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Archaeological, Palynological and Geological Contributions to Landscape Reconstruction in the Alluvial Plain of the Guadalquivir River at San Bernardo, Sevilla (Spain)

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Archaeological, palynological and geological studies carried out in the San Bernardo district (Sevilla) allowed us to reconstruct the changes that have taken place in vegetation and landscape relief over the areas studied. Evidence of diverse human activity in the area was also examined. These changes appear to have been influenced by frequent flooding in the area.

Keywords: PALAEOENVIRONMENT, ARCHAEOLOGY, PALAEOPALYNOLOGY, GEOLOGY, POLLEN ANALYSIS.

Introduction

General background

In recent years, multidisciplinary approaches have been increasingly used in the study of archaeological sites. A site's findings can be more broadly explained by combining archaeological, geological and palynological criteria, to give a much clearer and more accurate picture of the events occurring. Multidisciplinary studies are still rare in the field of Urban Archaeology. In Sevilla, to date, they have been carried out at very few sites, including Virgen de los Reyes Square, the ancient Buhaira Palace, the Cartuja de Santa María de las Cuevas, the Atarazanas and in the grounds included in the Special Inner Reform Plan, "San Bernardo-3".

Palaeopalynology is an indispensable tool in identifying former vegetation and its evolution at a site over time. It also helps to describe the changes that have occurred in the environment as a result of man's activities. Prehistoric or archaeological pollen analyses are rare in Spain, especially in the south. Among the most noteworthy studies are Asquerino (1987) in Pontones (Jaén), Carrión (1992) in Piñar (Granada), Florschütz, Menéndez-Amor & Wijmstra (1971) in Padul (Granada), López & López-Sáez (1994) in Montoro (Córdoba), Martín-Consuegra & Ubera (unpublished data) in Almadén de La Plata (Sevilla), Martín-Consuegra, Ubera & Hernández-Bermejo (1996) in Córdoba, Menéndez-Amor & Florschütz (1964), Pons & Reille (1986) in Padul (Granada), Stevenson (1984, 1985) and Stevenson & More (1988) in Huelva.

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From the study of relief forms and their evolution, and from the soils and sediments of a site and its surroundings, it is possible to obtain information about the environment in which human activity evolved. In this way changes and evolution induced by both natural geological processes and man can be identified. Owing to the conditions of the excavation site and its location in an alluvial plain, sedimentological and edaphic considerations have been given priority over geological factors. Previous studies with similar characteristics are numerous; some of the most noteworthy are: Borja & Díaz del Olmo (1988), Borja (1989*a*, 1992) and Moreno & Cantano (1993) in the City of Sevilla; Borja (1989*a*), Borja, Campos & Pozo (1991, 1993) on the Huelva coast; and Borja (1989*b*) at the mouth of the Guadelete river.

At the San Bernardo site, where this investigation was carried out, a combined archaeological, geological and palynological study was employed in order to interpret and reconstruct the historical process of the area's formation, in addition to obtaining an idea of how vegetation and landscape relief may have evolved.

Location, physical environment and vegetation

The city of Sevilla is located in the south of the Iberian Peninsula at 37°23′15″N and 5°59′20″W, at an average altitude of 10 m above sea level. It lies in the Lower Valley of the Guadalquivir river, which meanders from north to south, dividing the city in two. The San Bernardo site is in the southeastern part of the city (which for centuries was crossed by the Tagarete stream), on the edge of the historical suburb of San Bernardo and La Buhaira palace, and near the Prado de San Sebastián area (Figure 1).

The climate can be defined as warm–hot, with very dry summers with high temperatures, low rainfall and mild winters. Average annual rainfall is approximately 550 mm and the temperature range is 18°C; hence the area is in a hot meso-mediterranean bioclimatic stage, although in fluvial zones, where thermicity is higher, thermo-mediterranean formations with dry–subhumid ombroclimate appear (Rivas-Martínez, 1987).

Geologically and geomorphologically, the San Bernardo site, like most of the city of Sevilla, is located on the Guadalquivir alluvial plain (Figure 1). To the east, the plain joins older fluvial deposits corresponding to Pleistocene terraces (Baena, 1993), which in turn join Pliocene calcarenites at Alcores. These calcarenites, which form part of the Tertiary fill in this sector of the Guadalquivir Basin, show a slight inclination towards the west and disappear in that direction. Thus, the base of the most recent terraces of the alluvial plain corresponds to the lower parts of the Tertiary and, more specifically, to what is known locally as blue marl. To the west, the river's alluvium joins the sharp relief of the Aljarafe, forming an asymmetrical valley. This relief is formed by a thick and complete Mio-Pliocene succession consisting of the following

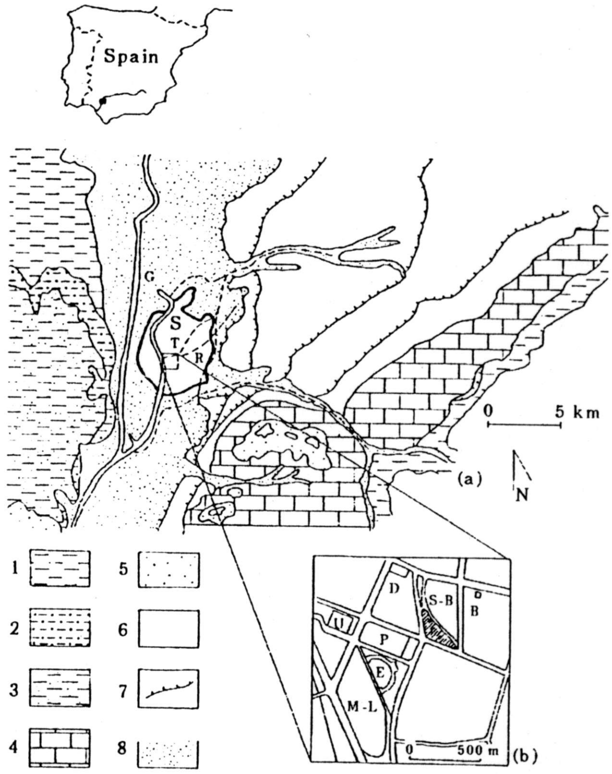

Figure 1. Geographical and geological location of the study area. (a) Geological deposits. 1, Blue loams; 2, silts and loams; 3, silts and sands; 4, calcarenites; 5, sands; 6, fluvial terrace; 7, terrace edge; 8, alluvial plain; S, Sevilla; G, Guadalquivir river; T, Tagarete stream; R, Ranillas stream. (b) Location site (▨). B, Buhaira Palace; S B, San Bernardo District; D, County Council; P, Prado de San Sebastián; U, University; E, España Square; M L, Maria Luisa Gardens.

lithological units: blue marls, mud and marls, mud and sand, and sand (González, 1986). All this Tertiary material constituting the area around the river valley is the source area of the sediments in its present alluvial plain (Moreno & Cantano, 1993).

The potential vegetation of the area would normally be of the river bed communities, greatly influenced by the presence of a large watercourse like the Guadalquivir. Today, this kind of vegetation is almost non-existent. The city has absorbed the river entirely, limiting the existing vegetation. To the north of the city (Sierra Norte), Mediterranean woodland predominates, together with its various phases of degradation; to the south, there are mainly salt marshes (Las Marismas), rice fields, cotton and vegetable crops; to the east is one of the richest and most important agricultural regions in the Iberian Peninsula (La Campiña); and to the west (El Aljarafe) there are mainly olive trees, vineyards and fruit trees.

Archaeological and historical background

The oldest chronological find in this area was made by chance at an unspecified point in El Prado, where a *soliferreum* was discovered inside an Iberian tomb, thus revealing the existence of a nearby necropolis. During the 1995 spring rebuilding project, new findings were added to this discovery. They consisted of ceramic remains from Roman times (mainly amphoras), unearthed at a depth of approximately 4 m. A few years ago, a *villa* and some burials from the late Roman Empire were partially excavated in neighbouring Buhaira (Fernández & de la Hoz, 1985). More recent excavations carried out near San Bernardo, at the County Council building, showed the existence of Roman remains at a depth of over 3 m. The nature of these findings suggests that the areas of La Buhaira, El Prado and San Bernardo were used for agricultural and burial purposes, possibly combined with some form of industrial activity in Iberian and Roman times. However, the depth at which the Roman levels appear at El Prado and in San Bernardo contrasts with the excavation contour heights at La Buhaira, thus demonstrating the need to combine archaeology with geomorphological and geological studies of the sector.

The only existing information from the Middle Ages was obtained by archaeological excavations in the Buhaira (Collantes & Zozaya, 1972; Campos *et al.*, 1985), an Almohade palace, which remained as a noble residence until the Modern Age. Additional information was provided by the 1990 excavation at the County Council building (Santana *et al.*, 1995) where the Jewish necropolis in Sevilla was found as well as a semi-rural residential level from Almohade times (1147–1248 BC). The latter finding indirectly confirms the existence of an Islamic suburb in the district of San Bernardo. This has been previously referred to in the chronicle of the conquest of Sevilla by Christian forces under Fernando III in 1248 and constitutes the only testimony of Islamic occupation of the area found to date.

Following the Christian re-conquest of Sevilla, hardly any mention is made in documents of this wide area of the city. San Bernardo was not to be consolidated as a district until the 18th century. Its decidedly industrial nature was in marked contrast with that of Prado de San Sebastián, which had been used by the Inquisition for autos de fé since the 16th century. This was not the only function of the zone; it was also used for grazing animals for slaughter, hence the origin of the area's name (prado in Spanish means meadow or pasture).

The area was consolidated in the 19th century when the Cattle Fair (later the April Fair) was set up at Prado de San Sebastián, and when the railway line and the San Bernardo and Alcalá stations were built (in the latter half of the century); these remained in existence until very recently. These urban uses have protected the archaeological remains from builders.

Methods of Study

The absence of data made the mechanical digging of large trenches and sectors up to a determined depth necessary, in order to investigate the substratum and record the basic lines of historical development. The drilling depth was determined by that of the previous findings at El Prado. The trenches were dug up to 2·5 m in order to avoid overhang. In order to reach deeper layers and prevent possible overhangs, sector excavations of up to 4 m depth were envisaged. A total of four trenches, four sectors and six geotechnical drillings were made (Figure 2), with the dimensions shown in Table 1. Although the planned depth for the sectors was 4 m the results of the excavation of sectors 3.1 and 4.1 indicated the need to excavate sectors 1.1 and 2.1 to 5 m.

Three stratigraphic columns per trench and one per sector appeared to be sufficient to reconstruct the historical occupation. The appearance of a Roman occupation level at sectors 1.1 and 2.1 made it necessary to widen each of the cuttings in order to facilitate the recording of the type of occupation and its chronology. The dimensions of cuts 1 and 2 were 2 × 2·5 m and 2 × 3 m respectively.

The geological study of this sector was made partly by analysing the direct observations of the trenches and partly by examining the six geotechnical drillings, five of which were 15 m in depth and one of them only 10 m (Figure 3). It has thus been possible to determine the lithological profile below trench depth.

Organic matter content was also determined on a transect of sector 1.1 (Figure 4). The oxidation method (Walkley & Black, 1934) was used to estimate organic matter content. This consists of adding Cr_2O_3K and SO_4H_2 and evaluating the excess of Cr_2O_3K with SO_4Fe. Later, the quantity of organic matter is calculated by multiplying the value of organic carbon by the factor 1.724.

Mineralogical analysis was considered unnecessary, as previous studies made at different points in the alluvial plain have revealed very consistent mineralogical compositions. The profiles of these samples are in turn almost indistinguishable from the Tertiary sediments surrounding the urban area of Sevilla (Galán & Pérez, 1989; Moreno & Cantano, 1993), the obvious source area.

Samples for pollen analysis were extracted from two stratigraphic columns, 1-B, in sector 1.1 and 2-B, in sector 2.1 (Figure 4). Table 2 shows sample number, altitude and stratigraphic unit.

The method used to separate pollen and spores from other sediments was: (1) sieving with 500 μm mesh; (2) removal of carbonates by cold CLH; (3) removal of clay minerals (Bates, Coxon & Gibbard, 1978); (4) removal of silicates by cold FH for 48 h; (5) removal of organic matter by a combination of hot KOH and cold CLH; (6) separation of pollen by flotation (Girard & Renault-Miskosky, 1969); and (7) staining and mounting slides (Cour, 1974). The acetolysis method (Erdtman, 1960) was not used, to enable us to distinguish contamination with reworked fossil pollen. The pollen grains and spores were identified and counted under a

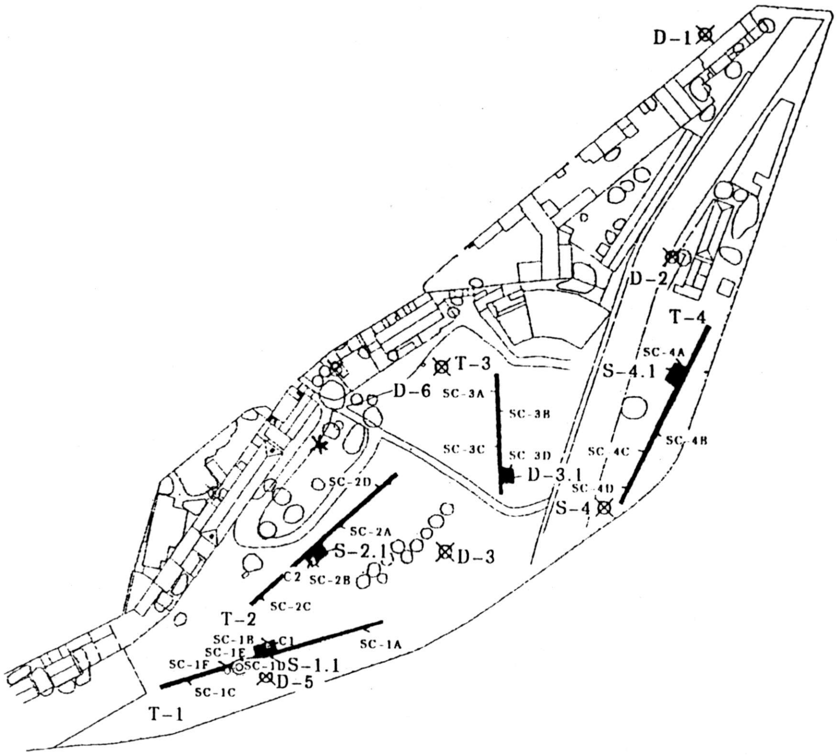

Figure 2. San Bernardo deposit plan. T, trench; S, sector; D, drilling; SC, stratigraphic column; C, cutting.

light microscope at magnifications of 1000 and 200. Pollen was identified following Valdés, Díez & Fernández (1987). Absolute pollen frequency, pollen grains and spores per gram of sediment (gr/g), were calculated by the formula proposed by Martín-Consuegra (1993).

Results and Interpretation

The results shown here are basically those obtained from sectors 1.1 and 2.1, where extractions for pollen columns were made.

Table 1.

Zone	Dimensions
Trench 1	100 m length
Trench 2	80 m length
Trench 3	50 m length
Trench 4	80 m length
Sector 1.1	4 × 9 m^2
Sector 2.1	5 × 10 m^2
Sector 3.1	5 × 7 m^2
Sector 4.1	5 × 10 m^2
Drilling 1	15 m depth
Drilling 2	15 m depth
Drilling 3	15 m depth
Drilling 4	15 m depth
Drilling 5	15 m depth
Drilling 6	10 m depth

Stratigraphy

The following general stratigraphic successions can be established from the different drillings (Figure 3).

(1) A wide section of gravels and coarse sands, constituting a typical fluvial deposit associated with the evolution of the main channel of the Guadalquivir river. Its characteristics indicate a more energetic regime than that of the present day river. Its uneven upper surface (up to 4 m of irregularity in the sector) shows a previous palaeotopography (Borja, 1992; Cáceres, unpublished data).

(2) Clayey silt, light brown in colour and of varying width, in contact with the previous unit. This material shows a reduction in energy of the environment, as it filled in the palaeotopography in the flood plain environment. This change was caused by a tendency in the river bed to rise, probably in relation to the sea level rise during the Flandrian transgression. This unit moves on progressively to the next term.

(3) A wide and homogenous section of grey clays, showing considerable vertical growth of the flood plain, probably as a result of the progressive withdrawal of the river mouth and the filling of the estuary by marshes (Cáceres, unpublished data). Intercalated layers of peat (S-5) and some layers of ceramic accumulation and other man-made remains are visible. Archaeological and palynological studies have therefore centred on this material, as it is the only autochthonous material to have been exposed by the exploration trenches. Study of previously mentioned

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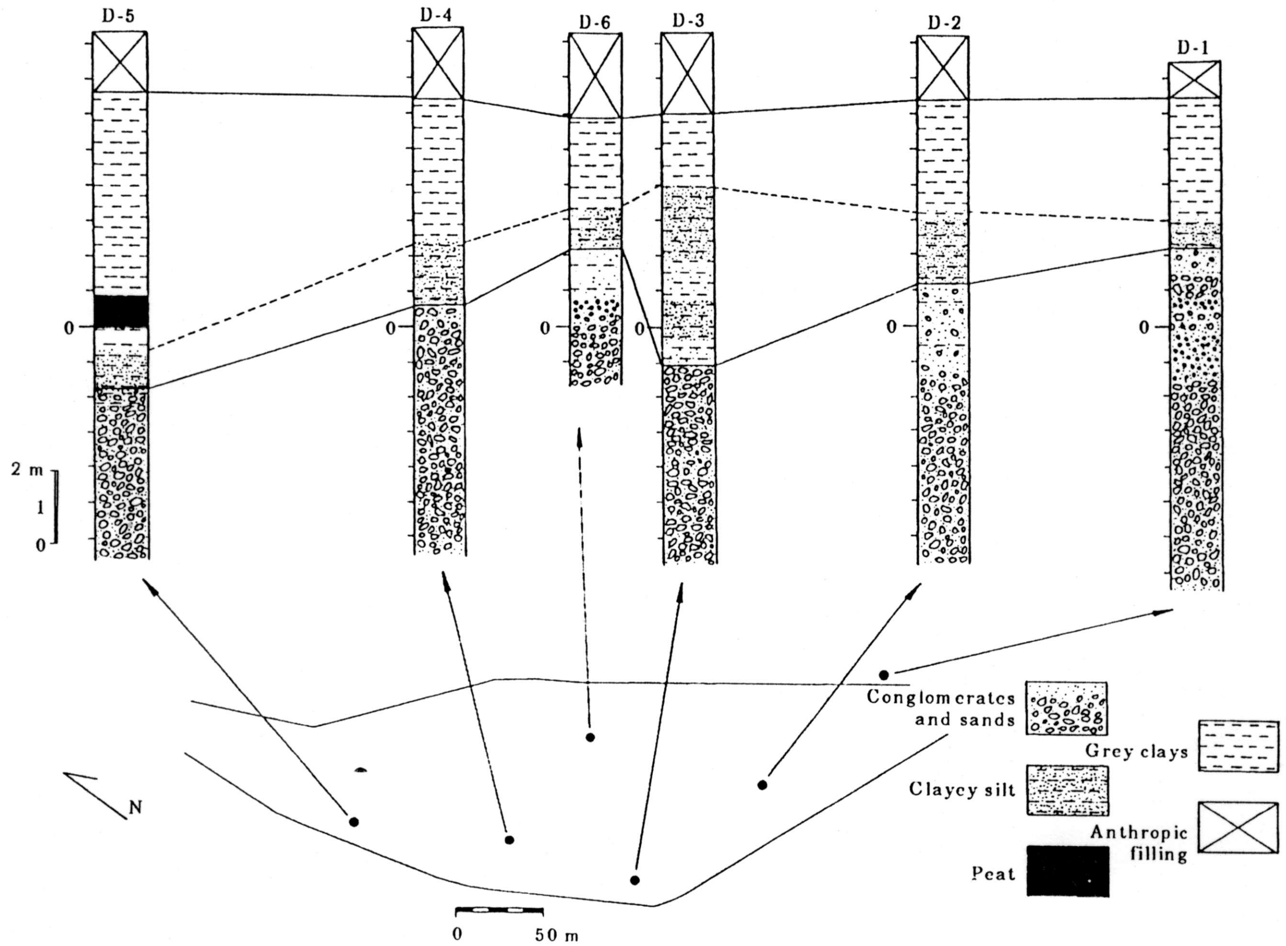

Figure 3. Geotechnical drilling. Location site and composition. O=average sea level.

organic matter, discussed under the next heading, also centres on these clays.

(4) Lastly, a heterogeneous section, up to 2·5 m in width, made up of sands, clays, gravels, slag, ashes and remains of man-made material. The latter is probably the result of the railroad's presence at this site during the last 150 years.

Organic matter content

Within the homogeneity present in the grey clay section, horizontal bands of lighter and darker material are clearly visible. Given the possible relationship between these bands and the sediment's organic matter content, several samples were taken from different bands over the vertical section of sector 1.1 (Figure 4). The results are shown in Table 3.

These results have a two-fold significance. Firstly, there appears to be no direct relation between darker shades and higher organic matter content. Thus, these bands may be correlated with variations in clay purity or with oscillation processes at phreatic level. Secondly, the previous results are of interest since they show an oscillation in the percentage of organic matter content throughout the clayey section. This is a typical characteristic of the soil in flood plains (Soil Survey Staff, 1985), where each flooding covers the incipient plant bed formed above the previous flood level. Thus, sedimentary processes predominate over edaphic processes.

Archaeological results

Sector 1.1 was analysed via the stratigraphic column 1-B (Figure 4). No significant information was obtained from the uppermost section. The first layers (units 106–110) correspond to the phase of the railway line. A deliberate and significant increase in contour heights has been attributed to its presence. Grey autochthonous clays begin to appear from unit 109 onwards, forming various strata of subtle differences. On this occasion, unlike other stratigraphic columns, various strata with small pottery accumulations were detected (units 113, 115, 117 and 118). This proves a certain degree of occupation along the section. Moreover, a clear level of Roman occupation was discovered at the base of the stratigraphic column.

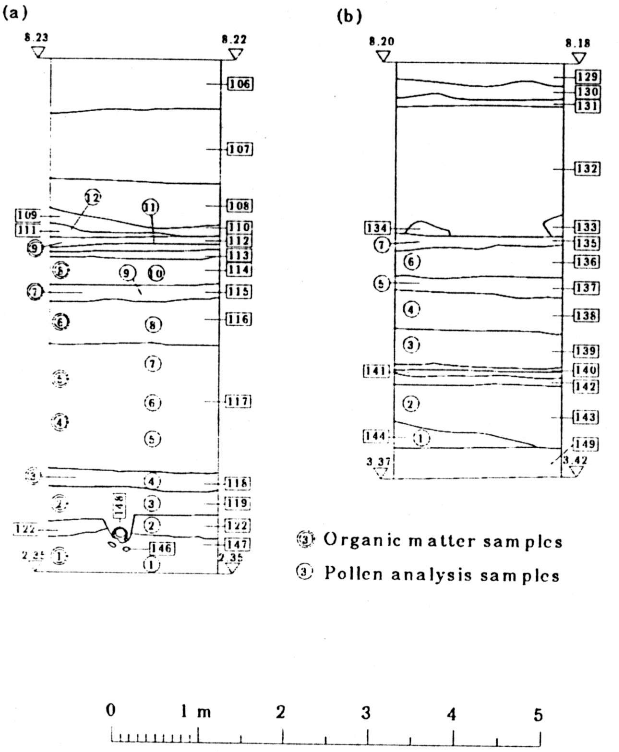

Figure 4. (a) Stratigraphic column 1-B sector 1.1 and (b) stratigraphic column 2-B sector 2.1.

Stratigraphic column 1-B sector 1.1

106. Dark earth with abundant charcoal, mixed with red clays and medium gravel. Fairly loose.
107. Red clayey sands with abundant carbonate. Compact.
108. Grey earth anthropic filling, fairly loose with abundant pottery remains and animal bones.
109. Grey clays, clear and compact.
110. Clayey sands, as in 107.
111. Grey clays, as in 109 but darker.
112. Grey compact clays.
113. Grey clays with some pottery remains, charcoal and slag.
114. Brown oxidized clays.
115. Grey clays with some pottery and construction remains.
116. Grey and brown oxidized clays.
117. As in 116, but dark grey and more oxidized.
118. Fine slimy clays with few pottery remains. Dark grey.
119. Clayey sands with abundant pottery remains.
120. Red compact clays, as in 112.
121. Roman water pipe.
122. Clayey sands, as in 119 but with fewer pottery remains.
146. Wedge of water pipe made with fragment bricks and pottery remains.
147. Grey compact and oxidized clays with scarce pottery remains.
148. Grey compact and oxidized clays.

Stratigraphic column 2-B sector 2.1

129. Dark earth with abundant charcoal and some very loose gravel.
130. Orangish compact clays with gravel.
131. Blackish earth with charcoal inclusion. Very loose.
132. Red clayey sands with carbonate inclusion. Thick dark red sands at the base.
133. Fine and light-coloured sands.
134. As in 133.
135. Grey compact clays with charcoal and pottery remains.
136. Light grey clays without charcoal, with dispersed rubble and plant roots.
137. Dark grey compact clays with charcoal, small pottery remains and animal bones.
138. As in 136, but lighter and with no remains.
139. Brown clays, as in 138.
140. Dark clays with charcoal, as in 138.
141. Brown clays, as in 139.
142. Burnt soil (?) with abundant pottery remains and rubble, some charcoal and unidentified red and black remains. Some animal bones and barnacles, glass, and metal.
143. Grey clays with pottery remains and gastropods.
144. Grey and brown fine clays with fewer gastropods.
149. Compact clays with pottery remains, animal bones and metals above and fewer materials below.

The first stratum of grey clays to yield Roman pottery is represented by unit 118 (contour heights 3·33/3·25 and 3·50 m). Stratigraphic unit 119 contains the most pottery and broken rubble, as well as a pipe *in situ* made of the mouths and necks of various types of amphoras fitted together. The discovery of this Roman level led us to make two new cuttings to study its features in greater detail.

Cut number 1 was made along the edge of stratigraphic column 1-B and had the same width (2 × 2·5 m, NW–SE). From this cut it was possible to excavate the strata represented by units 118 and 119, that had been partially damaged by the mechanical shovel, as well as the Roman pipe. This pipe lies on an uneven bed of rubble which serves as a foundation (unit 146). The small pit dug to hold the pipe breaks through other strata where pottery is considerably less abundant and also dates back to Roman times (units 122 and 147). The weak binding material of the pipe defines it as a

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Table 2.

Column 1-B			Column 2-B		
Sample	Altitude	Stratigraphy	Sample	Altitude	Stratigraphy
12	6·23	111	7	6·15	135
11	6·13	112	6	5·92	136
10	5·87	114	5	5·67	137
9	5·56	115	4	5·25	138
8	5·13	116	3	4·82	139
7	4·73	117	2	4·36	143
6	4·03	117	1	3·82	144
5	3·70	117			
4	3·43	118			
3	3·03	119			
2	2·82	122			
1	2·53	147			

Table 3.

Sample	1	2	3	4	5	6	7	8	9
Organic matter (%)	1·14	0·66	1·14	0·97	1·24	1·09	1·33	1·00	1·76

conveyor of non-drinking water flowing from SE to NE. The upper contour heights of the pipe range between 2·72 and 2·90 m.

All the units containing material from Roman times are composed of grey clays similar to those which later covered this occupation level and make up the bulk of stratigraphic column 1-B. The cut was abandoned at a contour height of 2·35 m without having exhausted unit 147, as material was then extremely scarce.

Due to the nature of this archaeological intervention and the limited size of the excavated surface, it was not possible to define the kind of occupation that existed in this zone in Roman times. The pipe was the only construction discovered and the accumulative character of unit 119 does not allow for conclusive interpretations. It appears to be a crazy paving of rubble (bricks, *tegulae* and amphoras) with a very fine layer of lime, which has almost disappeared but still clings to shards. There is a large quantity of common pottery.

Other pottery materials found in much smaller quantities are sigillates, ostensibly used for consumption *in situ*. There are Hispanic and south-Gallic sigillates; the latter being abundant and well made. At the same time, there are many amphoras originating from Cádiz. The chronology derived from these materials allows the Roman strata to be dated in the later Imperial times, between the first century and the first half of the second century AD.

As has already been mentioned, the limited size of the excavation ground and the almost complete absence of building structures make it impossible to specify the exact nature of occupation in this zone in Roman times. The pipe and apparent paving reveal a degree of permanent occupation. Given the poor construction methods used and the abundance of more complete remains of amphoras from Cádiz, it is reasonable to assume the existence of some kind of storehouse or industry in the area.

Sector 2.1 was analysed via stratigraphic column 2-B. Similarly on this occasion the ground was excavated to a depth of 5 m, in order to study the Roman occupation level and analyse the upper strata. It is possible to relate the upper strata (units 129 to 132) to the railway tracks in the area; they do not differ from those recorded in other columns. Autochthonous grey clays appear at a contour height of 6·22 m and make up various strata, distinguishable only by slight changes in colouring or by the presence of pottery (units 135 to 139). Cut number 2 was made at the base of the column, where once again a Roman occupation level, later shown in stratigraphic column 2-B, was excavated.

Column 2-B represents a considerable development in the form of a particular occupation level dated between the end of the 16th century and the mid-17th century (units 140–142). These units, particularly 142, are composed of very fine and non-compact black soil, with charcoal inclusions. This unit contains a large quantity of shards and rubble, barnacles, animal bones and glass and metal remains. The absence of building structures and the nature of these strata do not permit a definition of the type of occupation they involved. All evidence indicates that the black colouring is not the result of an accidental fire, and the possibility of some type of spill (possibly industrial) in the area must be considered. Unit 143 represents compact grey clays once again, where pottery fragments are sporadically detected. These are difficult to date and do not indicate long-term occupation. Further down, unit 149 reveals the presence of the Roman level already recorded in cut number 1.

Cut number 2 was made at the foot of column 2-B, with dimensions of 2 × 3 m. Unit 149, formed of grey clays with an accumulation of man-made material, begins at the contour height of 3·73–3·75 m and contains the same type of materials as cut number 1: fragmented and highly damaged rubble and a large quantity of shards, mainly of common types. No buildings were discovered on this occasion. As in the case of cut number 1 the chronology of the Roman occupation fits into a period between 1st century and mid-2nd century AD. The type of material does not vary significantly between cuts, although in cut number 2 there is a higher concentration of common pottery and fewer amphora fragments and sigillates. Building materials, particularly *laterculi*, are likewise abundant. Small remains of slate and marble slabs were also discovered, together with pieces of brick with carved lines, formerly part of loose paving stones.

Environmental and human influence on the site changes

The existence in the clays of interlayers of pottery at different depths and from different times provides interesting data on the phases and growth rate of the deposit. Roman levels from the 1st century to first half of the 2nd century AD were found in columns 1-B and 2-B (3·50–2·63 m and 3·75–3·55 m, respectively), while scattered remains and levels which appear above them are modern. In section 2-B, at about 70 cm above the Roman level, remains appear which date from the end of the 16th century and the mid-17th century. There is a distance of approximately 180 cm between these remains and the upper section of the clays (mid-19th century). This implies that this vertical growth in the flood plain occurred over 200 years (from the 17th to 19th century) more than twice the growth occurring in the previous 14 centuries (from the 2nd to 16th century). This finding supports information from other researchers on increasing flooding in Sevilla from the 17th century onwards. Flooding occurred most frequently between the end of the 18th century and the mid-20th century (Vanney, 1972).

Regarding the previous information, note must be taken of the difference in contour height that exists between the Roman levels and sections 1-B and 2-B: 92 cm for the lower limit and 25 cm for the upper limit. Given that both levels date from the same period, the lower limit variation of approximately 1 m thus implies the existence of local relief in the area.

On the other hand, the period of greatest stability, or least growth, separating the Roman level from the modern one, is characterized by the presence of a high concentration of gastropods (*Aegopinella aff. nitidula* and *Cochlicella* sp.) appearing in columns 1-B and 2-B. These organisms normally inhabit swamps and densely vegetated areas, which may indicate the presence of a more extensive swamp area in this zone, and explain the absence of townships. Vanney (1972) refers to an old marsh region close to the area of study which may have been of influence. Strictly speaking, it is more accurate to define it as a relatively dry, rather than a marshy region, where the possibilities of flooding are greater. In addition, it would have been closer to the outlets of some of the streams in the sector (the Tagarete and Ranilla).

Pollen analysis

Pollen analyses shown in Figure 5 and Figure 6 correspond to columns 1-B and 2-B respectively.

Column 1-B (Figure 5). The percentages of arboreal pollen (AP) are very low compared to those of herbaceous pollen (NAP) (see AP/NAP). Thus, arboreal pollen does not reach 10% at any stage and is scarcer at lower stages. Three stages have been defined, depending on the pollen types found. From bottom to top we find:

Stage 1, samples 1–3 (see Table 2). Mainly non-arboreal pollen types, such as Cardueae, Cruciferae, *Chenopodium*, *Erica*, Gramineae, Liguliflorae, *Plantago*, Tubiflorae and Umbelliferae. The principal arboreal taxa are *Olea*, *Pinus* and *Quercus*. Cyperaceae values are low (*c.* 100 gr/g).

The dominant taxa in this phase are principally those from man-made habitats. The presence of Cardueae, Cruciferae, *Chenopodium*, Gramineae, Liguliflorae, *Plantago* or Tubiflorae, which are typical pasture plants, indicates a grazing area. The absence of Cerealia pollen indicates that there were no cereal crops. The presence of Cyperaceae, plants typically found by the riverside, reveals the influence of a nearby watercourse. This is confirmed by the presence of *Fraxinus*, a tree typically found on riverbanks. On the other hand, the presence of *Quercus* and *Erica* indicates vegetation of Mediterranean woodland type in the surrounding area. In level 3 (3·03 m) there is a sharp decline in the total sum of sporomorphs, possibly due to a greater human impact.

Stage 2, samples 4–6 (see Table 2). What is most significant in this phase is the increase in Cyperaceae, with values around 1000 gr/g, particularly in sample 6. Taxa which appeared in the previous phase, like Cruciferae, Gramineae, *Plantago*, Tubiflorae and Umbelliferae are still present in similar concentrations. Others, such as Cardueae and *Chenopodium* appear in lower concentrations, while Liguliflorae increases its concentration. Arboreal pollen levels remain similar to those of the previous stage. The highest concentration of Cyperaceae in the entire section is found in this phase. This implies that the area was strongly affected by a watercourse and that the zone was possibly flooded for some time. Taxa previously mentioned as being typical of pastures are still present in this phase, although in lower concentrations. They would have grown alongside swamp zone vegetation. As in the previous stage, the effect of the Mediterranean woodland is likewise evident.

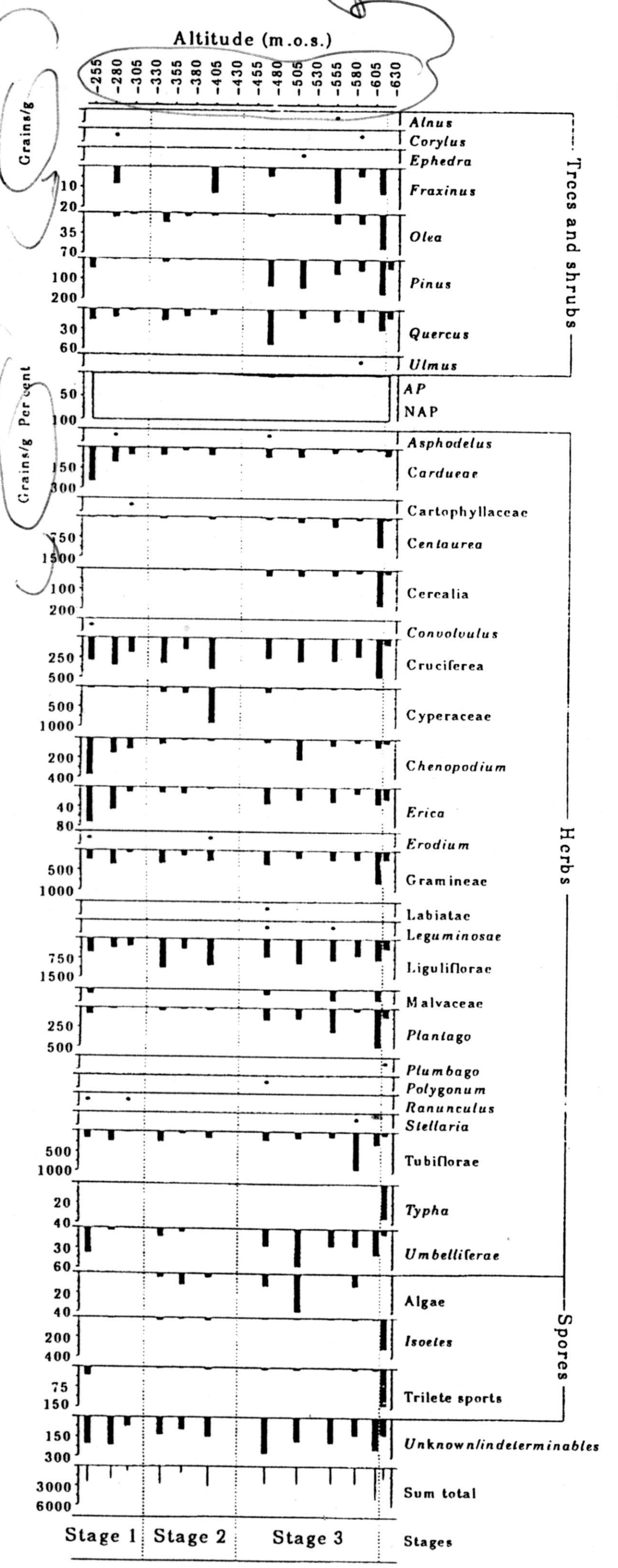

Figure 5. Pollen diagram column 1-B sector 1.1. AP, Arboreal pollen; NAP, non-arboreal pollen.

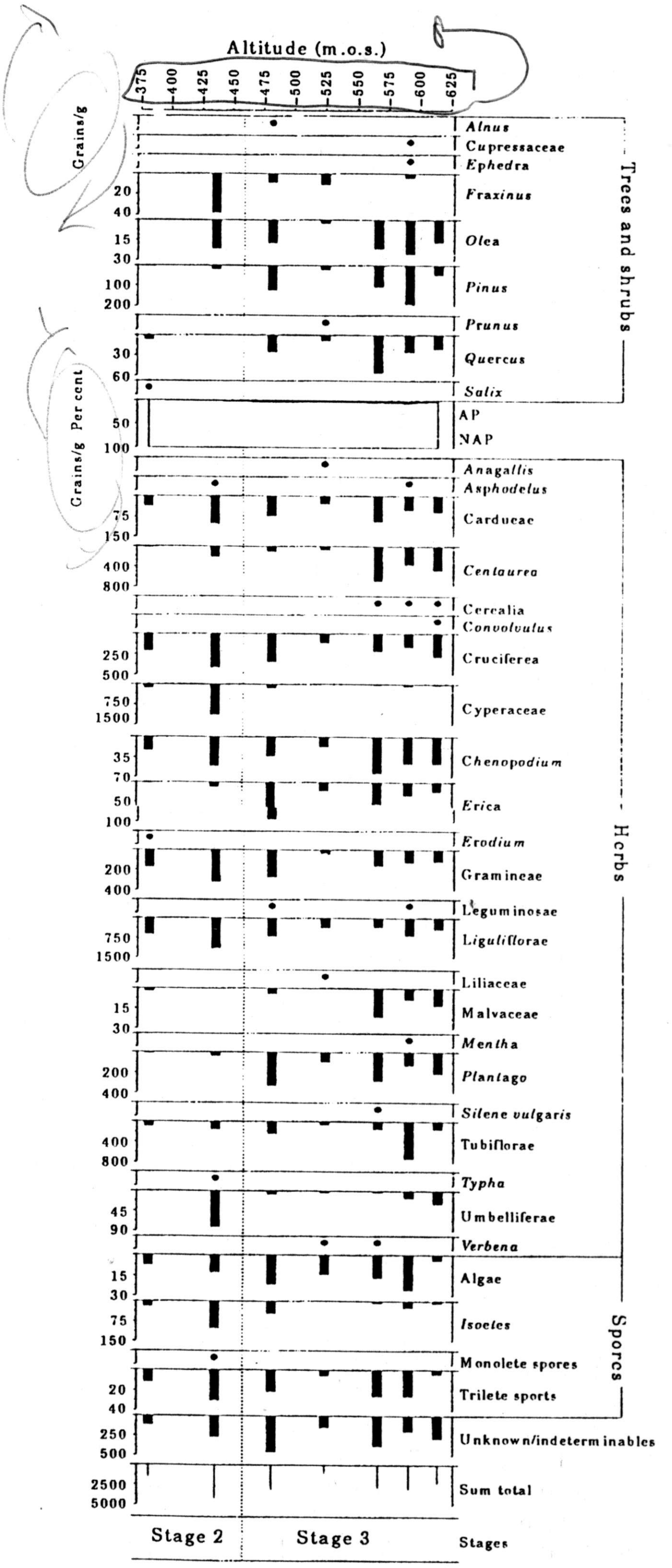

Figure 6. Pollen diagram column 2-B sector 2.1. AP, Arboreal pollen; NAP, non-arboreal pollen.

Stage 3, samples 7–11 (see Table 2). Cyperaceae levels decrease significantly (only 100 gr/g) while the *Centaurea*, Cerealia, *Chenopodium*, Malvaceae, *Plantago*, Tubiflorae and Umbelliferae levels increase. Other taxa such as Cardueae, Cruciferae, Gramineae and Liguliflorae remain unchanged, as in the previous recordings. Levels of arboreal pollen such as *Olea*, *Pinus* and *Quercus* rise. The reduction of Cyperaceae levels in this phase indicates a lesser influence of a watercourse. The flooded zone would have receded, although some degree of influence is still evident. Taxa such as *Centaurea*, *Chenopodium*, Gramineae, *Plantago*, Tubiflorae and Umbelliferae begin to increase, indicating a zone with more pasturing influences. The presence of Mediterranean woodland nearby is documented by the quantities of *Quercus* and *Erica*. Cerealia levels indicate the existence of cereal crops near the area, although not in great quantity as the highest counts do not exceed 4%. The *Pinus* count also increases in this phase. Its anemophilous pollination suggests that it probably comes from some distance from the site, as it is never found in high concentrations.

Concentrations in the upper layers of the diagram (sample 12) break with the previously observed patterns. There is a sharp decline in taxa such as *Centaurea*, Cerealia, Cruciferae, *Chenopodium*, Gramineae, Liguliflorae, *Plantago*, Tubiflorae and Umbelliferae, whilst other taxa such as *Isoetes* and triletes reach their highest concentration in this section. *Typha* also appears for the first time. The layers following this one consist mainly of fill typically used to level the ground. Since the layer analysed was very thin, it is possible that the two layers were mixed. Thus, one may assume that the fill came from swamp zones, owing to the high concentrations of *Typha*, *Isoetes* and triletes spores, all from plants typically found in these areas.

Column 2-B (Figure 6). Graph AP/NAP shows very low arboreal pollen percentages in relation to herbaceous pollen. Arboreal pollen peaks at sample 3 and 6, never exceeding 10%. Two stages can be defined, depending on the pollen types found. From bottom to top we find:

Stage 2, samples 1–2 (see Table 2). The high concentrations of Cyperaceae (>1000 gr/g) stand out. There are fewer pasture plants present, like Cardueae, Cruciferae, *Chenopodium*, Gramineae, Liguliflorae, Umbelliferae and *Isoetes*. The presence of *Typha* is noticeable. On the arboreal pollen, *Fraxinus* and *Salix* on one hand and low concentrations of *Quercus* on the other also stand out. High Cyperaceae concentrations indicate a zone greatly affected by a watercourse which may have flooded periodically. The appearance of *Typha*, *Fraxinus* and *Salix* seems to support this theory. There were clearly many pastures in the area. The presence of *Quercus* and *Erica* implies the influence of Mediterranean woodland, which may be expressed even in areas a short distance away.

Stage 3, samples 3–7 (see Table 2). Cyperaceae levels become significantly lower at this stage, remaining at approximately 100 gr/g. Taxa such as *Centaurea*, Cerealia, *Chenopodium*, *Plantago*, Tubiflorae and Umbelliferae increase. Others, such as Cardueae, Cruciferae or Liguliflorae remain unchanged. The appearance of new taxa such as *Prunus* and *Verbena* is significant.

The sharp decline of Cyperaceae levels indicates that the flooded zone was probably smaller, although the influence of inundation is still evident. The rise in concentrations of *Centaurea*, *Chenopodium*, *Plantago* or Tubiflorae indicates that this was a pasture zone, possibly used for grazing livestock. The appearance of *Prunus* and *Verbena* may indicate agricultural zones where fruit trees and vegetables were grown. The presence of Cerealia shows some degree of cereal cultivation nearby. Lastly, higher concentrations of *Quercus* and *Erica* show a strong influence of Mediterranean woodland in the surrounding areas.

From these two pollen diagrams it may be concluded that this was a zone with highly domesticated vegetation with few trees and where most of the vegetation was herbaceous. The zone must have been frequently flooded and there must have been predominantly pastureland nearby. This area probably expanded during periods when there were fewer floods. The influence of Mediterranean woodland on the area is marked at all times.

Conclusions

A combination of archaeology, palynology and geology has allowed us to reconstruct the palaeoenvironment in the areas studied and to gain some insight into the historical events occurring here between the 1st century and the 20th century AD.

The first moment of historical occupation dates back to the Roman Empire between the 1st century and the mid-2nd century AD, at a depth of between 4·45 m and 4·70 m. This discovery confirms the presence of Roman levels in a wide area between the new County Council building and El Prado de San Sebastián. The area was later buried under clays and flood silts, which reached up to 2·50 m in depth.

It was not possible to establish the precise nature of the Roman occupation of the area, given the type of remains found and the limitations of this type of study. However, the absence of soil formation, as well as the scarcity of Cerealia pollen, suggest that the occupation was not of an agricultural nature. The vegetation surrounding the ancient city indicates mainly grazing land, with some influence from a fairly distant Mediterranean woodland. Minor industries could have existed on the outskirts of the Roman city.

The clay analysis shows very few traces of other historical settlements since Roman times. Only small collections of shards were detected in some stratigraphic columns; however, none of them indicates a stable occupation. Neither was it possible to date them owing to the scarcity of the fragments found (unit 115 from column 1-B was dated to the 18th century). The only level worth mentioning is that represented by unit

142 (column 2-B), where pottery is very abundant and can therefore be dated between the end of the 16th and the first half of the 17th centuries. The 17th century remains (unit 142) are located only 0·70 m from the Roman level (2nd century AD). The proximity of remains from such distant times contrasts with the 1·80 m of clays which separate the 17th century from the mid-19th century. This is not only an indication of the absence of historical occupation for very long periods of time, but also clearly shows an important change in the dynamics of flooding in the area from the 17th century onwards. The area thus contained a large number of riverside plants and was surrounded by pasture, which must have been periodically flooded. The absence of clear levels of occupation can be attributed with precision to these floods and the frequent rise in water level.

The first half of the 19th century coincides with the upper section of the grey clays. By this period there are still no signs of clear soil formation, indicating that the area continued to be affected by frequent flooding, although possibly to a lesser extent, since there is a reduction in the number of riverside plants. The increase observed in particular species of pasture vegetation indicates that the zone was used for similar purposes as "El Prado" (meadow) of San Sebastián at that time, i.e. for grazing cattle. It was also soon to be used for cattle markets. Thus, the surface of the San Bernardo site, situated on the edge of the San Bernardo district and quite near El Prado, must have been an extension of this latter activity.

Above the levels of grey clays which form a rather flat surface, an important re-emergence of greater contour heights is evident, together with the fill from other areas. Most was bench gravel (red clays and sands) including a large quantity of plant material from marshy zones, although other types of fill were also used. Among those worthy of mention is one coming from a sink, dating from the 16th and 17th centuries. The artificial fill oscillates between a depth of 1·84 m and 2·50 m. This ground elevation is clearly related to the laying of the Sevilla–Cádiz railway line, which crossed this area from the east.

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