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Paleoenvironmental reconstruction using palynology and Geographic Information System (GIS): the Font Major Cave landscape

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Abstract

In this paper, we present a reconstruction of the Font Major Cave landscape in prehistoric times. We used a double methodology: on the one hand, a classic palynology research and, on the other hand, a GIS analysis. The combination of both methodologies allowed us to determine the fossil vegetal species and their distribution in space and time. Our main conclusion is that, from the Neolithic onwards, there has been an increase of open environments with the correspondent decrease in the forest mass, especially due to intensification in human activity and farming.

Keywords: Font Major Cave, palynology, palaeoenvironmental reconstruction, GIS, Neolithic.

Introduction

In this paper we present a reconstruction of the Font Major Cave landscape in the prehistoric period. The Font Major Cave is located in L'Espluga de Francolí (Catalonia, Spain) (Fig. 1), in the zone of the current fluvial park, at 400 meters above sea level. Due to its topography and its climatic conditions, the current vegetation around L'Espluga de Francolí is diverse, with natural formations (Holm oaks, pines and oak's forests) and agricultural landscapes (vineyard and olives trees), as well as industrialized zones and human settlements.

The cave was occupied for a long time. Several archaeological works (Vilaseca, 1969; Miró, 1988; Carreras, 2000) found materials from different periods: Palaeolithic, Neolithic, Bronze Age and Iberian period. However, there is very few information from this periods because no systematic excavations were carried out. Moreover, during the adequacy of the cave as a museum, part of the sediments from the cavity was extracted, only remaining the sediment of some walls. This sediment is the only evidence of the ancient periods. This sediment is known to be as old as the Neolithic period because Vilaseca (1969) extracted fragments of Cardial pottery from it.

The aims of the present work were to reconstruct the paleoenviroment of the Font Major Cave and to obtain a mixed methodology to map palynological data. Our work hypothesis was that knowing the environmental conditions of the site area and the phytogeography of the vegetal species, it was possible to find the most appropriate place where these species grew in the past.

Methodology

This research combined two disciplines: palynology and Geographical Information Systems (GIS). On the one hand, a classic palynology research was applied to see the evolution of vegetation in Neolithic period and, on the other hand, a GIS analysis was used to study the spatial distribution of the Neolithic vegetation.

To begin with, the palynology research consisted in three main phases: sampling, physicochemical treatment and analysis. These three phases were applied to two different samples: archaeological sediments and actual moss.

Obtaining of the archaeological samples was difficult due to an important lack of sediment. During the adequacy of the cave as a museum, part of the sediments from the cavity was extracted, only remaining the sediment of some walls. This sediment is the only evidence of the ancient periods and it was already studied by Vilaseca (1969). Fourteen samples were obtained from this sediment each 5 cm. On the other hand, the actual moss was collected around the cave. Four samples were taken, one from each main cardinal point to calculate the levels and effects of pollen rain. The objective was to obtain a reference point to compare our result with the actual vegetation of the area. Secondly, we applied the physico-chemical treatment (Burjachs *et al.*, 2003) to the fourteen archaeological samples and the four actual samples. Finally, the analysis was performed using an optic microscope (Olympus CX40) with 600x.

On the other hand, the GIS analysis was developed in three steps (Fig. 2). First, the study area was selected. Second, the main environmental and climatic features of this area were studied. Finally, a map of the potential location of the fossil vegetation was performed.

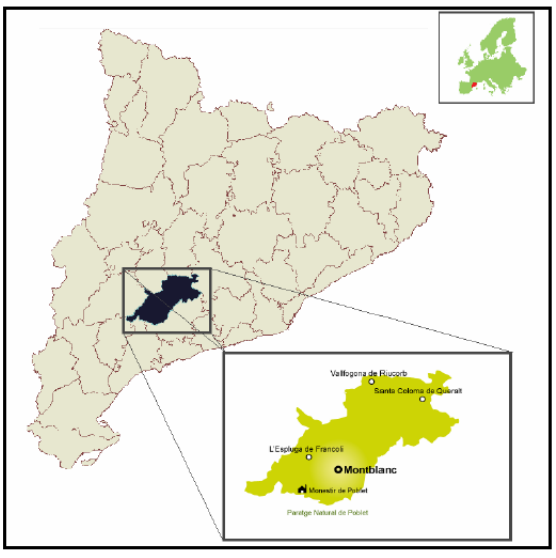

Fig.1. L'Espluga de Francolí's localisation map.

The area of study spread from the Conca de Barberà plain to the Prades Mountains (19000 hectares) (Fig. 1). To carry out the second step, the basic cartography of this area was collected: topographical maps, aerial photographs and tematical maps. Several current environmental conditions were studied: topography, climatology, habitats and uses of the ground. This information was combined with the basic cartography and was introduced into a digital elevation model (DEM) with a 30 m resolution. Therefore, we obtained the environmental conditions of the landscape every 30 m. Finally, the archaeological results were introduced in this DEM to establish their location optimum point, according to their phytogeographies or limiting factors. The final result was a localization map of the fossil species: the Neolithic map.

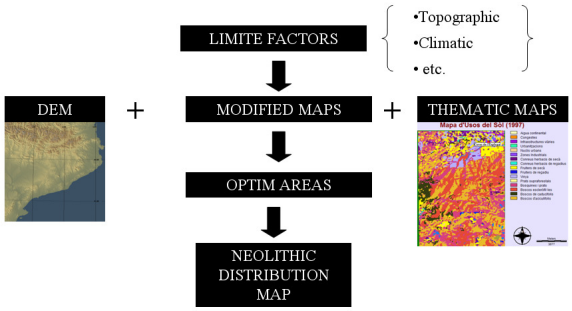

Fig.2. Steps of GIS analysis methodology.

Results

The Neolithic sequence from the cave showed a wooded environment, characterized mainly by Holm oaks and Pyrenean Oaks's forests (Figure 3). Other tree species were pines and Phoenician juniper / common juniper / prickly juniper (Juniperus sp.).

According to the environmental conditions of the area, the Zone A (Figure 3), and specially the sub-zones A1 and A2a represented the climacic forest, constituted mainly by several species of *Quercus*. The climacic forest would be the typical vegetation of the area before the human intervention. These Holm oak's forests, oak and pines would be also accompanied by a bank forest in the most humid zones. These humid zones would be located in the banks of the Francolí and Sec rivers, as well as in numerous ravines of this zone. The Ancient Neolithic period represented a maximum extension of both climacic and bank forest. From this moment on, the forest started decreasing slowly and continuously.

Over the 60 cm of depth (Fig. 3), the proportions of herbaceous experimented a slight increase (zone B), whereas other colonizer taxa such as pine, Cistaceae (*Erica* sp.) and *Ephedra*, increased. This change in proportions showed the

evolution towards an open landscape related with the age of the sample: the more modern the sample, the more open the landscape.

This opening of the landscape was accompanied by the increase of the herbaceous taxa, like the wild Poaceae and the Asteraceae, as well as the appearance of cereals. Towards the end of the sequence, the increase in the cereals' proportion showed an intensification of the human occupation in this zone (B2). This increase in human occupation was related to farming, as shown by the presence of ruderal taxa together with the cereals and the opening of the landscape.

The presence of hygrophyte taxa, like the willows (*Salix*), *Typha* and waterweeds, demonstrated that dampness was higher than nowadays. Comparing the results from the Neolithic period with the current ones, nowadays there is still some redoubts of Neolithic vegetation in the study area In this sense, the forests of Pyrenean oak (*Quercus pyrenaica*) are now residual and occupy only the higher altitudes of the area, whereas they would have occupied most of the landscape during the Neolithic period.

The Neolithic map (Fig. 4) showed the distribution of the species in three different areas: the oak forest, the bank forest and the mixed forest of Hoalm oaks and pines. The oak forest would be located in the highest areas. The bank forest would be located on both sides of the Francolí River and in the form of gallery along the numerous torrents that nourish this zone. Finally, the mixed forest would be located in the plains, nowadays occupied by the farming areas.

Finally, the DEM has showed the amount of forest lost due to human occupation of the area. 9000 hectares of forest were lost in all the area. The most affected forest was the bank forest. Although only 1000 hectares were lost, they represented almost the totally of this type of forest. the amount of with a loss of 1000 hectares. The 8000 hectares left corresponded to mixed forest and oak forest.

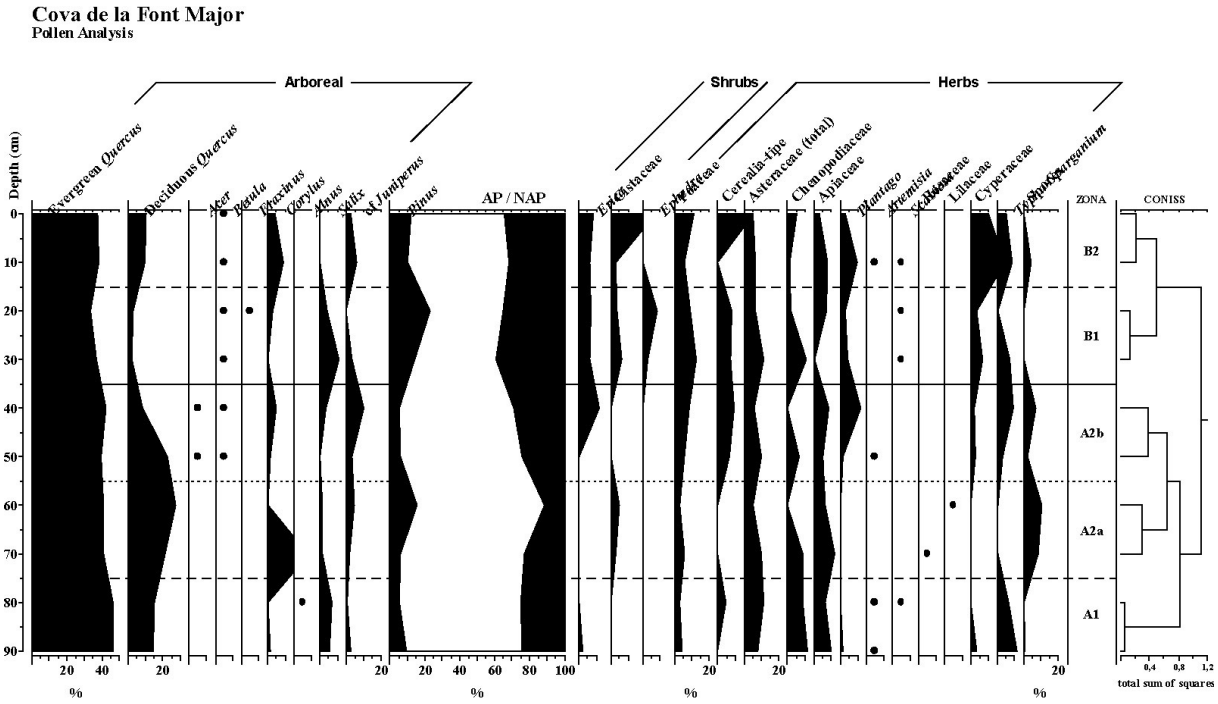

Fig.3. Font Major Cave's pollen diagram.

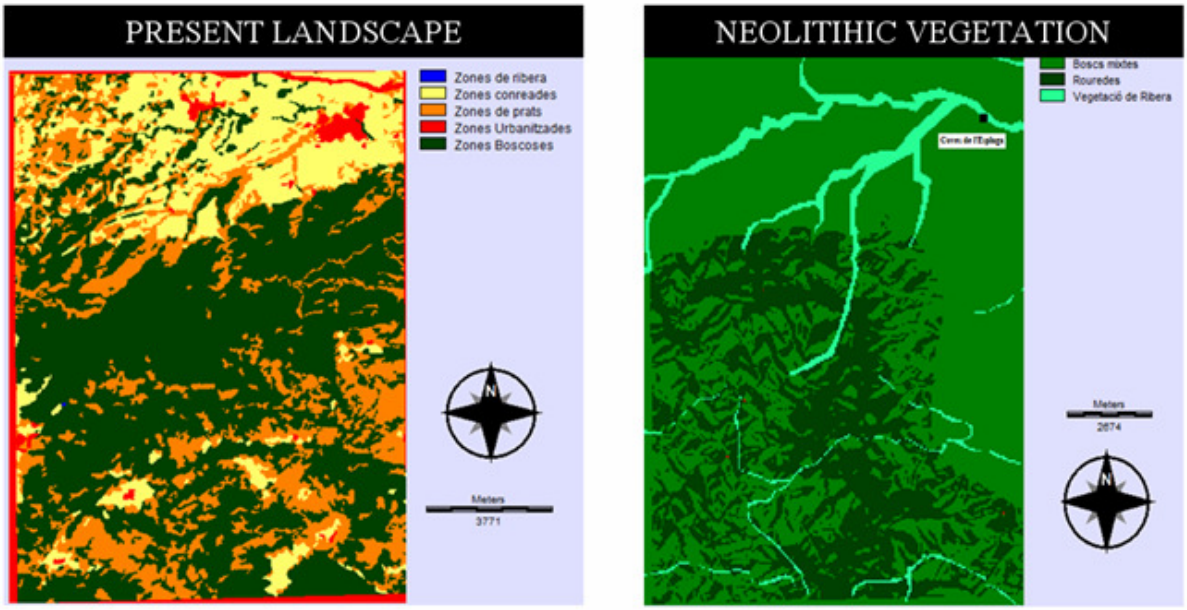

Fig. 4. Actual landscape and Neolithic vegetation.

Conclusions

Our pollen results showed that the intensification of the human occupation caused a decrease in the forest from our study area. This deforestation began with the onset of farming. Therefore, the three main types of forest – oak forest, bank forest and mixed forest – were gradually replaced by open area vegetation (i.e., Asteraceae, Poaceae, Chenopodiaceous, Cerealia and other), a tendency more evident from the end of the Neolithic onwards. On the other hand, the GIS analysis allowed localization the vegetal species and to quantify this backward step of the forest mass. Almost half of the hectares of forest from the Neolithic period have been lost. The most important loss has been the vegetation of bank, which has lost 90% of its potential extension. This result brought to light the importance of the Prades Mountains and the basin of the Conca de Barberà as existing vegetation redoubts in our days. We can highlight the redoubt of *Quercus pyrenaica* in the Prades Mountains, the bank vegetation redoubt in the ravine of the Titllar and the redoubt from Trinitat, all three of them included in the PNIN of the Poblet's Forest.

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