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Fusion of Cultures

Proceedings of the 38th Annual Conference on Computer Applications and Quantitative Methods in Archaeology, Granada, Spain, April 2010

Edited by

F. Contreras
M. Farjas
F. J. Melero

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F. Contreras, M. Farjas and F.J. Melero (eds.)

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In Conspectu Prope Totius Urbis: an Application of Different Visual Methods at the *ager Tarraconensis* Landscape

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We present in this paper the results of the application of several visual methods on a group of locations, dated between VI and I centuries BC, of the ager Tarraconensis (Tarragona, Spain) a Hinterland of the roman colony of Tarraco. The difficulty in interpreting the diverse results in a combined way has been resolved by means of the use of statistical methods, such as Principal Components Analysis (PCA) and K-means clustering analysis. These methods have allowed us to carry out site classifications in function of the landscape's visual structure that contains them and of the visual relationships that could be given among them.

Keywords: Viewshed, Tarragona, Clustering, Principal Components Analysis, Prominence, GIS.

1. Introduction

David Wheatley and Mark Gillings defined visibility as "cognitive/perceptual acts that served to not only inform, structure and organise the location and form of cultural features, but also to choreograph practice within and around them" (WHEATLEY and GILLINGS, 2002a:3).

These completely immaterial facts are however part of a mental process that explains a great part of the social underlying behavior of an individual and inside the group where he is integrated. Those are sensations, feelings and acts that remain subliminally. and that don't leave behind an archaeological print. But without them we cannot explain social contexts, as the corresponding to the last century of the roman republic, unless we appeal to the historical sources. For example we know from Cicero the interest of the patrician class to lift their houses in the highest and most visible places of the Palatine's hill in Rome. This way, they competed to occupy the highest place, like a form of highlighting their *gens* above the other ones. It is known the expression of this fact that Cicero states: *in conspectu prope totius urbis* (*De domo sua* 100), that is to say "exposed in view of almost the whole city". In the countryside the *villae* play a similar role to that of the *domus*, as they are a cultural symbol which expresses the individual's mastery over the rest. It is also significant that both the architecture and the conscious use of the topography were used in the design, prominence and organization of spaces and residential buildings. These uses responded to the need to identify the place at the same time as a residence, a management center, and specially as an evidence of the owner's presence in the territory, highlighting his property rights, wealth and social position

In this work we analyse the visual structure in iberian and republican times of the *ager Tarraconensis* landscape (Tarragona, Spain). We have studied diverse aspects of the territorial visual structure of the implied locations.

In particular we have studied the roman rural settlements and the *villae* in order to extrapolate what happened in Rome in the last century of the Republic to the rural landscape of the roman colony of *Tarraco*. We would see if the local elites followed the same pattern. That is to say, did they look for a predominant location visually with regard to the rest, in a kind of visual hierarchy? Evidently a similar study must lean on the archaeological, architectural, sculptural and epigraphic data that appeared in these *villae* subjects of study.

The "Estudi del paisatge arqueològic antic de l'*ager Tarraconensis* (a la dreta del riu Francolí)" project has been carried out by the "Institut Català d'Arqueologia Clàssica", ICAC (Catalan Institute of Classical Archaeology), among the years 2005 and 2009. As a wide scope project it has been implemented in

collaboration with diverse institutions that work together in this space. This project is included in the "Landscape, Settlement and Territorial Archaeology" research line of ICAC. It is also part of the project "Forma Orbis Romani" directed by the Academic International Union, represented in Catalonia by the Institut d'Estudis Catalans (IEC).

Due to the great extension of the *ager Tarraconensis*, we initially decided to study the area located in the right margin of the river Francolí, with an extension of 345 km^2. The project proposed an integral study of the territory in the antiquity and its evolution, from 500 BC to 712 AD. Therefore, it is a pluridisciplinar research that integrates diferent topics: settlements; territorial articulation and their communication routes, and diferent paleoenvironmental and geological approaches. This diversity of specialties has gathered the work of 28 national and international researchers. The project, directed by Drs. Marta Prevosti and Josep Guitart, has been from the beginning outlined as pluridisciplinar and diacronical approach.

2. Quantifiying Visibility

Intervisibility, prominence, analysis of superficial visible extensions are characteristic methods of a quantitative focus. All of them use mathematical and statistical methods with the intention of generating explanatory models.

Diverse methods evaluate the visibility. The first works correspond to Fraser (FRASER, 1983) who analyzed the intervisibility between two locations using the Line of Sigth(*LOS*). We know as viewsheed the binary map where each cell indicates the result of a LOS taked from an observation point.The Cumulative Viewsheed is the union of the calculations of individual visibility taken from each observation point. Renfrew (RENFREW, 1979: 15, figures 5) presented the results of Cumulative Viewshed indicating for each observer how many times it was seen by the group of observer points. Wheatley computed the method (WHEATLEY, 1995) and applied it to the study of the visual relationships among the neolithic barrows in Salisbury Plain. Another of the applications has been the definition of sacred landscapes or the demonstration of the possible relevance of certain monuments or prehistoric sanctuaries (GARCIA SANJUAN, WHEATLEY, 2008).

The visual structure of the landscape, or Total viewsheed, was defined by Llobera. It can be defined as the visibility extended to all the cells of the studied territory where all are now observers and observed. In other words this method defines a landscape description based on its inherent pattern of visibility (LLOBERA *et al.*, 2004)

Wheatley and Gillings (WHEATLEY and GILLINGS, 2002a) provided methods to define the visual panoramic obtained from a communication road. They also contributed examples of how to correct the visual quality in function of the distance. They made it on the basis of the works of Tadahiko Higouchi (HIGOUCHI, 1988: 9-23) who among other aspects defined the thresholds of change in the visual quality of the landscape's elements. Other calculations are guided in the comparison of the topographical preponderance among establishments, monuments and places with a symbolic strong importance. This way the index of topographical preponderance is expressed as a location that stands out above the rest (GARCIA SANJUAN, 2005: 220). LLOBERA (2001) defined the prominence as a function of the difference in altitude between an individual element and the environment that it surrounds it. The prominence also informs us about the morphology of the location.

3. Methodology

3.1. Integrating SGBD & GIS

In order to register and manage all the data obtained in the project, we created a Database using the DBMS Microsoft Access. In this database we included the data registered by Simon Keay and Millet on their land surveyors project's (CARRETÉ *et al.*, 1995). This project was developed between the end of 1980's and the beginning of the 1990's.

We also included and reviewed all the sites of this area registered at the database of the "Departament de Patrimoni de la Generalitat de Catalunya" (Genaralitat de Catalunya heritage departament). The new sites found in land surveyor works were also recorded in the database.

All this data was integrated in a GIS system, ARCGIS 9.3

3.2. Visual Methods

We have applied well-known methods to quantify and analyze the visibility pattern and we have also built some new functions.

GIS doesn't generally provide methods like those mentioned. Some of them may be programmed taking as a basis the function of accumulated visibility. For that reason some of the following functions have been implemented in Phyton, the native programming language of ARCGIS 9.3:

-Llobera's routine, which calculates the prominence starting from a group of points and in a certain radio.

-Visual Impact. Routine that quantifies the number of cells that observe each locations subjected to study.

-Visibility from the communication roads. Routine developed by David Weathley. It calculates the visibility from the vertexes that are part of a line, in this case a communication road.

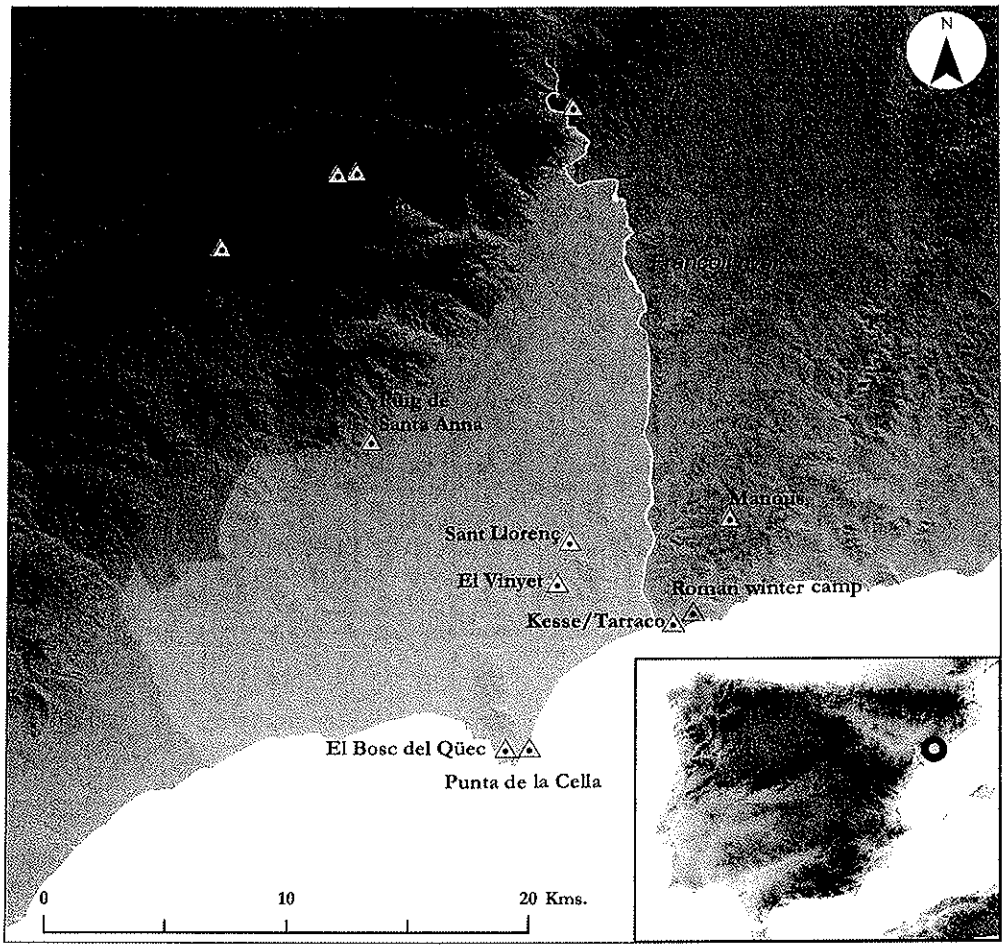

Figure 1: *The ager Tarraconensis research area and sites quoted on text.*

-Visual net. On the basis of the calculation of the simple visibility for a group of locations, a graphic net is built. We can see which are the visual interconnections among the observer points.

These functions were applied on data corresponding to locations of different chronologies, using a raster of 30 meters/pixel bought to the Cartographic Catalan Institute (ICC). The studied area measures 58x55 Km2, taking into account WHEATLEY and GILLINGS (2002b: 209) advices about the problems in choosing an adjusted workspace for the locations.

3.3. Statistical Methods

Using the data obtained in the different visual studies we implemented diverse statistical methods. The methods we used are the *independent sample t test*, the *Principal Components* Analysis (PCA) and the *K-means Cluster analysis.*

Independent sample t test is one of the statistical methods that allows the comparison among independent groups through a normal dependent variable (MORGAN *et al.*, 2004: 135-138). A sample will be significant if the test value is smaller than 0.05.

The Exploratory Factors Analysis (EFA) and the Principal Components Analysis (PCA) are the methods used by the researchers to represent a great number of relationships among variables in a more simplified way (LEECH et al., 2005: 75). The first conceptual difference between the two methods is that EFA postulates that a small group of non observed or latent variables exist, which are hidden between the observed variables and the measures. On the other hand, PCA obtains a reduced group of variables that represents a great part of the information contained in the total of the used variables. PCA method looks for the creation of factors that show a group of N variables in a space of representation of smaller dimension R. These R factors or components cannot be observed empirically. (SHENNAN, 2004: 265-302).

K-means clustering (MACQUEEN, 1967) is one of the learning algorithms without simpler supervision that solves the well-known clustering problem (SHENNAN, 2004: 216-264; CONNOLLY and LAKE, 2006: 162-173).

In order to see if it is possible to define diverse groups of visual behaviour, PCA has been applied on five variables: Cumulative Viewsheed, Visual Impact, Prominence at 500 meters, Prominence at 3000 meters, Prominence at 5000 meters. This procedure reduced the five variables in two components whose values have been analyzed by *k-means Clustering*. This technique

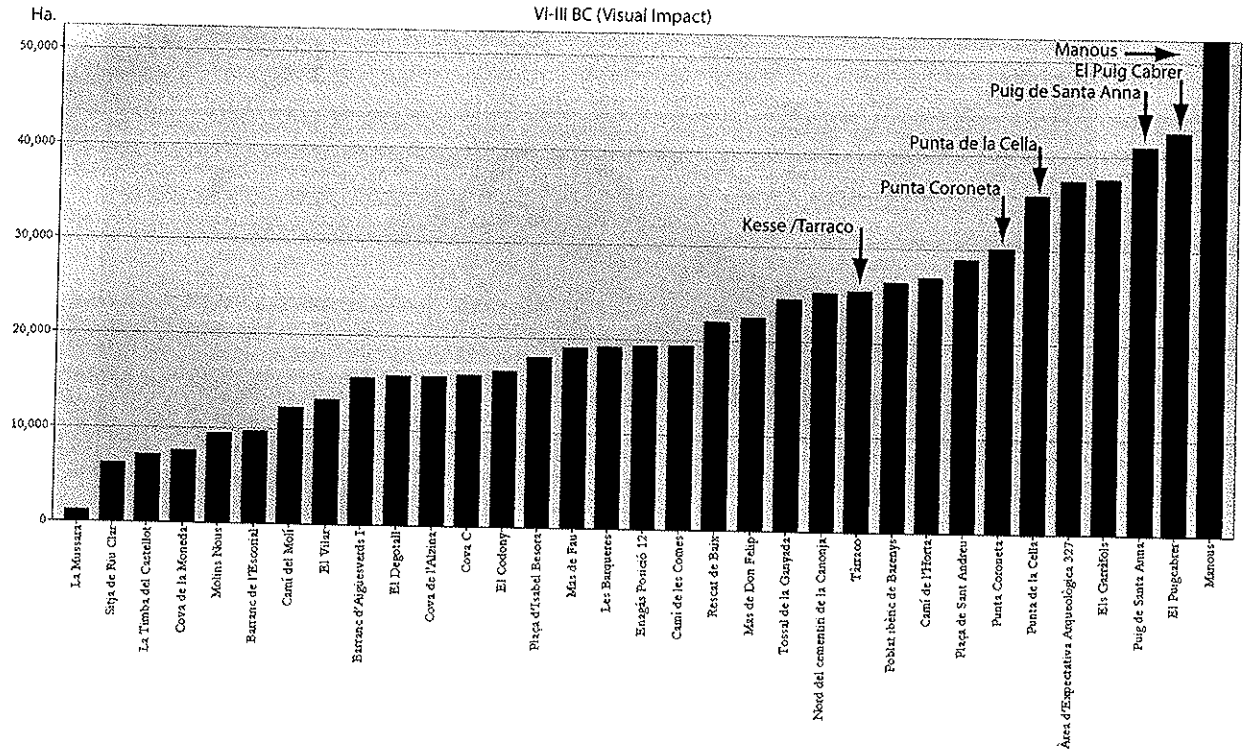

Figure 2: *Iberian Period. Visual Impact. Quantity of Ha. that visualize each site.*

has been used to determine, with more simplicity and precision, groups of similar visual behavior.

4. Results

4.1. Visual Methods

Iberian period VI-III century BC

For this chronological period we know up to 27 sites, Unfortunately the archaeological information that we have is scarce and the structures are not well-known.

Our study began applying a 500 meters prominence analysis, detecting 5 sites with more than 80% prominence. These were Punta Coroneta; Puig Cabrer; Manous; Punta de la Cella and Puig de Santa Anna (figure 1).

Then the other analyses gave similar results and also highlighted the five mentioned locations. All of them seemed to have similar visual and topographical characteristics: highly prominent and very visible from the rest of the territory. This fact could be related to control centers. Particularly we will point out three sites that obtained the best results: Puig de Santa Anna, Puig Cabrer and Manous (figure 2).

A different functionality could be detected observing the results of the cumulative viewshed analisys. Most part of the vision of Puig Cabrer and Manous is long distance vision (more than 10 Km) while most part of the vision of Puig de Santa Anna has a distance of less than 10 Km. That is to say, first both would exercise a regional control of the territory as well as of the natural communication roads, while Puig de Santa Anna would exercise as a more local control centre over the nearest sites. On the other hand we could affirm that, in this cronological period, *Kesse/Tarraco* is not the best perceived. Taking into account the visual classification it is a second range site, below Puig de Santa Anna.

II Century BC

The beginning of this period is characterized by the last years of the second Punic War and the construction, near *Kesse,* of a military roman camp between the 218 and the 206 BC. Its functionality varies, going from winter barracks, headquarters of the allied assembly to warehouse for the supplies. Later on, with the creation of the *Citerior* and *Ulterior provinciae* in 197 aC, their singularity will be developed by adding an italic population formed by *publicani* and *negotiatores*. These will boost an economic and a commercial growth dew to oversea tradewith Italy (RUIZ OF ARBULO, 2007: 571 -572).

During II Century BC we can observe an increase of the number of sites (47). We also detected a new sites convivence with iberian sites. This last were uninhabited along this century. This iberian villages were Puig de Santa Anna and Punta de la Cella.

But one of the most important changes of the *ager Tarraconensis* settlement is that the majority of the new sites were near of *Kesse/Tarraco.*

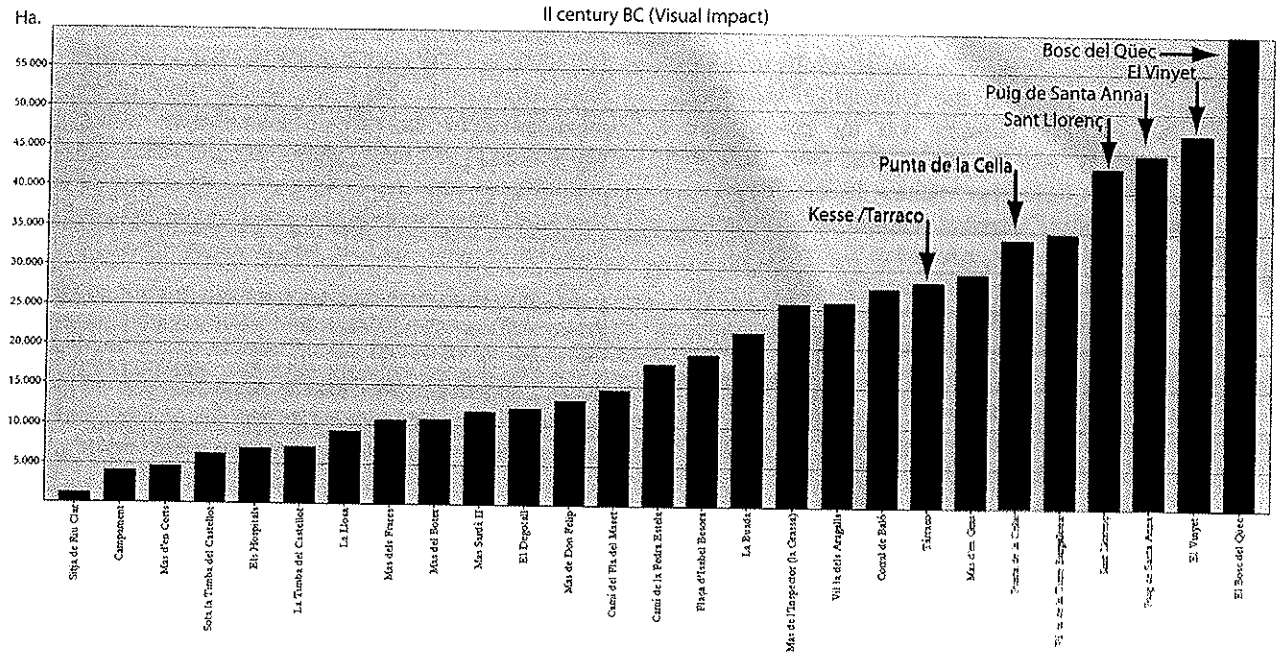

Figure 3: *II century BC. Quantity of Ha. that visualize each site.*

Evidently the results for the iberian sites are related to the visual landscape structure and are similar to the previous period. Only changing the cumulative viewshed analysis. Results show us that the importance of these iberian sites have changed for the rest of the settlements. But it is interesting to contrast this results with the prominence of 3 new sites: Bosc de Qüec, Sant Llorenç and el Vinyet. These new sites had similar visual results to Puig de Santa Anna (figure 3).

Initially these sites were classified as rural structures. This resemblance leads us to doubt of their initial classification, as that those may be control centers of the territory.

Also the pathviewshed analysis detected that Puig de Santa Anna was still the place best viewshed of the landscape, but one of the three new sites, Bosc del Qüec, has similar results. Could a rural site have a 40 % of positive vision from the communication route?

I Century BC

In this chronological period we detected another increase in the number of sites (62). These new sites settled in uninhabited areas in the previous century.In this century, the iberian sites end their activity and *Kesse*, now *Tarraco,* had an outstanding and ambitious urban development (arround 100 BC) and a higher

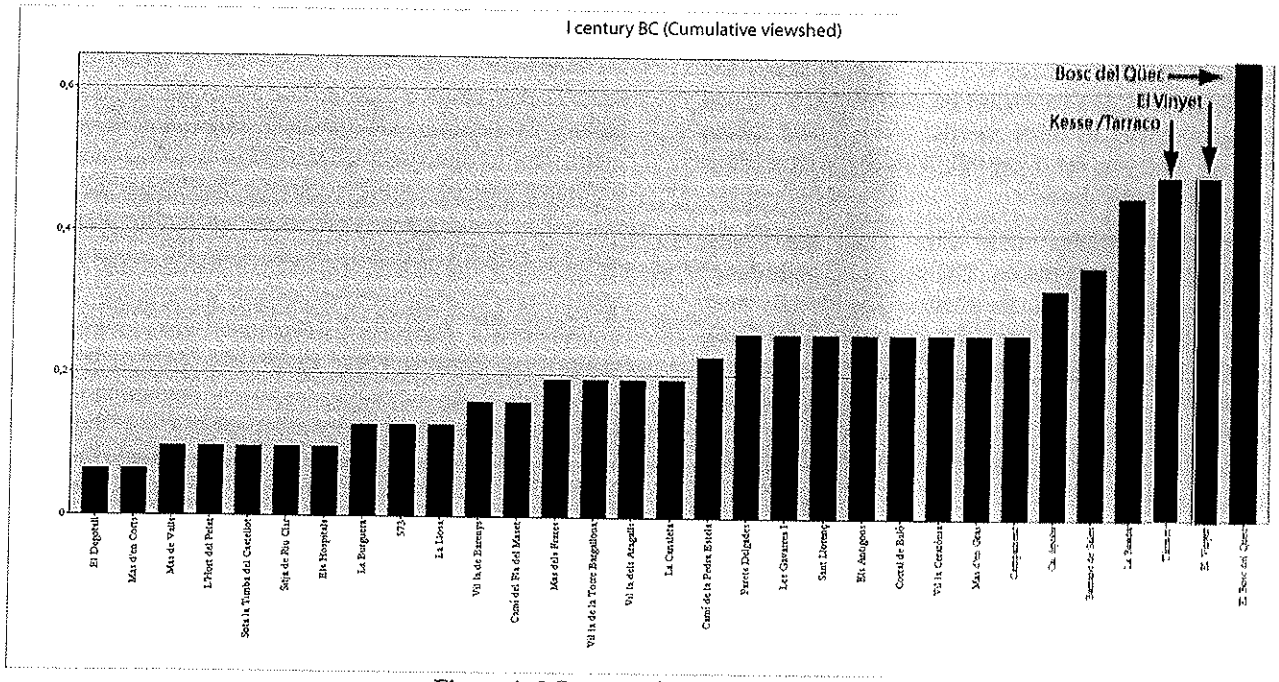

Figure 4: *I Century BC. Cumulative Viewshed.*

juridical status, becoming a roman colony between 48-44 BC (RUIZ DE ARBULO, 2002)

The prominence analysis provide similar results to those of the II century BC and the cumulative viewshed analysis show us that *Tarraco* was the place more viewshed (figure 3) from the rest of sites. Only Bosc of Qüec and el Vinyet have larger values. It coincides then with the conversion of *Tarraco*, into an administrative center of the *Tarraconensis province.*

4.2. Statistical results

The studies of visibility carried out on the five variables allow to identify groups in which we can classify the locations in function of the attention or the prominence that its location provokes on other sites. However, it is difficult to extract general conclusions from the studied visual behaviours. Applying PCA has been much easier than analysing all the individual results. The application of the k-means clustering allowed us to define four possible groups that maintain part of the structure of the previous period.

Iberian period

If we combine in a scatter dot the two components of the *PCA & K-means Clustering* application it allows us toobserve one group (5.1) that shows the higest levels of prominence, cumulative viewshed and visual impact. The sites that integrate this cluster are: Manous, Els Garrafols, Puig de Santa Anna, Punta de la Cella and Punta Coroneta. These sites were located in more prominent and visible places in the landscape than the other sites and had a visual control of the territory.

Remember that *Kesse/Tarraco* (5.3) became a provincial capital of the Roman Empire. But it belongs to a cluster that have no significative or a half prominence, and other visual components.

We want to emphasize La Mussara and la Cova de la Moneda (5.2). These sites were located in the most prominent places, but they can't be viewed from the rest of the landscape. In other words: "You know where there it is, but you can't see it". This sites have been dated to the Bronze Age.

Our hypothesis is that these sites could have been simbolic and religious places. The symbolic importance of a topographical prominent element has already been studied in other cases like, for example, the visual relationship between the dolmen of Menga the Peña de los Enamorados near the cave sanctuary of Matacabras (Antequera, Spain).

II Century BC

PCA results show us that one group is integrated by the last iberian sites: Puig de Santa Anna and Punta de la Cella. New sites as El Bosc del Qüec, El Vinyet and Sant Llorenç have a similar prominence and visibility patterns (6.1).

We have several explanations for these results: those three sites could be local elite's rural places, that remained along the early Roman Empire although we don't know if they were roman *villae.* Another possibility is that they could have been roman territorial control centres. Nowadays we don't have archaeological explanations that could assert these hypothesis.

Also, the PCA results are interesting with regard to *Tarraco/Kesse.* The visual and prominence patterns are the same as those related to iberian times. This result doesn't surprise us, because an important part of PCA is the prominent data related to the site's topographycal context. The cluster that contains it (6.2) has a non significative prominence and visibility pattern. We could even say that *Tarraco/Kesse* is an outlier inside its group. The reason is that the Cumulative viewshed proved that *Tarraco/Kesse* had similar values than Puig de Santa Anna. On the other hand, the difference on the PCA is the increment of positive visuals between *Tarraco/Kesse* and the other sites.

Between PCA of the Iberian period and that of the 2nd century BC, we can observe a change in the territorial visual pattern distribution. However one of the groups (figures 5.1 and 6.1) presents similarities related with the iberian settlements that subsist during this century. This iberian settlements were situated in places with the best values of cumulative viewshed, visual impact and prominence at all distances.

I Century BC

In the 1rst Century BC the data obtained by applying all the methods doesn't seem to indicate a variation of the pattern of the 2nd century BC. It is certain that the Iberian settlements have been abandoned (figures 6.1, 7.1) and an increment has taken place in the number of habitats with lower visual values (figure 6.4 & 7.4), but the structure of the visual landscape is apparently the same as the previous period. The group 7.1 persists even having the Iberian settlements disappeared. It is also interesting to observe how *Kesse/Tarraco* had increased its visual pattern in the second group along the three studied periods and how it seems an outlier inside its group during the 2nd and 1rst centuries BC.

Taking as a starting point the results of PCA we wanted to check if a significant difference exists in the 2nd century BC between those rural locations that later on, in the end of the Republic era and in the beginnings of the early Empire, will be transformed in villae and those that will maintain its character of rural establishments. With 95% of confidence and applying an independent sample T test we could say that the visual patterns were not significant in the election of the rural establishments that become villae later on (table 1).

However the application of the independent samples t test to the 1rst century BC provides a result different

from the preceding period. One of the components, with a 95% of confidence, is significant.

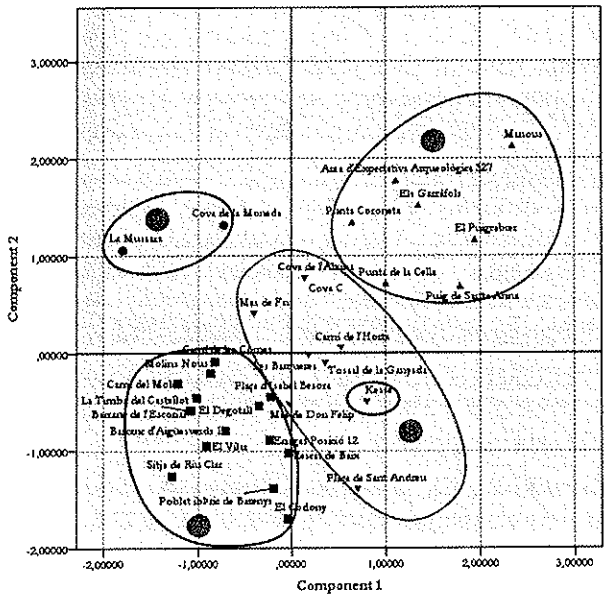

Figure 5: *PCA & k-means clustering results: Iberian settlements.*

Therefore those rural establishments, that later will be transformed in *villae*, have a visual component that is different to those whose initial and finalfunctionality correspond to a production center and to an agricultural exploitation.

Conclusions: *in conspectu prope totius urbis*

The individual analysis of the results obtained from diverse visual methods is too complex to extract general conclusions. PCA is a statistical tool of great utility to simplify and to visualize the visual patterns.

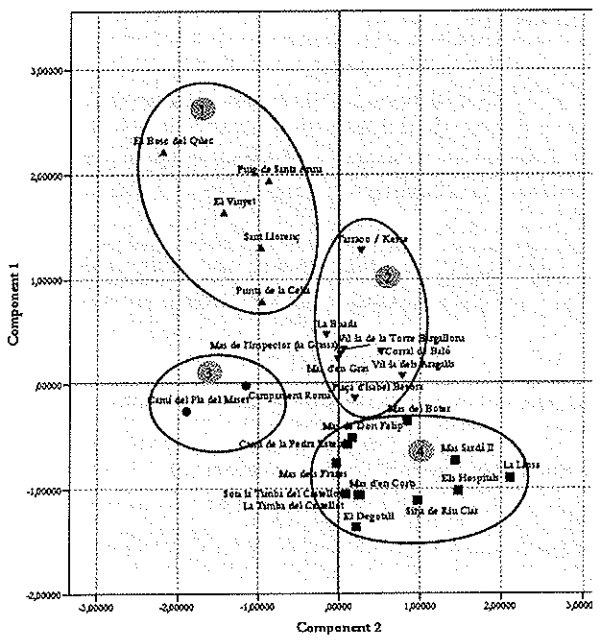

Figure 6: *PCA & k-means clustering results: s II BC .*

We also have seen how part of the visual structure of the iberian territory remains during the romanization (1.1,2.1,3.1). This indicates us that the new occupant had to take advantage of part of the social previous dynamics allowing the permanency of locations or the creation of new ones with similar visual patterns.

The use of the cumulative viewshed in PCA allows to check which is the evolution of the visual pattern of an establishment. It is the case of *Kesse/Tarraco*, for which we see its transformation from an iberian *oppidum* of second order to a provincial capital of the Roman Empire. The locations chosen as habitat appear to look for positions from where the new colony is contemplated.

But the main conclusion of our study, using PCA and then *independent sample t test*, confirm the possible imitation of Rome's social context described by Cicero.

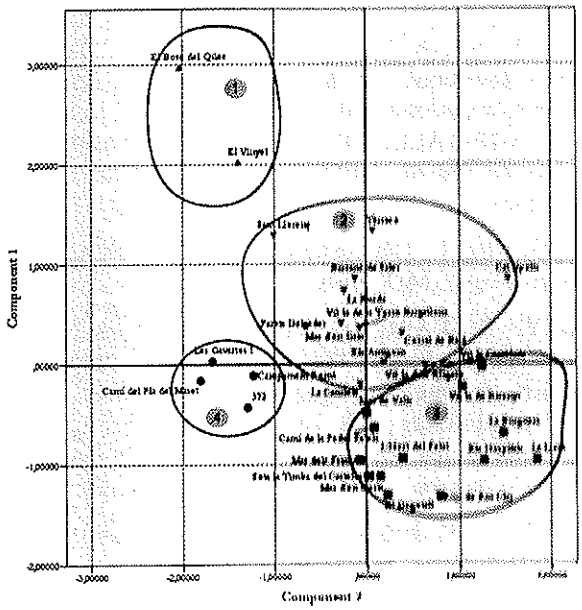

Figure 7: *PCA & k-means clustering results: s I BC .*

The new elites of the Colony of *Tarraco* begun in the 1st century BC to look for those locations which physical prominence, symbolizing both, thethe political prominence and the clientelar relationships.

Independent Sample t test	
	Sig. (2-tailed)
1. Component 2 s. II BC	.491
2. Component 2 s. I BC	.047

Table 1: *Independent sample t test results.*

Further studies

Further studies are needed to better understand and explain these results of analyzing the landscape's visual context: territorial definition using watersheeds, the creation of visual nets to highlight areas with a social deep cohesion and finally the application of other statistical methods (for example *Twostep Cluster analysis*). We also need to apply these visual methods

on other Mediterranean contexts in order to check if this visual pattern is similar in other areas.

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