Abstract

Palynological analysis of three Mousterian sites from southeastern Spain (Carihuela, Beneito and Perneras caves) show that, for much of the last glacial period, changes of vegetation are strongly related to geographic location and more particularly to continentality. The centre of correlation lies in stage 3 of the marine oxygen-isotope scale. Carihuela, the most continental and coldest of the three, presents a diagram with significant climatic fluctuations. Perneras, on the Mediterranean coast, offers a very homogeneous and thermophilous sequence, whereas Beneito would represent an intermediate situation. The three sites registered a period of mild climate. Thermal conditions are especially evident throughout Pemeras diagram, where the presence of some pollen, such as Periploca, more typical of African than of European records, is remarkable.

INTRODUCTION

The great diversity of the Mediterranean world is well known. Different topographic, climatic, floral, edaphic and other characteristics, often over short distances, are common, and the researcher in these areas has to obtain numerous data if he wants reliable results. To date, global models seem difficult to apply to extensive zones of such a complex region as the Iberian Peninsula where multiple studies are required.

Available information is still very scarce on palaeoenvironmental evolution of southeastern Spain during the last glacial period. Except for the site of Padul in Granada (Florschütz et al., 1971; Pons and Reille, 1988), humid sites, are infrequent and mainly Holocene in age. Therefore, recourse to cave deposits has to be made for Pleistocene pollen records, which may point not only to biotic and climatic aspects, but also to interesting ethnological ones.

In this paper, results are brought together from three Palaeolithic sites in southeastern Spain. Although the deposits involved are mainly associated with the Mousterian "culture", some sedimentary sections also contain Upper Palaeolithic artefacts. Thermoluminescence-dating series show a time span of some 70,000 years, approximately from 83,000 to 13,000 BP, for the longer sequence (Carihuela Cave).

The sites studied (Carihuela, Beneito and Perneras) serve as examples of Mediterranean environmental diversity. Their location forms a scalent triangle, the longest side of which — Beneito to Carihuela Cave — is approximately 300 km, the other two being under 200 km (Text-Figure 1).

Environmental interpretations based on pollen from archaeological sites have been often questioned. The reader will find an experimental basis for that criticism in the article by Bottema and Woldring in this volume. The present paper does not deal with methodological aspects, therefore it will not attempt to justify globally the value of archaeopalynology for reconstructing palaeoenvironments. Much has been commented about this matter. However, it is perhaps worth remembering that critical investigations demonstrating that such inferences are possible, also appear in the literature (Dimbleby, 1985; Davis, 1990; Horowitz, 1992). In the view of Professor G. Dimbleby (written commun., 1992), "the presence of
Asparagus albus, etc. Elements characteristic of degradational physiognomy, local propagation of spinose species, and a remarkable proliferation of r-strategy assemblages, mainly nitrophilous or halonitrophilous.

**METHODOLOGY**

Field and Laboratory Methods

Sampling was undertaken on vertical profiles and, afterwards, treatment followed conventional procedures (Girard and Renault-Miskovsky, 1969). In the case of Carihuela, several correlative profiles were studied. Palynomorph percentages from different sections, but the same layer, tend to present slight variations but always below 10% for the main types (Carrión, 1992a). On the contrary, excavations at Beneto and Pemeras only yielded one profile suitable for sampling. Consequently, it was not possible either to avoid strata lacking pollen by sampling additional sections or to contrast horizontal variation in pollen spectra.

The interests of archaeologists and palynologists are often unconvergent and exceptional archaeological deposits may be unsuitable for pollen analysis. Moreover, experimental studies are not yet enough to determine what sediment will contain palynomorphs and to what extent these will be deteriorated. We were surprised with the results of Carihuela Cave, where the most successful sediments were dry and calcified whereas the organic strata of unit XII lacked pollen (Carrión, 1992a).

Pollen Diagrams

Results are presented in three synthetic pollen diagrams, showing percentage variation of selected taxa together with ecologically interesting groupings (Text-Figures 2, 3, 4). Black dots indicate percentages below 2%. Differences in organization between the diagrams are due to different assemblages within sometimes strongly dissimilar environments. The aim of establishing comparisons has inevitably led to loss of some particular data. For those, the reader is referred to the original diagrams in several papers (Carrión, 1992a, 1992b; Carrión et al., in press). In any case, it is necessary to give some consideration to the make-up of the taxa used in these diagrams.

Concerning the subdivision of pollen diagrams, an important topic requires comment in the Mediterranean context and particularly in southeastern Spain, namely, that the distinction between arboreal (AP) and non-arboreal pollen (NAP) is impractical in our view. First, within many Mediterranean ecosystems we are unable to distinguish categorically between two vegetation strata, a number of species varying from chamaephytic to phanerophytic forms according to very diverse influential factors. This would be the case for Quercus, Olea, Phillyrea, Rhamnus, Pistacia, Erica, Juniperus, etc. Secondly, traditional criteria used in northwestern European countries are hardly applicable to these communities. Thus, it is problematical to evaluate inclusion of such taxa as e.g. Ephedra, Erica, Thymelaeaceae, Fabaceae, etc. Even many regional Chenopodiaceae become high shrubs. Partition based on woody or herbaceous form is quite impossible, not only because of pollen identification problems, but also because of the frequent propensity of many herbs to acquire shrubby mode. Furthermore, ecological significance of such a division would be difficult to evaluate. In our opinion, "ecological pollen groups" of Janssen (1981), successfully analyzed in Valle di Castiglione (Follieri et al., 1988), is the most appropriate method for fractionating pollen diagrams. Each diagram should, in any case, display its own division in accordance with the supposed floristic assemblages, and general rules do not appear tenable.

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Artemisia, Poaceae and Chenopodiaceae are the main taxa which might be embraced within the classical NAP-group. At Perneras, Artemisia prevails over Chenopodiaceae, and Plantago also plays its rôle. Ephedra distachya type includes both this species and E. nebrodensis.
POLLEN DATA FROM MOUSTERIAN SITES IN SOUTHEASTERN SPAIN

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mophilous shrubs, many of them being allegedly centered on North Africa (e.g. *Periplaneta angustifolia*, *Maytenus europaea*, *Wuthania frutescens*). Present-day vegetation also contains a number of shrubs typical of the *Chamaerops-Rhamnetum* (Rivas-Martínez, 1987) such as *Olea europaea*, *Chamaerops humilis*, *Pistacia lentiscus*, *Asparagus albus*, etc. Elements characteristic of degradation stages include abundant Lamiaceae and Cistaceae. There is noteworthy the abundance of saline soils, flora here being rich in endemic Chenopodiaceae, *Artemisia*, Poaceae, Thymelaeae, *Lycium*, etc. Such a botanically exceptional area has, however, suffered strong human disturbance, inducing adaptation of high shrubs to chamaephytic physiognomy, local propagation of spinose species, and a remarkable proliferation of r-strategy assemblages, mainly nitrophilous or halonitrophilous.

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*Artemisia*, Poaceae and Chenopodiaceae are the main taxa which might be embraced within the classical NAP-group. At Perneras, *Artemisia* prevails over Chenopodiaceae, and *Plantago* also plays its rôle. *Ephedra distachya* type includes both this species and *E. nebrodensis*. 
Zoophilous Asteraceae have been excluded from the pollen sum, in accordance with their hypothetical overrepresentation, chiefly by differential transport, in the deposit. As regards Pereras, other allegedly zoogamous herbs were also excluded from the total sum. It goes without saying that many other taxa included in this sum are pollinated by animals, and even that introduction of anemophilous pollen may have taken place by biotic agents. The decision to exclude or include has also taken into account the potential palaeoecological value of the group involved.

PALYNOLOGICAL RESULTS

Carihuela Cave (Carrion 1991, 1992a): Text-Figure 2

The diagram has been divided into 16 pollen zones which reveal woodlands alternating with open vegetation sometimes accompanied by some Pinus and Juniperus. The main arboreal taxon represented is pine which, in some phases (Y, W, T, P), surpasses 80%. These phases correspond generally to the presence, or even some increase, of Mediterranean taxa which, given the area complexity, might be indicative of the regional development of Mediterranean vegetation.

If we accept an overrepresentation of other Asteraceae, and eliminate them from the pollen sum, Poaceae and Artemisia are the main herbs during the phases of open landscape. Herbaceous formations are rich from a floristic point of view. Sometimes, occasional increases of some minor taxa (Ephedra cf. distachya, Plantago, Chenopodiaceae, Caryophyllaceae) correspond to the disappearance of therophylloous groups.

Pollen zone R, with an important development of Mediterranean vegetation, mainly Olea and Quercus, is quite interesting in this complex, where mesothermophilous taxa are not abundant. The sclerophyllous oak canopy seems to have been quite open and would have permitted development of numerous shrubs (Phillyrea, Pistacia, Myrtus, Rhamnus, Cistaceae, Ericaceae, Rosaceae).

Benito Cave (Carrion, 1991, 1992b): Text-Figure 3

Four principal pollen zones have been defined, the two lowermost corresponding to Mousterian stone tools. The basal one (A) is dominated by Pinus (30-60%). Juniperus and Olea are also well represented. The landscape was open, with stands of pines, and an herbaceous stratum chiefly represented by Poaceae and Chenopodiaceae; the Asteraceae pollen are also abundant. A fringe of mixed oak forest could have developed in the more humid and protected areas of the Agres valley.

The next pollen zone (B) presents an open holly oak forest (19-32%) and an extension of Mediterranean floristic elements (Olea, Phillyrea, Rhamnus, Myrtus, Lonicera, Helianthemum, etc.), while the frequencies of Pinus decline. Although associated with a dry and warm climate, this open vegetation, with abundant heliophytes, may also owe partly to the steep topography, which makes difficult development of thick soils in these climatic conditions. The vegetational change from A to B might be a result of increased temperatures and some greater overall annual rainfall.

Zone C is characterized by decrease in pollen of trees and shrubs, while there is significant increase in Asteraceae and Chenopodiaceae. Pollen zone D, shows a slight re-establishment of the pine forest; therophylloous and mesophilous shrubs and trees must have been isolated. Poaceae and Chenopodiaceae are the main herbaceous components, but Asteraceae maintain high values. The climatic deterioration registered in zone C is also present, although a biostratigraphical hiatus is noted between C and D.

Perneras Cave (Carrion et al. in press): Text-Figure 4

Although sedimentary studies show some differences in the 212 cm of the sampled profile, the sequence broadly consists of two major units. The lower part of the profile, some 90 cm, was sterile, while the upper levels provided enough pollen. It is necessary to point out that the site was first excavated by Siret a hundred years ago and that the main part of the archaeological assemblage artefacts has not been stratigraphically ascribed. The lower levels, with a Mousterian industry, seem undisturbed, but archaeologists think that most of the superficial sediments, attributed to the Upper Palaeolithic, must have been removed (Siret, 1893, Fortea, 1973, Vega-Toscano, 1988, etc.). The whole diagram is rather homogeneous, and, in the synthetic one (Text-Figure 4), zone B can be differentiated by its high amounts of Cichorioideae, as well as poorly preserved grains. When excluding Asteraceae and "Other Herbs" from the pollen sum, other curves also appear to characterize zone B, namely those of "Other Mediterranean Shrubs". Taking into account, both possibilities of mixing in the Upper Palaeolithic levels, the industry of which has been assigned to cultures from the Aurignacian to Magdalenian, and pollen deterioration, the zonation at Perneras should not be interpreted in the light of palaeovegetational evolution, but, rather, as brought about by sedimnetary changes, including modification in pollen taphonomical processes. Thus, predominance of Asteraceae at zone B may be a consequence of differential
Text-Figure 3. Synthetic pollen diagram of Benito Cave. (a) Oleaceae. (b) Other mesothermophilius taxa.
preservation. Nevertheless, the number of taxa is relatively high.

The pollen sequence at Perneras shows little variation. Nonetheless, the following points are worth mentioning. First, there is noteworthy predominance of Artemisia-Chenopodiaceae, an association that recurs in stadial stages of a number of Quaternary pollen records. Steppes with Artemisia and Chenopodiaceae are found today in the Anatolian and Turanian plateaux, suggesting low temperatures, strong thermal contrasts, and marked aridity (Walter, 1975). However, communities dominated by Chenopodiaceae and Artemisia, with frequent Poaceae and Plantago species, are also abundant in coastal areas of southeastern Spain under a thermomediterranean bioclimate and growing on dry saline soils.

Amounts of sclerophyllous Quercus are not insignificant, and may be ground enough on which to suspect a certain local presence. Morphological variation does not indicate that Q. coccifera is the only species involved. Today, Quercus-dominated communities develop in more continental, less xeric places in Murcia. This is why absence of Quercus forests in coastal ranges of southeastern Spain has been largely attributed to the semi-arid regime (Alcaraz et al., 1991). Certainly, a possibility of more humid environment during some Pleistocene stages cannot be rejected: only a small eastward displacement of the anticyclone centered in the Gulf of Cádiz would be sufficient to increase availability of water remarkably. This might further fit in with presence of such taxa as Betula, Alnus, Corylus, Fraxinus and Salix in the Mousterian of Perneras. In any case, biogeography of Quercus in southeastern Spain is still a subject of debate because anthropogenic disturbance is very old, and historical data suggest wooded landscapes in coastal regions (Sánchez-Gómez, 1990). Geobotanical investigations in present-day ecosystems of North Africa (Wojterski, 1990) show that very similar shrub formations to those growing today in the area are a result of degradation of oak forests by human impact. Field work also shows that high precipitation is not necessary for presence of oak communities. Geomorphic heterogeneity favours existence of biotopes where they are able to grow. Good examples are some watercourses in Lorca (Murcia) which serve as humid refugia for Quercus faginea, Quercus rotundifolia, Ulmus minor, Celtis australis, Populus nigra, etc. within an overall semi-arid environment. The characteristics of these sites are not particular as regards geomorphology. Their singularity is rather due to low anthropogenic pressure.

Another feature which deserves attention is appearance of some pollen perhaps more typical of African and European records. The most remarkable is that of Periploca, but there are several other to be noted such as Thymelaeaceae, Cosentinia, Oxyris, Solanaceae, etc. All of these, together with Oleaceae, Myrtus, Pistacia, Rhamnaceae, Ephedra fragilis, Cistus, Ruta, and Lamiales, indicate dry, warm conditions.

Presence of Periploca during parts of the Pleistocene in the area is, of course, outstanding, since that species is indicative of nearly complete lack of frost. A post-Tertiary introduction of the species into the Iberian Peninsula is inadmissible from available palaeobiogeographical information. Presumably, relicts such as Periploca angustifolia, Tetraclinis articulata, Maytenus europaeus and Calicotome intermedia found suitable refugia along the coastal areas of southeastern Spain during the Quaternary.

Accepting the validity of the Mousterian pollen record at Perneras, vegetation may have been very like that at present, perhaps with a higher regional extension of steppes communities, closer patches of Quercus- and Pinus-dominated formations and lesser development of the xerosclerophyllous, thermophilous Mayteno-Periplocetum.

**CHRONOLOGY AND CONCLUSIONS**

The three sequences described have been correlated with the period represented by isotopic stages 5 to 2 (Text-Figure 5). Several data support this attribution. Geochronological information is available for Carihuela and Beneito, with some problems of definition which have been widely discussed previously (Carrión, 1992a, 1992b). Thermoluminescence data from Carihuela place the sequence between ca 83,000 and 13,000 BP, and 14C data from Beneito suggest that zone B might be placed around 40,000 to 35,000 BP.

The archaeology is largely characterized by Mousterian artefacts, with an abrupt passage towards Upper Palaeolithic industries, except at Carihuela where the Middle Palaeolithic is extraordinarily persistent. Admittedly, the Mousterian artefacts hardly yield chronological markers for the sequences involved because archaeologists have been unable to show any internal evolution.

The centre of correlation lies in stage 3. Both mesothermophilous taxa and sedimentation pattern suggest such a correspondence. At Perneras, it is perhaps less certain, because floristic markers of warm climate may have been present in the area during the whole Pleistocene. Correlation with cold stages 4 and 2 is especially indicated at Carihuela, with regression of the mesothermophilous taxa, development of steppe elements, and presence of xerophyllum microfauna, as well as sedimentation of thermoclastic scree. A more precise attribution to particular substages within isotope stage 5 in the Carihuela sequence is for the moment, unachievable, because the
When we compare results from these three relatively close sites, for a supposedly similar chronological period, the importance of their geographic location is evident. Continentality is here the most important factor conditioning response of vegetation to climatic changes. Carihuela presents more accentuated fluctuations of thermophilous taxa. Constant representation of Mediterranean assemblages at Perneras shows the importance of the sea as temperature regulator. This phenomenon is registered in other palynological studies of the eastern Spanish coast for different periods (e.g., Dupré, 1988; Dupré et al., 1988; Viňals et al., 1993; Badal et al., in press). Beneito represents an intermediate situation, with some minor fluctuations. Although they never disappeared completely, a decrease of thermophilous species in the upper part of this sequence may suggest a climatic deterioration.

Within a contemporaneous phase of stage 3, these three diagrams, which mainly correspond to a final Mousterian industry, register an expansion of Mediterranean vegetation which indicates a climatic amelioration.

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