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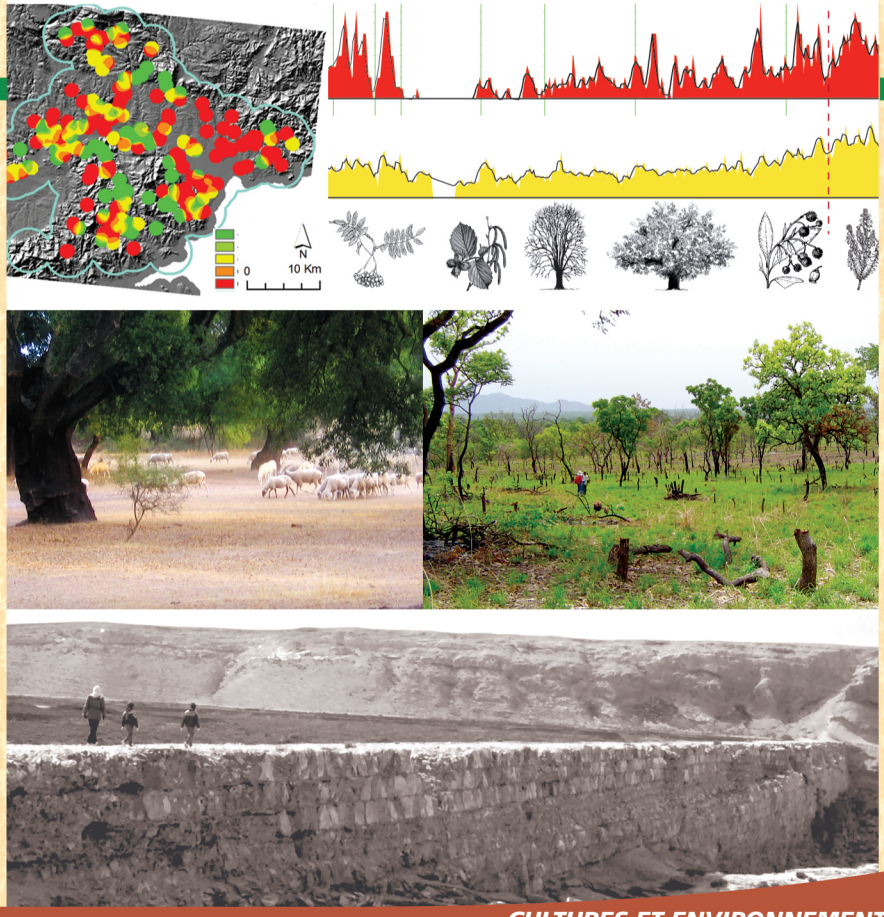
VARIABILITÉS ENVIRONNEMENTALES, MUTATIONS SOCIALES

Nature, intensités, échelles et temporalités des changements

Sous la direction de
Frédérique Bertoncello et Frank Braemer



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Sommaire

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The role of the Montjuïc promontory (Barcelona) in landscape change: human impact during roman times

***Josep Maria Palet*[a], *Ramon Julià*[b], *Santiago Riera*[c], *Hèctor A. Orengo*[a], *Llorenç Picornell*[c], *Yolanda Llergo*[c]**

Abstract
A multidisciplinary (historical, archaeomorphological, archaeological, palaeobotanical, and sedimentary) and multi-scale study was carried out to gain a better understanding of the long term landscape shaping of the Montjuïc promontory as a result of land use and palaeoenvironmental changes. Evidence suggests that, especially the southern slope of the promontory, was cultivated and used for grain storage during the Iberian Iron Age period. The presence of a Roman quarry, probably related to the foundation of *Barcino,* was also confirmed. Despite the prevalence of agriculture during the Roman period, pollen studies suggest that there were no significant changes in the plain of Barcelona.
Keywords: Montjuïc, landscape, archaeomorphology, palaeoenvironment, land use, human impact.

Résumé
Des recherches pluridisciplinaires et multi-échelle comprenant des études archéomorphologiques, historiques, archéologiques, paléobotaniques et sédimentologiques ont été réalisées sur la colline de Montjuïc (Barcelone) et ses environs. L'objectif principal était de comprendre les formes du paysage sur la longue durée en relation avec l'exploitation du sol et les dynamiques paléoenvironnementales. Durant la période ibérique, une intense activité agricole et de stockage dans des silos est bien attestée, notamment sur le versant sud de la montagne. Une carrière romaine, probablement liée à la fondation de *Barcino*, est également attestée. Le caractère agraire de Montjuïc est maintenu pendant la période romaine, mais les études palynologiques montrent, pour cette période, l'absence de changements paysagers majeurs dans la plaine de Barcelone.
Mots clés: Montjuïc, paysage, archéomorphologie, paléoenvironnement, occupation du sol, anthropisation.

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Introduction

The Mediterranean coast is characterised by steep valleys, very low tides and river mouths that form delta fans with deep lagoons in old talwegs and shallow marshes dammed by spits or bars. In these relatively flat but highly diverse plains, coastal promontories play a major role in territorial organization, human settlement, land use and cultural landscape shaping. Moreover, these rocky promontories provide complementary natural resources, such as water from springs, stones from quarries and lithic raw materials.

The present study analyses the role of these promontories in territorial organization and on the regional environmental evolution from the Iron Age to Medieval periods.

On the Barcelona plain, the Montjuïc promontory has played an important part in the History of the town. This promontory has been occupied since Prehistoric times. Its watchtower controlled the plain and the sea and has been occupied by the military since the medieval period. The promontory contributed to the configuration of the ancient natural harbour. Furthermore, its high quality stone was exploited from Neolithic times until the 20th century. Quarrying for building stone, which started in Roman times, was the activity that had the biggest impact on human occupation.

Montjuïc was the subject of several studies on landscape evolution during the 1990s (PALET, RIERA, 1993, 1994 and PALET, 1997). This research has recently been updated and enlarged in the context of new urban planning and urbanisation (PALET, in press; JULIÀ, RIERA, 2012).

Site description

Some neogene promontories such as Montjuïc (185 m a.s.l.) and *Mons Taber* (16 m a.s.l.) protrude from the coastline of the Barcelona coastal plain, which is a glacis constituted by the coalescence of alluvial fans draining the Collserola Coastal Range (fig. 1).

The Montjuïc promontory, which is located between the Besos and the Llobregat river deltas, is made up of silicic sandstones and marls, and is characterized by a remarkable asymmetric morphology, with a steep sea cliff and gentle slopes towards the Collserola Range.

The Barcelona coastal plain resulted from the fluvial sediment supplied by the Besos and Llobregat rivers, and the southward redistribution of these sediments by the longshore marine currents. These currents together with easterly storms constitute the main geomorphological processes in this microtidal Mediterranean zone. The progradation of these delta plains shows the progressive formation of barrier sands damming backshore lagoons.

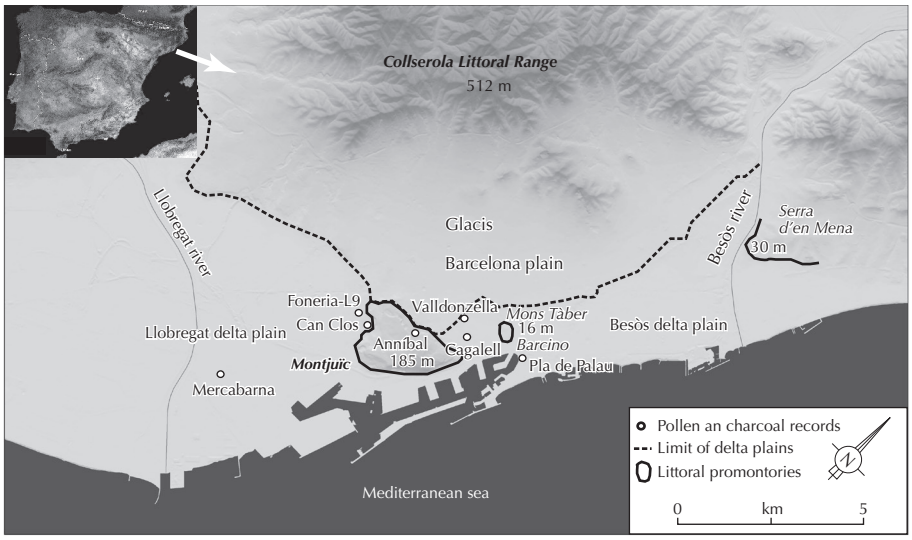

Fig. 1. *Location of Montjuïc and* Mons Taber *promontories in the Barcelona Plain, with indication of paleobotanical records.*

The human settlement of Montjuïc has a long history. The first references to settlements, which date from the Epipaleolithic, were found at the top of the promontory. Evidence for settlement from the Early Neolithic to the Iron Age has been found at the foot of the promontory. Important Iberian (6th-2nd centuries B.C.) sites have been discovered in the upper part and on the southern slopes, where 50 large pits provide evidence of a large storage capacity (ASENSIO *et alii,* 2010).

In Augustan times, the plain of Barcelona is characterised by the development of the *Barcino* colony, a town created *ex novo* on the *Mons Taber*, a small promontory near the coastline north of Montjuic (fig. 1). This urban centre implied the spread of rural settlements and the configuration of a centuriated network over the plain in accordance with the Roman norms of landscape management (PALET, FIZ, ORENGO, 2009). During Late Antiquity, *Barcino* attained the status of an Episcopal office. After sharing a border with Muslim territories, which was situated southern along the Llobregat river (fig. 1), *Barcino* was repopulated in the 9th-11th centuries A.D., which resulted in a continuous economic growth until the end of the 14th century.

During Antiquity and the Medieval period, Montjuïc remained as a rural area, with the presence of farms and rural settlements. Since the Late Medieval period, Montjuïc has undergone a progressive decline in population and the promontory has become a marginal area of Barcelona during the Modern period and recent times. The morphology of the Roman landscape determined the shape of the area until the urban development of the 19th century, which inherited a great deal of the ancient Roman territorial organization.

Methodology

Landscape transformation of Montjuïc and its surroundings were deduced from cross-related historical, archaeological and palaeoenvironmental data.

The integration of a wide variety of sources is necessary when studying thoroughly transformed areas such as urban spaces. In this regard, GIS is a suitable tool for data integration that has a geographical basis such as palaeoenvironmental or archaeological evidence. GIS allows data correlation and integration in a multilayered and multiscale environment where diachronic analysis can be performed (ORENGO, PALET, 2010).

Geographical database and GIS-based archaeomorphology

Archaeomorphological research was conducted in a GIS environment. The GIS database included geographically referenced cartographic and orthophotographic data. The digital 1:5 000 topographic base and orthophotographic series of the Cartographic Institute of Catalonia (ICC) were used as a starting point for the georeferencing of rasterised cartographic sources. On the basis of these sources, it was possible to georeference the city plan of Barcelona prepared by the City Council Topographical Service between 1933 and 1936; and even older maps, specifically, the topographical map produced by Ildefons Cerdà and the land division map for the area within the limits of Barcelona in 1851 (GALERA *et alii*, 1982). The aerial photographs taken by the Americans in 1956-1957 and the CETFA's orthophotographies from 1947 were also included in this geodatabase. A digital terrain model (DTM) was constructed (5 × 5 m / cell) using the topographic information contained in the ICC's digital 1:5 000 topographical base for the area of study (fig. 2).

Fig. 2. *GIS 3D restitution of the* Plano de la Plaza de Barcelona *(anonymous before 1714) (Archivo General Militar de Madrid B-38-18), including the DTM of Montjuïc and the road network (from H. A. Orengo).*

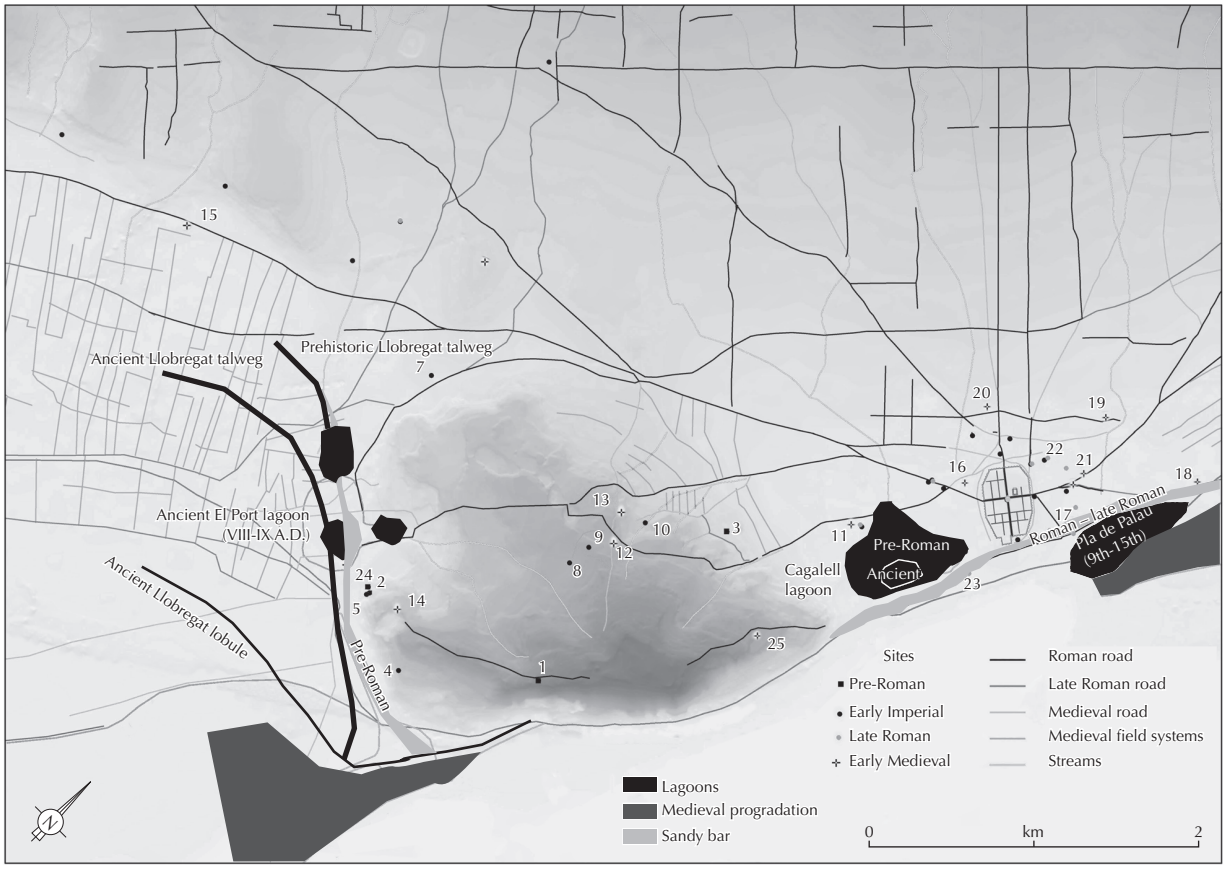

Fig. 3. *Palaeotopography and archaeological sites in Montjuïc hill. Roman landscape reconstruction with indication of palaeogeographical traits.*
Sites:
1. Camí de la Font de la Mamella; 2. Iberian pits and structures of the port sector; 3. Annibal street 4. Roman villa of the southeastern cementery; 5. Roman quarry; 6. Foneria L-9; 7. Roman villa of Ntra. Sra. del Port; 8. Estadi Olímpic Iberian pits; 9. Estadi Olímpic kilns; 10. Passeig de Santa Madrona structures; 11. Sant Pau del Camp; 12. Sant Julià; 13. Sant Fructuós; 14. El Port castle; 15. Roman villa of Santa Eulàlia de Provençana; 16. Santa Maria del Pi; 17. Santa Maria del Mar; 18. Santa Eulàlia del Camp; 19. Sant Pere de les Puel·les; 20. Santa Ana; 21. Sant Cugat del Rec; 22. Santa Caterina; 23. Govern Militar; 24. Ntra. Sra. del Port; 25. Vista Alegre-Miramar cementery.

This cartographic database enabled the revision of earlier works on the historical morphology of the landscape (PALET, 1997). A database-linked vector layer enabled the differentiation between the types of historical traces, and attributed them to different cultural periods. The location of rural settlements, milestones and funerary elements were included (fig. 3). Written documents were also studied, placing especial emphasis on the Montjuïc promontory, Llobregat delta and the city of Barcelona (BANKS, 1980). The study consisted of assembling all this information to provide a global interpretation of the landscapes at Montjuic in relation to the transformation of the Barcelona plain. Thus, historical landscape is modelled through a superposition of new elements over earlier landscape structures.

Sedimentology

Although Montjuïc has been the subject of a number of geological studies and archaeological excavations, the Quaternary stratigraphy of the hill and the changes that occurred during the Holocene have received scant consideration. Sedimentological data used to determine Holocene environments have been obtained from:

— Field work focused on the survey of lithological profiles cropping out in the foundation trenches and drainage channels of buildings and works in the city.

— Analysis of documentation available at the archive of the City History Museum of Barcelona to document the lithology and archaeological remains that establish a chronostratigraphic framework of the different lithological units and their spatial continuity.

— Collection and analysis of records of subsoil surveys carried out to determine the geotechnical characteristics for new buildings and infrastructures.

— The chronology of the lithological units was based on 22 C^{14} dates. In addition, archaeological remains were also used to establish the chronological framework.

The geormorphological evolution was based on lithological correlations and the chronological framework. The elevation of each level differentiated in the lithological column was restored as a function of the sea level. This was achieved in accordance with the topographic data base of the city available at the Map Information Centre of the Barcelona Municipal Council.

Vegetation landscape evolution pollen and charcoal analysis

The vegetation history of Montjuïc during the Holocene is incomplete, mainly because of the scarce chronological dates of sedimentary records used for pollen analysis. The evolution of the vegetation landscape of Montjuïc and surrounding areas is based on pollen studies from natural sediments and charcoal analyses carried out in both natural and archaeological records (fig. 1).

Five pollen sequences are available near Montjuïc. On the NE slope, the lagoons of Cagalell-Drassanes (RIERA, 1995) and Pla de Palau-Baluard del Migdia (JULIÀ, RIERA, 2010) furnish data about Mid-Holocene and Medieval times, respectively. On the SW slope, three pollen diagrams from marsh sediments covering the Holocene are available at Can Clos, Foneria-L9 station, and Mercabarna (PALET, RIERA, 1993, 1994; RIERA, 1994, 1995, 1996). Furthermore, charcoal data were obtained at the Bronze Age and Early Iron Age archaeological sites of Anníbal Street and natural sediments of the Valldonzella alluvial fan.

Results and discusion: Main landscape changes in the plain of Barcelona and Montjuïc

This multiproxy approach allowed us to characterize the landscape evolution from a multiscale perspective. As a result it was possible to differentiate three main phases of landscape shaping between Iberian and Medieval times; the Early Roman Empire (1st and 2nd centuries A.D., especially the Augustus' times), Late Antiquity (from 6th to 7th centuries A.D.) and the Early Medieval Age (from 10th to 13th centuries).

Prehistoric period environmental data

The Cagalell lagoon occupied about 20-25 Ha between Montjuïc and *Mons Taber* (fig. 3). The older C14 dates indicate that this lagoon system was active from Mesolithic times. Similar lagoon systems are reported in the Llobregat plain near Montjuïc, where C14 provides dates of about 7300 to 6000 cal B.C. These chronologies indicate that these lagoon systems were established during a period of lower sea-level (fig. 3).

Sedimentological data records the maximum marine transgression in the Llobregat delta plain at approximately 2500 cal B.C. During this period, coastal sands at 0 m.a.s.l. were deposited at about 3 km inland in the Llobregat delta and at about 2 km inland in the Besos delta. These trangressive sands are located at about 500 m inland near *Barcino*. In the course of this transgression, the alluvial fans on the southern Montjuïc slopes graded into the sandy gravels of the fluviomarine delta. The main process of the delta plain progradation is related to the formation of sand barriers damming lagoons where organic rich sediments were deposited. Two main pulses of delta plain progradation may be differentiated. One pulse is well defined by a sand barrier damming the lagoons filled with organic sediments from Neolithic to Roman times. This coastal bar records the presence of burials from Roman times. The other pulse occurred during Early Medieval times when a new sand barrier system formed parallel to the Roman coast, damming a new lagoon system (JULIA, RIERA, 2010; 2012).

A coastal bar or spit anchored at the foot of Montjuïc developed on the Llobregat delta plain. This sand barrier has an elevation of +2 m above sea level and provides evidence of archaeological structures dating from the 2nd century B.C., which suggests that this area was already cultivated.

During the Late Bronze Age and Early Iron Age, the charcoal analyses at Anníbal Street on the northern slope of Montjuïc and at Valldonzella Street on an alluvial fan suggest that the vegetation of the promontory resulted from clearances of the evergreen forest. This landscape is also characterized by the expansion of shrubby vegetation due to the use of fire. These clearances, also reported in pollen diagrams, could contribute to the erosion increase and the aggradation of alluvial fans on the plain.

Roman times

On the Barcelona Plain, the foundation of *Barcino* (ca. 15-10 B.C.) entailed the centuriation system of landscape organization, which was the most common organization of land in Roman times (PALET, 1997; PALET, FIZ, ORENGO, 2009). Rural settlements show a non-continuous spatial distribution, which could mean that the occupation of certain sectors had priority (fig. 3).

Although pollen records suggest the prevalence of a forested landscape, there is strong evidence of farming, mainly in the surroundings of the Llobregat delta, south of Montjuïc. At local scale, landscape clearings may be significant giving rise a sort of "mosaic" landscape. The southern slopes of the Montjuïc promontory were covered by cleared woodlands of evergreen oaks, pine trees and deciduous trees together of vineyards and cereal crops, as is indicated by the pollen records at Can Clos (PALET, RIERA, 1994). These farming activities are also evidenced by the presence of farms, *villae* and *dollia* and *amphorae* kilns as well as a complex road network linking *Barcino* to the Llobregat plain through Montjuïc (GRANADOS, 1991; PALET, 1997; MIRÓ, 1998). In Roman times, these woodlands also covered the inland sector of the Llobregat delta and the northern part of the Barcelona plain, in the Besos delta (fig. 1). The absence of a generalized open landscape suggests that the centuriation at *Barcino* did not have a strong impact at regional scale. However, the existence of a Roman quarry, face 50 m in length and 10 m in height, on the southern slope of Montjuïc indicates a strong territorial management during this period (GUTIÉRREZ, 2010).

Furthermore, Roman settlement structures have been found on organic lagoon sediments in the Besos delta plain and on the Cagalell marsh. This suggests that at least some parts of these lagoon systems had already dried. Moreover, since these structures are near the present day soil surface, the aggradation processes in these delta plains seems to be negligible.

Late Antiquity

Montjuïc promontory and the plain of Barcelona underwent a significant change during Late Antiquity (6th-7th centuries). In this regard, the abandonment of the centuriation system was accompanied by the construction and a redesign of new routes that linked the Collserola Coastal Range to the delta, which was probability due to grazing activities (fig. 1). Pollen records provide evidence of forest clearances mainly caused by wildfires, proved by the high concentration of charcoal particles in natural sediments (RIERA, 1995). This resulted in the deforestation of large areas of the plain. Moreover, pollen data indicate the expansion of grasslands and wet pastures at the expense of agriculture on the delta plains. All these data point to the predominance of grazing activities at this time. This process of forest clearance also occurred in Montjuïc where oak woodlands were drastically reduced and pine and shrubby communities expanded because of frequent wildfires, as indicated by charcoal content in sediments. This new land-use is

coeval with a general decline in agriculture and rural settlement at Montjuïc. However, during this time, new crops such as olive trees and hemp were cultivated in the hill (Riera, 1995).

The geomorphological response to this deforestation is not homogeneous around the promontory. Sediments, 15 m thick, were deposited on the southern slope of Montjuïc after Roman times, whereas sedimentation over the archaeological remains around *Barcino* is negligible. Unstable slopes and erosive processes were probably related to the change in landscape management, which involved forest clearances and the expansion of grasslands and pastures. The relationship between alluvial fans and delta plain transgression is complex because of the frequent avulsion of the Llobregat channel at the foot of the Montjuïc. One of these river channels has been C^{14} dated between ca. VI cal. B.C. and VII cal. A.D. (fig. 3). The geomorphological features of the area at this time could support the existence of harbour activities using the abandoned channel. In this sense, the presence of harbour activities in the southern slope of Montjuïc have been suggested on the basis of the presence of Iron Age storage pits (Asensio *et alii,* 2010) and Roman quarries. In addition, Early Medieval written sources referred the area as *Portum* (Banks, 1984).

Middle Ages

The Early Middle Ages (9th to 11th centuries) are characterised by a radial path network with the centre in the town of Barcelona. Furthermore, written sources record an expansion of farming lands in the inner sectors of the Barcelona plain on the glacis and in the delta plains, which is probably due to an increase in population (Bonnassie, 1979-1981). The inner part of Montjuïc, in St. Julià and St. Fructuós sectors also provide evidence of an increase in farming activities especially at the end of the 11th and the 12th centuries, which is attested in written sources (Palet, Riera, 1994). This expansion has been documented around Montjuïc in relation to the new territorial organization associated with new churches and religious centres. Pollen sequences demonstrate the prevalence of an open landscape until the 9th century (Julià, Riera, 2010), but subsequently, during the 10th and 11th centuries, oak forests made a slight recovery. The Middle Ages are mainly characterised by a gradual increase in cultivated lands. The definitive configuration of a farming landscape occurred at ca. 1 200 A.D. when pollen sequences record a new retreat of woodlands and the expansion of crops such as olive trees, vineyards, cereals and hemp (Riera, 1995 ; Julià, Riera, 2010).

The sand bars were stable at least until Roman times but a new progradation phase occurred at ca. 7th century A.D. (Julia, Riera, 2012). This is well documented in the Besos and Llobregat delta plains where new lagoon deposits have been reported close to the present day sea shore and dated between 7th / 9th cal A.D. and 15th A.D. From 15th century onwards, the construction of harbour structures have

deeply modified the natural longshore currents and sediment accumulations of the Barcelona coast. As a result, the littoral dynamic became triggered by human activities (fig. 3).

Conclusions

Landscape evolution of Montjuïc hill constitutes an example of the interest and potentiality of data integration in a GIS environment for the characterization of past cultural landscapes by means of the combination of historical, archaeological and palaeoenvironmental data.

Obtained results indicate that the Roman period was characterised by littoral stability, marsh drying and low aggradation of delta plains. These processes occurred simultaneously with the prevalence of a wooded landscape. However, farming activities are well attested by pollen evidences and the existence of a scattered rural settlement and a centuriated field system. This shaping of the landscape ended with a landscape change during the Late Antiquity. During this period, littoral areas destabilization produced the formation of new sandy bars and lagoons, and the local development of slope deposits. These environmental changes are synchronous with a large process of deforestation and the increase of fires and grazing activities in the plain. Archaeological evidences indicate a low human occupation between Late Antiquity and Early Medieval times, suggesting the end of the Roman system of landscape organization as indicated by the abandonment of Roman settlements and *centuriatio* from the 5th century A.D.

These data indicate that environmental impact is more related to land management systems than with the intensity of human occupation. On Barcelona plain and Montjuïc, it has been shown that stronger impact occurred during periods of decrease in human settlement.

Recent palaeonvironmental data obtained in Montjuïc promontory allowed to locally verify regional changes occurred in landscape evolution in the Barcelona plain reinforcing the utility of a multiscale approach in Landscape Archaeology. Moreover, the integration of data of different nature allowed us to identify these regional trends at a local scale. In this sense, Montjuïc case study verifies the main landscape phases observed in the Barcelona plain, but it appears as an area with singular traits. It constituted an area of more intense land use and resource exploitation, probably linked to the proximity of *Barcino*. In addition, it is also characterized by its great dynamism, as is mainly evidenced by the geomorphological changes occurred in the southern slope and in the progradation of the Llobregat delta plain.

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VARIABILITÉS ENVIRONNEMENTALES, MUTATIONS SOCIALES

Nature, intensités, échelles et temporalités des changements

Sous la direction de Frédérique Bertoncello et Frank Braemer

La perception des interactions entre les facteurs naturels et anthropiques sur l'évolution des environnements et des sociétés est une préoccupation majeure de la communauté scientifique, au croisement des sciences de la Terre, de l'Environnement et de la Société. La question centrale est celle de l'impact respectif des processus naturels (climatiques essentiellement) et anthropiques dans les dynamiques sociales et environnementales, que l'on peut désormais restituer avec de plus en plus de finesse. Pour dépasser les interprétations déterministes et mécanistes qui recherchent des relations directes de causes à effets, et envisager les relations sociétés-milieux dans la perspective d'un système en co-évolution, il est nécessaire de proposer des modèles de représentation et d'interprétation de plus en plus nuancés et adaptés à la variabilité des situations étudiées et des fonctionnements régionaux des géosystèmes et des anthroposystèmes. Cela passe par la mobilisation de données hétérogènes (climatiques, paléoenvironnementales, archéologiques, historiques…), souvent lacunaires, de résolutions chronologiques et spatiales variées et différents degrés de précision. De même, les effets des changements climatiques et des actions anthropiques sur les environnements et les sociétés ne se manifestent pas avec la même intensité, selon les mêmes rythmes ni les mêmes échelles. Pour confronter, dans l'espace et dans le temps, des dynamiques environnementales et sociales, des outils méthodologiques permettant de mesurer et de modéliser le changement commencent à être élaborés.
Ce sont ces questions de nature, d'intensité, de seuils, d'échelles et de temporalité des impacts climatiques et anthropiques, principaux enjeux de la modélisation des dynamiques socio-environnementales, qui ont été explorées au cours de ce colloque.

Our perception of the interactions between natural and human factors on environmental and social dynamics is a major concern of the scientific community at the crossing of Earth, Environmental and Social Sciences. The central question is the relative impact of natural (mainly climatic) and human processes on the evolution of ancient environments and societies, which we can now perceive with more accuracy. In order to go beyond mechanical and deterministic interpretations seeking direct causal links, and to consider on the contrary human-nature interactions in a co-evolutive perspective, it is necessary to propose finaly-tuned models adapted to the regional diversity of the geosystems and anthroposystems. This implies to mobilise heterogeneous data (climatic, palaeoenvironmental, archaeological, historical…), often incomplete, with various chronological and spatial resolutions and degrees of accuracy. Moreover, the intensity, rhythm and scale of the impacts of climatic changes and human activities on the environments and societies can differ greatly. News methods and tools allow change measurement and modelling in order to compare environmental and social dynamics, in space and time. This conference aimed to investigate these questions of nature, intensity, threshold, scale and temporality of the climatic and social impacts, key issues in the modelling of socio-environmental dynamics.

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