Lucerna*, 5: 361-375, 2 fig. 3 pl.

FERREIRA, O. da Veiga (1984) – O mais importante nível de ocupação do caçador neandertal da Gruta Nova da Columbeira (Bombarral). *Volume d'hommage au géologue Georges Zbyszewski*. Paris: Ed. Recherche sur les Civilisations, pp. 365-370, 2 fig., 2 pl.

JEANNET, M. (2000) – Figueira Brava: les Rongeurs. *Memórias da Academia das Ciências de Lisboa, Classe de Ciências*, XXXVIII: 179-243, 34 tab. 7 pl.

KLINGEL, M. P. (1991) – *Das Plateau von Cesaredas, Mittel Portugal*. Geologische Diplomarbeit der Universität Stuttgart. 108 p., 15 pl.

DE LAPPARENT-DE BROIN, F. & Antunes, M. T. (2000) – Pleistocene Chelonians from Gruta da Figueira Brava (Arrábia, Portugal). *Memórias da Academia das Ciências de Lisboa, Classe de Ciências*, XXXVIII: 105-116, 3 figs., 1 tab.

MANUPPELLA, G. (Coord.), ANTUNES, M. T.; PAIS, J.; RAMALHO, M. M. & REY, J. (1999) – *Carta Geológica de Portugal na escala de 1/50000* - 30-A. Notícia Explicativa da Folha 30-A Lourinhã. 83 p., 4 fig., 5 tabl. Lisboa.

MEIN, P. & ANTUNES, M. T. (2000) – Gruta da Figueira Brava: Petits mammifères – Insectivora, Chiroptera, Lagomorpha. *Memórias da Academia das Ciências de Lisboa, Classe de Ciências*, XXXVIII: 163-177, 3 fig., 1 tab.

MOURER, C. (2000) – L'Avifaune pléistocène et holocène de Gruta da Figueira Brava (Arrábida, Portugal). *Memórias da Academia das Ciências de Lisboa, Classe de Ciências*, XXXVIII: 129-161, 5 tab., 2 pl.

RAPOSO, L. & CARDOSO, J. L. (1998) – Las industrias líticas de la Gruta Nova da Columbeira (Bombarral, Portugal) en el contexto del Musteriense final de la Península Ibérica. *Trabajos De Prehistoria*, 55, 1, (1998): 39-62, 14 fig., 9 tab. Madrid.

RAPOSO, L. & CARDOSO, J. L. (2000) – Mousterian Industries of the Gruta da Figueira Brava. *Memórias da Academia das Ciências de Lisboa, Classe de Ciências*, XXXVIII: 319-337, 10 fig., 2 tab., 1 pl.

RIBEIRO, A.; ANTUNES, M. T.; FERREIRA, M. P.; ROCHA, R. B.; SOARES, A. F.; ZBYSZEWSKI, G.; ALMEIDA, F. Moitinho de; CARVALHO, D. & MONTEIRO, J. H. (1979) – *Introduction à la Géologie du Portugal*. Serviços Geológicos de Portugal, Lisboa, 114 p., 5 + 21 + 40 fig. [Chapter 3.2.11. Quaternaire, pp. 85-89, by ZBYSZEWSKI, G., pp. 85-89.]

ROCHE, J. & FERREIRA, O. da Veiga (1970) – Stratigraphie et faunes des niveaux paléolithiques de la grotte de Salemas (Ponte de Lousa). *Comunicações dos Serviços Geológicos de Portugal*, LIV: 263-269, 2 fig.

SANTOS, M. Farinha dos (1972) – *Pré-história de Portugal*. Ed. Verbo, Lisboa, 174 p., 158 fig.

SHEILS, L. (1991) – *A study on cave sediments in Gruta da Figueira Brava, Portugal; and their environmental significance*. Part assessment of final year BSc. (Hons) degree in Environmental Science. University of Ulster at Coleraine. 80 + 11 p., 14 photos, 22 tables, 27 fig. [Umpublished report].

SILVA, C. T. da & SOARES, J. (1986) – *Arqueologia da Arrábida*. Lisboa, Serviço Nacional de Parques, Reservas e Conservação da Natureza, Série Parques Naturais, 15, 211 p., 164 fig.

ZBYSZEWSKI, G. (1963) – Jazidas quaternárias de Salemas (Loures) e de Columbeira (Bombarral). *Bol. Acad. Ciências de Lisboa*, 35 (N.S.): 137-147.

ZBYSZEWSKI, G.; LEITÃO, M.; PENALVA, C. & FERREIRA, O. da Veiga (1980-81) – Paléo-anthropologie du Würm au Portugal. *Setúbal Arqueológica*, 6/7: 7-23, 12 fig., 1 tab., 4 pl.

ZBYSZEWSKI, G. & TEIXEIRA, C. (1949) – Le niveau quaternaire marin de 5-8 m au Portugal. *Bol. Soc. Geol. Portugal*, 8 (1/2): 1-6, 4 pl.

ZILHÃO, J. (1987) – O Solutrense da Estremadura portuguesa. Uma proposta de interpretação paleoantropológica. Lisboa: Instituto Português do Património Cultural – Departamento de Arqueologia, *Trabalhos de Arqueologia*, 4: 92 p., 28 fig.

ZILHÃO, J. (1997) – *O Paleolítico Superior da Estremadura Portuguesa*, 2 vol. Lisboa, Colibri. Vol. 1, 309 p., vol. 2. 850 p.