

Digital Cartographical Databases and their Application to Archaeology

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Topographical studies in Archaeology are undergoing fundamental changes as a result of the advances, which have taken place in three complementary fields: Geographical Information Systems (GIS) programs, computer operating systems for PCs, and computerised data bases, which are constantly appearing on the market and inexorably replacing conventional, analogue cartography. These factors will substantially improve topographical information and, in particular, will enable us to look more closely at aspects, which were previously beyond our reach, or they will simply facilitate the graphical representation of the results of a topographical study, which, in the past, could only be expressed in writing, or by means of somewhat, inaccurate cartography.

Although we have been using GIS for various aspects of Spatial Archaeology for more than five years, the high cost, until recently, of the equipment needed to run the programs, made its widespread use, by archaeologists, difficult. In addition, their complexity, the price of the software, and the shortage of digital cartographic bases, meant that they took a long time to produce, which, in many cases, did not justify the effort involved. Fortunately, the situation is changing rapidly.

Archaeology now has access to very useful and reasonably priced software, which is relatively simple to operate and can be used on PCs. There are also PC versions of most of the complex programs, initially intended exclusively for UNIX workstations; in addition, these versions have different modules, that can be purchased separately, depending on the user's needs. All this makes it worth using, both from an economical point of view, and because of the easier handling.

At the same time, this trend has been helped by the release, onto the market, of cartographic databases, that do not require lengthy digitalisation processes, and avoid the problems of maladjustments, which occur during the tedious process of patching together data from different maps, having complementary layers of thematic information, or adjacent

territories. This new situation is just beginning to take shape, since there is still little digital cartography available, which can provide detailed information at a reasonable price. We hope that the widespread use of these new cartographic databases will bring down the cost dramatically.

In this situation, it would seem clear that the tasks, related to topographical studies, will have to gradually adapt to the use of these new tools, not so much because these instruments open up new fields of knowledge, but rather, because they can solve, more rapidly and, what is more important, more accurately and objectively, any questions we might ask, clearly cutting the time needed, compared to traditional, analogue cartography procedures.

Recently, one of the authors (ESPIAGO, J., and BAENA, J., 1997) reviewed existing digital cartography, so, we will not cover the same ground again here; although, since a few months have passed, a few points need to be updated. In particular, the prices of cartographic series are now very reasonable. Although the scale still tends to be rather small, the resolution is very acceptable, and allows quite precise studies in work, which deals with the geographic relationships of medium- and macroscales.

Although any general synthesis of digital cartographic products that can be used for common archaeological work, will inevitably become out-dated very quickly, as of April, 1998, the cartographic databases for the Iberian Peninsula – and more specifically, Spain – with a digital format, which have proved to be most suited for our field of work, and which have been accessible are the following:

a) Ordinance survey series (produced by the *Servicio Geográfico del Ejército*) of altimetric and planimetric maps with scales of 1:50 000, 1:250 000 and DTMs (digital terrain models) of 25x25, 100x100 and 200x200 sq. km cells.

b) National Geographic Institute (*Instituto Geográfico Nacional*) Series with scales of 1:25 000 and 1:200 000, and a DTM.

c) The maps produced by the Autonomous regions of Spain (*Comunidades Autónomas*) in various scales. These are more heterogeneous, both in origin and in editorial standard, so they are difficult to use for the peninsula, as a whole. However, since they cover smaller areas, they are produced in scales, which show greater detail. For example, in the Madrid region, the Regional Government's maps (*Servicio Cartográfico Regional de la CAM*) are produced to scales of 1:1000 (for urban areas), 1:5000, 1:25 000, 1:100 000, 1:200 000 and 1:500 000.

d) The planimetric and topographical cartographic databases produced from earlier analogue series (National Geographic Institute and Autonomous Community Series), compatible with specific programs. This is the case of the UAM's Cartography Service's Digital Terrain Model (DTM) series, or the series published by ESRI-Spain (Muniview, etc.).

e) Several integrated packages have also been released onto the market, which combine management systems and digital data banks. We have two series of the Carta Digital de España (Digital Map of Spain), published by the *Servicio Geográfico del Ejército*. The first of them works on a vector cartographic database, while the second uses raster data. In both cases, there is a wide range of options; but, while the process is slow in the first series, in the second, with the raster format, it is notably faster. These series incorporate DTMs, derived from relief, with a contour distance of 100 meters, and the planimetric bases are obtained from the digitalisation of 1:250 000 ordnance survey, series sheets.

The use of these integrated packages, of management systems and digital databases, allows archaeologists to have their first contact with handling digital cartography, and enables them to become familiar with the new cartographic systems. They are, however, just a small sample of what the GIS can offer, for studying terrain in Archaeology, since their advantages over analogue cartography mean that they will be commonly used within a very few years.

Applications of GIS in Archaeology

Briefly, GIS, first of all, permit the creation of databases, in which alphanumeric and geographic data can be integrated. These can then be used for a number of useful applications, both in the field of **heritage management**, and the more general field of **archaeological and heritage research**.

By way of example, we will mention some of the most common uses, for which this instrument has proved effective.

- **Designing and undertaking archaeological surveys for archaeological mapping.**
- **Reconstruction of models.** Both in relation to palaeolandscapes and agrarian archaeology, and certain public works (roads, aqueducts, etc.).
- **Determining protected areas and areas of "sensitivity"** (spaces likely to contain archaeological remains).
- **Analysis of spatial relationships** (on the three levels: micro-, meso- and macrospatial).

There are a great many variables in this latter category. Those which we have worked with most, include the generation of

visibility and intervisibility polygons, Thiessen polygons, the calculation of optimal routes, and the approximate determination of catchment areas.

But, as with any other kind of tool, how useful it is, depends more on using it in the right way, than on its innate effectiveness, since the right choice of maps is fundamental. But, it is also necessary to know, which thematic series are the right ones to use, and the scale that should be used, for each particular purpose, and the hypothesis to be tested. Similarly, the accurate input of archaeological data is fundamental (suffice to say, that the difference of a few metres, in locating a site, can produce markedly different visibility polygons).

Having established the fundamental precepts, we can still come up against a great many other problems.

Although we would agree that, "a map, no matter how good the computer that holds it, is simply a representation, and not a form of interpretation" (BARCELÓ, J.A., 1997: 66); it is, nonetheless, true that digital cartography makes it possible to adapt, almost automatically, to the scale needed, at any given time and to superimpose the layers of information, which interest us, eliminating those that produce interference; and, what is most important, digital cartography makes it possible to show, accurately, and in graphical form, certain information, such as visibility polygons, that can only be transferred to analogue cartography, with difficulty.

Thus, for the archaeologist, GIS should not be an end in itself, but an aid to the interpretation of all those phenomena, that, one way or another, are involved in spatial relationships, such as patterns of settlement, trade, land use and obtaining raw materials, etc. In all these cases, purely geographic representation is insufficient, since we need to use other analytical techniques and sources of information, but is also clear that the cartographic images, that we can now obtain, will give us a better understanding of space in Archaeology, and will expand this field, of archaeological research, a little more.

Our experience using GIS, for very different purposes, allows us to reflect on its advantages and also on its potential, and we are optimistic that its use will become widespread; but, it also makes us emphasise, that, without the support of conventional resources, traditionally used in Archaeology, it is impossible to be rigorous, or reach any firm conclusions. For this reason, any kind of interpretation is still impossible, without good information; and this information can only be obtained from first-hand studies and surveys, carried out in the field, where the use of precision instruments, for determining co-ordinates, as well as the meticulous identification of archaeological remains and the geographical characteristics of the surrounding area, are essential.

Only in this way, can distribution maps become trustworthy documents, either for heritage management, or any kind of spatial research. Particularly, if one considers that some of the information contained in conventional maps may be of little use, for studies of the ancient past and may, in some cases, even be contradictory. For example, on maps showing mining and metallurgical resources, some veins, that are profitable for present-day industry, could not have been worked with less sophisticated technology; but, on the other hand, small veins, that are no longer of interest, because of their low yields, could have been exploited, and do, in fact, show indications of having been worked, in some horizons. The classification of the agricultural potential of land is a similar case. Other aspects,

related with palaeogeography, may, likewise, not appear on conventional maps, but nevertheless, exist, such as old water sources, or fossilised river beds, which may have been determining factors in locating a site, or deciding to farm a particular piece of land.

None of these points, however, invalidate the use of GIS. On the contrary, proper data collection and the evaluation of its limitations make this tool much more effective, and it is in these cases that their use becomes really worthwhile. As we have said, the ability to integrate databases, with georeferenced information bases, produces reliable documentation, which can be used in the purely administrative management of the archaeological heritage. Systems, created for this purpose, allow us to update the information rapidly, and design a protection policy, ahead of the development, or the laying of an infrastructure. But, at the same time, this system can also be used for archaeological research of the terrain. Furthermore, all the information, that can be obtained in this way, automatically enriches the database and improves the information, available for future studies.

The accumulated information, from all these tasks, can serve as the point of departure for other kinds of research, such as studies of catchment areas (operative chains), or those concerning any kind of relationship, between different communities. In these cases, direct surveys are necessary to collect additional information, such as information, relating to the location and composition of various raw materials.

The simultaneous use, of other techniques and work methods, is even more important for other aspects, that can also be shown by digital cartography and handled, using GIS.

The greatest advantage, of the two Digital Map of Spain editions, is the possibility of integrating, into one product or package, digital databases and associated, analytical procedures, very similar to the results that could be obtained, using a GIS. The program allows us, at any given moment, to know the exact location of the area, on which we are working (also very useful for integrating cartographic results into other programs); it also allows us to convert different systems of coordinates (UTM to geographic, including different projections use), while also, at the same time, show DTM altitudes, using hypsometric colours (figure 1), carrying out profile analysis (figure 2), visibility, slope calculations, user-defined DTM generation (figure 3), etc.

Limitations are due both to the scale, which does not allow good results for maps of areas less than 50 km wide, and to difficulties in accessing the cartographic base, digitally. The possibilities of output in raster formats, that exist in the first version, permit integration of results, into GIS programs that work with raster data (Idrisi, ArcView Spatial Analyst, Arc:Info Grid, Intergraph, etc.), by using simple processes of image georeferencing. Although the user interface of the second version has been notably improved, permitting much faster and user-defined analyses (also including the possibility of representing two layers simultaneously), it has still been designed as an integrated product, with little possibility of exportation or conversion. Similarly, there is no possibility of intervention in or control of the interface.

In spite of the limitations we have mentioned, these integrated databases allow simple models to be produced, on the basis of a large number of pre-established parameters; and, at the same time, basic archaeological information can be integrated, thus,

enabling interesting approximations to be made, which makes them an interesting product, at a very reasonable price.

To give some examples of how digital cartography can be used in Archaeology, and, in particular, the improved quality of the information it offers, we carried out some tests, to get a better idea of its potential. We took, as a starting point, the geographic database of the first edition of the Digital Map of Spain; in some cases, the altitude was shown with maximum definition shading, and in others, hypsometric colours. In both cases, the results were more than acceptable for the size of the area, on which we were working (in the first two examples, we looked at), whereas, in the third (Amblés Valley), with an area of about 30 by 20 sq. km, we were at the limit, for obtaining acceptable resolution.

In this study, using these cartographic bases, we looked at some territorial questions, in relation to three Meseta tribes from the Second Iron Age: the *Vaccei*, *Vettoni* and *Carpetani*. In each case, we took, as the base, a background showing altitude, either by shading or hypsometric colour. This background was exported to one of the GIS, that works on a PC (ArcView, Idrisi or Arc:Info for NT), for managing data. Finally, either GIS modules, that work in a raster format, or the image processing programs, themselves, were used, to superimpose the various layers or images.

"Vaccei" area:

This is one of the regions that has been the object of recent synthesis studies, amongst which a number have concentrate on settlement (SAN MIGUEL, L.C., 1993 and DELIBES, G. and others, 1995). Taking the cartographic bases, published in the first of these works, and using the documentation provided by some lists (SAN MIGUEL; L.C., 1993: 27, 28 and 34), the area of study was selected and its altitude represented, using shaded relief, with the Digital Map of Spain. Then, a hydrography overlay, showing the most important river basins, was created, taken from the Digital Map of the World. This map was then exported to ArcView, and this program was used, to produce a geo-referenced database, which included, in addition to the coordinates, the altitude of the sites, their size and chronology (Iron Age I or Iron Age II), which allowed us to automatically select the sites, on the basis of these parameters.

After compiling this data, we represented, in map format, some of the conclusions, arrived at by the authors of the above-mentioned studies, but which they, themselves, did not represent graphically. In particular, L. C. San Miguel, when referring to the characteristics of the settlements of the Soto Horizon, as prototypes of the *Vaccei* settlement, emphasised intervisibility as a tactical factor, a factor that, in the opinion of that author, ceased to be important in the Second Iron Age, to the extent that a good proportion of the Iberianized sites were not within sight of each other (SAN MIGUEL, L.C., 1995: 27).

Although some aspects, such as our poor knowledge of visual communication in antiquity and the intense and persistent fog banks of the area, obliged us to treat the visual reference factor with some caution (SAN MIGUEL, L.C., 1993: 27); it seemed virtually essential to evaluate it, along with other factors, such as proximity to marshlands and livestock tracks (DELIBES, G. and others, 1995: 61). In order to check these observations, we selected the First Iron Age sites, between the Douro and Pisuerga Rivers. The companion program, to the Digital Map of Spain, used this data to generate visibility, from one or more points. In our case, we obtained this information for two of the

more typical sites: Soto de Medinilla and Las Quintanas de Valoria la Buena, both with Iron Age I and Iron Age II levels. Because of program design limitations, the visibility was restricted to a 15-km radius, but the result was most enlightening.

The representation of visible areas (figure 4) confirmed that these two sites could be seen from other sites, on the same horizon; so, we found that four sites could be seen from Soto de Medinilla and five, from Las Quintanas, in both cases, two more than estimated, in the work of L.C. San Miguel. But, in addition, it could be observed that both sites could keep watch over the Pisuerga River, that flowed between them. In view of this evidence, it is uncertain whether the strategy was, in fact, aimed at watching over other settlements, or if the strategy had to do with the river itself, as a means of communication and a connection, to better-irrigated lands and more productive livestock and crops. Therefore, we should ask ourselves, which was the real strategy: keeping watch over the fertile valley and the places along it, or, on the contrary, having the ability to keep other human groups in sight.

If the latter assumption is correct, we should be cautious of reaching definitive conclusions, since "we know neither the chronology of most of the settlements, nor their duration, and, therefore, whether or not they could have been contemporary with each other" ("desconocemos, asimismo, no sólo la cronología de la mayor parte de los asentamientos, sino también su propia duración y, por tanto, su coetaneidad", DELIBES, G. and others, 1995: 60), a determining factor for reaching firm conclusions.

On the other hand, we must point out that surveillance of the rivers seems to have been common to other groups of the First Iron Age, or, at least, we have evidence for it, in sites belonging to the same horizon, the lower basin of the Manzanares, where the changes in the location of First Iron Age sites, compared to the Late Bronze Age, denote a greater command over the surrounding area and a better visual control of the river basin. This conclusion would seem to be confirmed in other inland areas of the peninsula, such as the Manzanares Valley.

The second part of this work was a study of the Carpetanian territory. The objective was to apply computerised cartography to a geographic framework, that adapted well to the characteristics of scale, used by the ordnance survey, digital series, and allowed us to find out how effectively it could solve the problems, that arose, as a result of combining information on different scales.

We are aware of the dangers of making territorial assumptions, about the pre-Roman horizon, and of the predicament involved, in trying to establish the boundaries of the geo-historic groups, which populated the Iberian peninsula in the first millennium, B.C., in the first place, because distinct political units did not exist, and, in the second, because of the absence of clearly defined frontiers, throughout this period (CASTRO, P. and GONZÁLEZ, P., 1989). It seems more appropriate, therefore, to talk about more local borders, those of each settlement, that provided a relative, collective and cultural border, that of *ethnicity*, which we take to mean, an imprecise and general, territorial guideline, which can only be drawn, with the help of other defining principles, which we shall consider below.

As classical sources tell us, Carpetania broadly coincided with the present-day province of Madrid and central and eastern Toledo. Its fringes also appear to have extended to western

parts of Cuenca, the western border of Guadalajara and the north of Ciudad Real. So, Carpetanian territory coincided with the region of the mid-Tagus basin and its central tributaries: the Alberche, Guadarrama, Jarama, Tajuña and Algodor. This space was defined by natural borders, to the north and the south: the Sierra of Guadarrama and the strip, formed by the Toledo mountains and the marshy area of the mid-Guadiana, respectively. It is more difficult to determine the limits, to the east and the west; although, in the west, the border with the *Vettoni* can be established, with the help of certain cultural elements, such as the characteristic *verracos*.

Starting from this idea, which takes into account information from written sources, and also certain archaeological features, as well as geographic phenomena, we selected a topographical base, represented by hypsometrical coloured relief, and integrated it, into a GIS, into which we had built a complete alphanumeric database of the archaeological sites, known in that area, where aspects such as ethnic group, age, function (necropolis, settlement, *verraco*), etc., had been introduced.

By using criteria, other than those we have referred to (written sources, archaeological features, and geographic elements), on variable scales, and always using different cartographic bases within the GIS, we were able to establish tentative limits, which had to be treated with due caution (figure 5). These limits defined a broad area of predominantly flat land, suitable for a mixed agrarian and pastoral economy, in contrast with the stock raising of the surrounding territories, occupied by people, such as the Celtiberians and Vettones. This fact can be related to the model of occupation, seen in the Carpetanian territory, characterized by small settlements, with perishable structures, which were not occupied for long.

The limits, that we proposed, differed somewhat from those established by other authors, in previous studies. In general, they were closer to the limits proposed, some years ago, by González Conde (GONZÁLEZ CONDE, P., 1992: 305), although, we extended the territory to the south, incorporating the uplands of the Toledo mountains, and using the Cigüela River as a possible dividing line, between Carpetania and Oretania. Similarly, we also think that Carpetania probably extended a little further to the Northeast, along this frontier stretch, with the Celtiberians, than according to González Conde, taking into account the characteristics of the sites and the materials they have produced, as well as the reference to ancient *Segontia* (Sigüenza) being an Arevaci city, very close to Carpetania (Livy XXXIV, 19, 10).

On the other hand, our hypothesis differs more radically from that, proposed by Rabanal and Bragado (RABANAL, M. A. and BRAGADO, J. M^a, 1990), who extended the limits of Carpetania to the Guadiana River, in the south, and as far as the upper Jalón River in the Northeast, including some of the castros and necropoleis, which recent studies (LORRIO, A., 1997), have considered, in view of their spatial and architectonic characteristics and their material culture, to be fully Celtiberian. They are, moreover, located in a mountainous area, much more in keeping with the rest of Celtiberia, than most of the Carpetanian territory.

The third, and last, part was focused on one of the most typical areas of the *Vettoni* territory: the Amblés Valley, where there are a number of *oppida*, which must be included in any study of this pre-Roman group: Cogotas de Cardeñosa, Ulaca, Sanchorreja and La Mesa de Miranda. From the

methodological point of view, we chose the cartography of a relatively small area (about 30 by 20 kilometers) for the scale, used in the Digital Map of Spain, which explained the poor definition of the image, when compared to the maps, shown previously; although, it was sufficiently expressive, to show the specific conditions of this clearly-defined, geographic unit.

This work should be seen as a continuation of and a complement to the research carried out in recent years, by one of the authors at the sites of Cogotas and Ulaca and as the zoomorphic sculptures of the Ávila province, the characteristic *verracos* (MARINÉ and RUIZ ZAPATERO 1988; ÁLVAREZ-SANCHÍS 1993 and 1997; RUIZ ZAPATERO and ÁLVAREZ-SANCHÍS 1995). It was a continuation, in that it related to the geographic area of the Amblés Valley, in the province of Avila, where these *oppida* and stone statues were located (ÁLVAREZ-SANCHÍS 1990 and 1994), dealing with questions raised when studying it previously; and it was complementary, in as much as it was designed to study the basic space, or territory, of pre-Roman communities, using the methodology of spatial analysis and Geographic Information Systems (LLOBERA 1996; BAENA, BLASCO and QUESADA 1997). We have concentrated on two key aspects: the general pattern of settlement and the sociological interpretation of the sculptures.

As in previous studies, we selected the area of study, in the Digital Map of Spain, and took as the base, one map showing altitude, by shading, and another, in which altitude was indicated, using hypsometric colours. A hydrographic overlay, from the Digital Map of the World, was superimposed on them. The settlements and *verracos*, previously located on analogue maps, were geo-referenced onto this image. Then, the digitalisation of the livestock tracks was added into ArcView. All this information was subsequently used, to produce various thematic maps, which we refer to below.

The pre-Roman settlements in the Amblés Valley, were basically spread out in a line (figure 6); their distribution followed the network of rivers, generated by the upper Adaja River, its tributaries, and the mountain ranges that formed its boundaries: the sierras of Ávila, Villanueva, La Serreta, Ojos Albos y La Paramera (the latter in the northern foothills of the Gredos). The valley itself, covers an area of 900 sq. km and has a strong geographic unity.

In general, the sites were grouped into two main areas. One was the foothills of the mountain ranges, surrounding the valley, where most of the fortified settlements were found: the big *oppida* of Cogotas, in the Cardenosa district, with an area of 14.5 ha (CABRÉ, J. 1930 y 1932), La Mesa de Miranda, in Chamartín de la Sierra, with an area of 30 ha (CABRÉ, J., CABRÉ, M^a.E. and MOLINERO, A., 1950) and Ulaca, in the Solosancho district, the largest of all, with an area of over 60 ha (LANTIER and BREUIL. H. 1932) (which only includes the area within the walls). Some evidence suggests that it is probable that another pre-Roman town, of some importance, is to be found under the city of Ávila, the ancient *Obila*, mentioned by Ptolemy (II, 5, 7), although no conclusive materials have been found, which would date it earlier than the mid-first century, B.C. (MARTÍN VALLS, R., 1976: 383 and note 31).

As we have said elsewhere, these towns were complemented with small, unfortified settlements on the valley floor, known of from the Provincial Archaeological Map, simply through

materials found in surface surveys. In any case, an idea of the difference, between them and the larger settlements, can be established from a set of variables, ranging from visibility to the minimum distance between them, and taking into account aspects, such as the topography, or the potential for arable or cattle farming:

(1) the average distances to the neighbouring settlements, which suggest differences in the pattern of settlement. The settlements on the plain are relatively closer together (around 4000-5000 m), but the *oppida* are farther apart, with many above-average distances,

(2) visual communication between the villages. The ability to see each other affects them differently, because they are sites with a clearly-defined topographic location, accentuated by the topographical conditions of the fertile valley (which are more favourable for the sites on the plains). In the case of the *oppida*, there is a very clear interest in being able to keep watch over the territory, as a whole, rather than maintaining close visual contact with other sites. The position of Ulaca, at the top of a great hill, overlooking the whole valley, shows its importance, in this respect. Its size suggests that it ranked as the hierarchical centre of the region, if we also take into account its religious function, which it alone, of all the settlements in the region, appears to have exercised (ALMAGRO-GORBEA, M. and ALVAREZ-SANCHÍS, J. 1993: 177 ff.),

(3) an analysis of land use. Generally speaking, the population of the Amblés Valley seems to have established a dual economy: the *oppida*, in the upland regions, with good livestock resources, and the small settlements on the plains, with greater arable potential, working the fertile alluvial soils of the Adaja river,

(4) the functions of the *oppida* and the smaller sites. The first can be characterised by (a) their development of a variety of industrial activities, well documented in the Las Cogotas pottery and the Ulaca quarry, (b) their involvement in trade networks, as demonstrated by the decorations on pottery, or weapons, in the necropoleis, (c) their strong fortification, and (d) their construction (in the case of Ulaca) of monumental structures, with a religious function. These features contrast with the deductions, that can be made, about the settlements on the plains, whose production was limited, and which provide no evidence of long-distance contacts, or defensive or religious structures (RUIZ ZAPATERO, G. y ALVAREZ-SANCHÍS, J. 1995: 229-230, table 1),

(5) while the evidence from the territory is sufficiently explicit for a hierarchical pattern of settlement to be deduced, the impression obtained, from an analysis of Las Cogotas and La Osera necropoleis, also allows certain conclusions to be drawn (CASTRO, P. 1986; KURTZ, W. 1987; MARTÍN VALLS, R. 1986-87). In the context of this study, we would like to draw attention to two aspects of the Vetton cemeteries: (a) the existence of separate, or independent, areas within the necropoleis, and (b) the existence of a strong social hierarchy, evidenced by differences in the grave goods.

The "verracos" in the landscape

The stone sculptures of bulls and pigs, the characteristic *verracos* of the Vettoni area, should also be included in this settlement model. Traditionally, it was thought that they might have had a magical value in the Iron Age, protecting and

bestowing fertility on livestock, or that they were funerary monuments (MARTÍN VALLS, R., 1974). In recent reviews, however, we have proposed a different, but complementary, explanation, that we think fits the evidence better. A very considerable proportion of the sculptures lack a precise archaeological context; they are located several kilometers outside the villages, and they are to be found in areas of good pastures. For that reason, we think that the effort, invested in making these sculptures, would only make sense if they acted as landmarks, or fixed points of reference in the landscape, marking the boundaries of critical resources, like winter pastures. To this first, general interpretation, as boundary markers of critical resources (ÁLVAREZ-SANCHÍS, J. 1990 and 1994), we have added a second reading, from a micro-locational perspective, which has allowed us to discover the sculptures' complex, visual role in the landscape, which, from this standpoint, is not merely one of passive support (ÁLVAREZ-SANCHÍS, J. and RUIZ ZAPATERO, G., forthcoming).

Seeing this art form, in the context of the Iron Age, socio-economical universe, gave us important results in the Amblés Valley, consistent with the region's hierarchical pattern of settlement, which must necessarily be related to the large fortified *oppida*. The preliminary study, which was carried out on a sample of approximately 100 sculptures, scattered over 37 sites (generally between one and four pieces in each place, apart from a few, in larger groups), gave us excellent results and enabled us to develop an analytical methodology, that we consider useful and are trying to perfect; it is based, mainly, on the application of the GIS and on the reconstruction of land use.

In this respect, an initial evaluation of the topography, that paid particular attention to direction, visibility, and access routes, and took into account factors, such as the ease of moving livestock, the location of springs for watering the animals, and the location of the richest and longest-lasting pastures, enabled us to evaluate a number of key elements:

(1) The level of attraction exercised by, and from, the landscape. It is important to emphasise that the strong concentration of *verracos* in the Amblés Valley, contrasts markedly with their absence, towards the East of the valley – the border between the *Vettoni* and *Carpetani*. And, there are very few known sculptures, towards the north (the cereal-growing lands of the Douro valley), where there are more *Vaccei* communities (in the west, or in the south, where the Gredos mountain range forms a great natural frontier). This would suggest that the valley formed some kind of unit for the communities, that inhabited it, during the latter centuries of the first millennium, B.C. It must have been an area, with a concentrated population, and a relatively dense settlement.

(2) More than 70 per cent of the sculptures are located in areas close to, but not right beside, the settlements, on the average, between 2000 and 4000 m away; and they are not apparently associated with dwellings, or areas of specific activity. But, despite the distance between the *verracos* and the settlements, each has a clear view of the other, which would seem to suggest that they were connected, in some way.

(3) The sculptures are located very close to the tracks, along which livestock were driven, which means that the animals could easily have been taken to the areas, where we assume they were pastured (figure 7). In trying to determine the relationships, that existed between the stone statues and the

livestock routes, statistical analysis has been very revealing. For example, if the total space, which we considered, was close to 2400 sq. km - including, not only, the Amblés Valley depression, but also, the mountain ranges that surround it, and the cereal-growing lands to the north, and, the "buffer zone", or area of proximity, which is about 860 sq. km (i.e., the space between the tracks and their immediate surroundings), which we estimated at 1.5 km, on either side of each track – the reading was as follows: only 35% of the area studied, was within that area of proximity to the tracks; however, more than 72% of the sculpture sites, were within that area. That is, the *verracos* were clearly cited, in the proximity of the tracks, used by the livestock.

(4) These same points coincided with the best pastures and water sources, which means that it would be easy to move the livestock, for watering. In other words, it would seem that easily identifiable sources of subsistence were sought in the landscape.

So, the *verracos* were studied, *in situ*, from two points of view: the way they were perceived in the landscape, and what could be seen from the sites of the sculptures (ÁLVAREZ-SANCHÍS, J. and RUIZ-ZAPATERO, G., forthcoming). Space was active, not passive. What is of interest are the social practices, followed in the territory (BARRET 1994). The *verracos* would simply be the material and symbolic expression of the use of space, and the livestock economy, of Iron Age *Vettoni* communities, a way of ordering the landscape in a small region, with a relatively dense occupation.

In conclusion, the advantage of these databases, with integrated management programs and analyses, is that they allow a simple approach to the spatial framework, in which archaeological sites are set, facilitating an interactive approach to the general characteristics of the distribution of space, and they are an effective tool for the objective definition of patterns of settlement. In particular, the examples given facilitate an understanding of some of the hypotheses, proposed by various authors, or simply, show the conclusions obtained in various studies, in graphic form (as analogue cartography is unable to do), and they also enable us to advance in the field of spatial Archaeology.

In the case of visibility of ancient, Iron Age settlements, in the mid-Douro Valley, we have been able to confirm the hypotheses proposed, concerning the intervisibility of settlements, and, in addition, the ability to control the river basins has also been confirmed, which was, perhaps, a strategy of similar importance.

With regard to the limits of the Carpetanian area, we have only been able to obtain a large-scale level of accuracy, in the study of an extensive area, that requires a perspective, which can only be obtained from very small scales; and, finally, the applications developed, in the *Vettoni* area, have confirmed the close relationship that existed between the siting of the *verracos* and the good stock raising areas, and, in particular, with the tracks used by sheep and goats. These results show that, even working with small scales, GIS offer major possibilities for the study of land use, in Archaeology.

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